The OpenVX™ Specification

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Chapter 1. Introduction

1.1. Abstract

OpenVX is a low-level programming framework domain to enable software developers to efficiently access computer vision hardware acceleration with both functional and performance portability. OpenVX has been designed to support modern hardware architectures, such as mobile and embedded SoCs as well as desktop systems. Many of these systems are parallel and heterogeneous: containing multiple processor types including multi-core CPUs, DSP subsystems, GPUs, dedicated vision computing fabrics as well as hardwired functionality. Additionally, vision system memory hierarchies can often be complex, distributed, and not fully coherent. OpenVX is designed to maximize functional and performance portability across these diverse hardware platforms, providing a computer vision framework that efficiently addresses current and future hardware architectures with minimal impact on applications.

OpenVX contains:

- a library of predefined and customizable vision functions,
- a graph-based execution model to combine function enabling both task and data-independent execution, and;
- a set of memory objects that abstract the physical memory.

OpenVX defines a C Application Programming Interface (API) for building, verifying, and coordinating graph execution, as well as for accessing memory objects. The graph abstraction enables OpenVX implementers to optimize the execution of the graph for the underlying acceleration architecture.

OpenVX also defines the `vxu` utility library, which exposes each OpenVX predefined function as a directly callable C function, without the need for first creating a graph. Applications built using the `vxu` library do not benefit from the optimizations enabled by graphs; however, the vxu library can be useful as the simplest way to use OpenVX and as first step in porting existing vision applications.

As the computer vision domain is still rapidly evolving, OpenVX provides an extensibility mechanism to enable developer-defined functions to be added to the application graph.

1.2. Purpose

The purpose of this document is to detail the Application Programming Interface (API) for OpenVX.

1.3. Scope of Specification

The document contains the definition of the OpenVX API. The conformance tests that are used to determine whether an implementation is consistent to this specification are defined separately.

1.4. Normative References

The section “Module Documentation” forms the normative part of the specification. Each API definition provided in that chapter has certain preconditions and post conditions specified that are normative. If these normative conditions are not met, the behavior of the function is undefined.

1.5. Version/Change History

- OpenVX 1.0 Provisional - November, 2013
- OpenVX 1.0 Provisional V2 - June, 2014
- OpenVX 1.0 - September 2014
- OpenVX 1.0.1 - April 2015
- OpenVX 1.1 - May 2016
- OpenVX 1.2 - May 2017
- OpenVX 1.2.1 - May 2018

1.6. Deprecation

Certain items that are deprecated through the evolution of this specification document are removed from it. However, to provide a backward compatibility for such items for a certain time period these items are made available via a compatibility header file available with the release of this specification document (VX/vx_compatibility.h). The items listed in this compatibility header file are temporary only and are removed permanently when the backward compatibility is no longer supported for those items.

1.7. Requirements Language

In this specification, the words *shall* or *must* express a requirement that is binding, *should* expresses design goals or recommended actions, and *may* expresses an allowed behavior.

1.8. Typographical Conventions

The following typographical conventions are used in this specification.

- **Bold** words indicate warnings or strongly communicated concepts that are intended to draw attention to the text.
- `Monospace` words signify an API element (i.e., class, function, structure) or a filename.
- *Italics* denote an emphasis on a particular concept, an abstraction of a concept, or signify an argument, parameter, or member.
- Throughout this specification, code examples given to highlight a particular issue use the format as shown below:

```
/* Example Code Section */
int main(int argc, char *argv[])
{
   return 0;
}
```

- Some "mscgen" message diagrams are included in this specification. The graphical conventions for this tool can be found on its website.

1.8.1. Naming Conventions

The following naming conventions are used in this specification.

- Opaque objects and atomics are named as `vx_object`, e.g., `vx_image` or `vx_uint8`, with an underscore separating the object name from the "vx" prefix.
- Defined Structures are named as `vx_struct_t`, e.g., `vx_imagepatch_addressing_t`, with underscores separating the structure from the "vx" prefix and a "t" to denote that it is a structure.
- Defined Enumerations are named as `vx_enum_e`, e.g., `vx_type_e`, with underscores separating the enumeration from the "vx" prefix and an "e" to denote that it is an enumerated value.
- Application Programming Interfaces are named `vxsomeFunction`() using camel case, starting with lowercase, and no underscores, e.g., `vxCreateContext()`.
- Vision functions also have a naming convention that follows a lower-case, inverse dotted hierarchy similar to Java Packages, e.g.,

```
"org.khronos.openvx.color_convert"
```

This minimizes the possibility of name collisions and promotes sorting and readability when querying the namespace of available vision functions. Each vision function should have a unique dotted name of the style: *tld.vendor.library.function*. The hierarchy of such vision function namespaces is undefined outside the subdomain "org.khronos", but they do follow existing international standards. For OpenVX-specified vision functions, the "function" section of the unique name does not use camel case and uses underscores to separate words.

1.8.2. Vendor Naming Conventions

The following naming conventions are to be used for vendor specific extensions.

- Opaque objects and atomics are named as `vx_object_vendor`, e.g., `vx_ref_array_acme`, with an underscore separating the vendor name from the object name.
- Defined Structures are named as `vx_struct_vendor_t`, e.g., `vx_mdview_acme_t`, with an underscore separating the vendor from the structure name and a "t" to denote that it is a structure.
- Defined Enumerations are named as `vx_enum_vendor_e`, e.g., `vx_convolution_name_acme_e`, with an underscores separating the vendor from the enumeration name and an "e" to denote that it is an enumerated value.

- Defined Enumeration values are named as `VX_ENUMVALUE_VENDOR`, e.g., `VX_PARAM_STRUCT_ATTRIBUTE_SIZE_ACME` using only capital letters staring with the “VX” prefix, and underscores separating the words.
- Application Programming Interfaces are named `vxSomeFunctionVendor`() using camel case, starting with lowercase, and no underscores, e.g., `vxCreateRefArrayAcme()`.

1.9. Glossary and Acronyms

Atomic

The specification mentions *atomics*, which means a C primitive data type. Usages that have additional wording, such as *atomic operations* do not carry this meaning.

API

Application Programming Interface that specifies how a software component interacts with another.

Framework

A generic software abstraction in which users can override behaviors to produce application-specific functionality.

Engine

A purpose-specific software abstraction that is tunable by users.

Run-time

The execution phase of a program.

Kernel

OpenVX uses the term *kernel* to mean an abstract *computer vision function*, not an Operating System kernel. Kernel may also refer to a set of convolution coefficients in some computer vision literature (e.g., the Sobel “kernel”). OpenVX does not use this meaning. OpenCL uses kernel (specifically `cl_kernel`) to qualify a function written in “CL” which the OpenCL may invoke directly. This is close to the meaning OpenVX uses; however, OpenVX does not define a language.

1.10. Acknowledgements

This specification would not be possible without the contributions from this partial list of the following individuals from the Khronos Working Group and the companies that they represented at the time:

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Chapter 2. Design Overview

2.1. Software Landscape

OpenVX is intended to be used either directly by applications or as the acceleration layer for higher-level vision frameworks, engines or platform APIs.

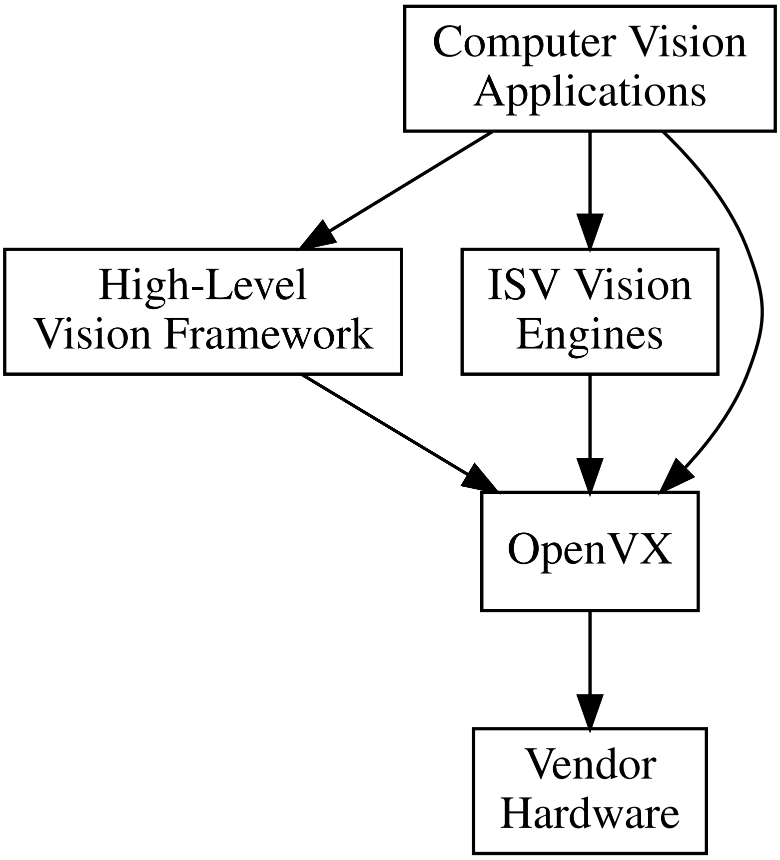


Figure 1. OpenVX Usage Overview

2.2. Design Objectives

OpenVX is designed as a framework of standardized computer vision functions able to run on a wide variety of platforms and potentially to be accelerated by a vendor's implementation on that platform. OpenVX can improve the performance and efficiency of vision applications by providing an abstraction for commonly-used vision functions and an abstraction for aggregations of functions (a "graph"), thereby providing the implementer the opportunity to minimize the run-time overhead.

The functions in OpenVX are intended to cover common functionality required by many vision applications.

2.2.1. Hardware Optimizations

This specification makes no statements as to which acceleration methodology or techniques may be used in its implementation. Vendors may choose any number of implementation methods such as parallelism and/or specialized hardware offload techniques.

This specification also makes no statement or requirements on a “level of performance” as this may vary significantly across platforms and use cases.

2.2.2. Hardware Limitations

The OpenVX focuses on vision functions that can be significantly accelerated by diverse hardware. Future versions of this specification may adopt additional vision functions into the core standard when hardware acceleration for those functions becomes practical.

2.3. Assumptions

2.3.1. Portability

OpenVX has been designed to maximize functional and performance portability wherever possible, while recognizing that the API is intended to be used on a wide diversity of devices with specific constraints and properties. Tradeoffs are made for portability where possible: for example, portable Graphs constructed using this API should work on any OpenVX implementation and return similar results within the precision bounds defined by the OpenVX conformance tests.

2.3.2. Opaqueness

OpenVX is intended to address a very broad range of devices and platforms, from deeply embedded systems to desktop machines and distributed computing architectures. The OpenVX API addresses this range of possible implementations without forcing hardware-specific requirements onto any particular implementation via the use of *opaque* objects for most program data.

All data, except client-facing structures, are opaque and hidden behind a reference that may be as thin or thick as an implementation needs. Each implementation provides the standardized interfaces for accessing data that takes care of specialized hardware, platform, or allocation requirements. Memory that is *imported* or *shared* from other APIs is not subsumed by OpenVX and is still maintained and accessible by the originator.

OpenVX does not dictate any requirements on memory allocation methods or the layout of opaque memory objects and it does not dictate byte packing or alignment for structures on architectures.

2.4. Object-Oriented Behaviors

OpenVX objects are both strongly typed at compile-time for safety critical applications and are strongly typed at run-time for dynamic applications. Each object has its typedef’d type and its associated enumerated value in the `vx_type_e` list. Any object may be down-cast to a `vx_reference` safely to be used in functions that require this, specifically `vxQueryReference`, which can be used to get the `vx_type_e` value using an `vx_enum`.

2.5. OpenVX Framework Objects

This specification defines the following OpenVX framework objects.

- Object: Context - The OpenVX context is the object domain for all OpenVX objects. All data objects *live* in the context as well as all framework objects. The OpenVX context keeps reference counts on all objects and must do garbage collection during its deconstruction to free lost references. While multiple clients may connect to the OpenVX context, all data are private in that the references that refer to data objects are given only to the creating party. The results of calling an OpenVX function on data objects created in different contexts are undefined.

- Object: Kernel - A Kernel in OpenVX is the abstract representation of a computer vision function, such as a “Sobel Gradient” or “Lucas Kanade Feature Tracking”. A vision function may implement many similar or identical features from other functions, but it is still considered a single, unique kernel as long as it is named by the same string and enumeration and conforms to the results specified by OpenVX. Kernels are similar to function signatures in this regard.
- Object: Parameter - An abstract input, output, or bidirectional data object passed to a computer vision function. This object contains the signature of that parameter’s usage from the kernel description. This information includes:
  - *Signature Index* - The numbered index of the parameter in the signature.
  - *Object Type* - e.g. `VX_TYPE_IMAGE`, or `VX_TYPE_ARRAY`, or some other object type from `vx_type_e`.
  - *Usage Model* - e.g. `VX_INPUT`, `VX_OUTPUT`, or `VX_BIDIRECTIONAL`.
  - *Presence State* - e.g. `VX_PARAMETER_STATE_REQUIRED`, or `VX_PARAMETER_STATE_OPTIONAL`.
- Object: Node - A node is an instance of a kernel that will be paired with a specific set of references (the parameters). Nodes are created from and associated with a single graph only. When a `vx_parameter` is extracted from a Node, an additional attribute can be accessed:
  - *Reference* - The `vx_reference` assigned to this parameter index from the Node creation function (e.g., `vxSobel3x3Node`).
- Object: Graph - A set of nodes connected in a directed (only goes one-way) acyclic (does not loop back) fashion. A Graph may have sets of Nodes that are unconnected to other sets of Nodes within the same Graph. See Graph Formalisms.

2.6. OpenVX Data Objects

Data objects are object that are processed by graphs in nodes.

- Object: Array An opaque array object that could be an array of primitive data types or an array of structures.
- Object: Convolution An opaque object that contains an M × N matrix of `vx_int16` values. Also contains a scaling factor for normalization. Used specifically with `vxuConvolve` and `vxConvolveNode`.
- Object: Delay An opaque object that contains a manually controlled, temporally-delayed list of objects.
- Object: Distribution An opaque object that contains a frequency distribution (e.g., a histogram).
- Object: Image An opaque image object that may be some format in `vx_df_image_e`.
- Object: LUT An opaque lookup table object used with `vxTableLookupNode` and `vxuTableLookup`.
- Object: Matrix An opaque object that contains an M × N matrix of some scalar values.

- Object: Pyramid An opaque object that contains multiple levels of scaled `vx_image` objects.
- Object: Remap An opaque object that contains the map of source points to destination points used to transform images.
- Object: Scalar An opaque object that contains a single primitive data type.
- Object: Threshold An opaque object that contains the thresholding configuration.
- Object: ObjectArray An opaque array object that could be an array of any data-object (not data-type) of OpenVX except Delay and ObjectArray objects.
- Object: Tensor An opaque multidimensional data object. Used in functions like `vxHOGFeaturesNode`, `vxHOGCellsNode` and the Neural Networks extension.

2.7. Error Objects

Error objects are specialized objects that may be returned from other object creator functions when serious platform issue occur (i.e., out of memory or out of handles). These can be checked at the time of creation of these objects, but checking also may be put-off until usage in other APIs or verification time, in which case, the implementation must return appropriate errors to indicate that an invalid object type was used.

```
vx_<object> obj = vxCreate<Object>(context, ...);
vx_status status = vxGetStatus((vx_reference)obj);
if (status == VX_SUCCESS) {
    // object is good
}
```

2.8. Graphs Concepts

The *graph* is the central computation concept of OpenVX. The purpose of using graphs to express the Computer Vision problem is to allow for the possibility of any implementation to maximize its optimization potential because all the operations of the graph and its dependencies are known ahead of time, before the graph is processed.

Graphs are composed of one or more *nodes* that are added to the graph through node creation functions. Graphs in OpenVX must be created ahead of processing time and verified by the implementation, after which they can be processed as many times as needed.

2.8.1. Linking Nodes

Graph Nodes are linked together via data dependencies with *no explicitly-stated ordering*. The same reference may be linked to other nodes. Linking has a limitation, however, in that only one node in a graph may output to any specific data object reference. That is, only a single writer of an object may exist in a given graph. This prevents indeterminate ordering from data dependencies. All writers in a graph shall produce output data before any reader of that data accesses it.

2.8.2. Virtual Data Objects

Graphs in OpenVX depend on data objects to link together nodes. When clients of OpenVX know that they do not need access to these *intermediate* data objects, they may be created as `virtual`. Virtual data objects can be used in the same manner as non-virtual data objects to link nodes of a graph together; however, virtual data objects are different in the following respects.

- Inaccessible - No calls to an Map/Unmap or Copy APIs shall succeed given a reference to an object created through a virtual create function from a Graph external perspective. Calls to Map/Unmap or Copy APIs from within client-defined node that belongs to the same graph as the virtual object will succeed as they are Graph internal.
- Scoped - Virtual data objects are scoped within the Graph in which they are created; they cannot be shared outside their scope. The live range of the data content of a virtual data object is limited to a single graph execution. In other word, data content of a virtual object is undefined before graph execution and no data of a virtual object should be expected to be preserved across successive graph executions by the application.
- Intermediates - Virtual data objects should be used only for intermediate operations within Graphs, because they are fundamentally inaccessible to clients of the API.
- Dimensionless or Formatless - Virtual data objects may have dimensions and formats partially or fully undefined at creation time. For instance, a virtual image can be created with undefined or partially defined dimensions (0x0, Nx0 or 0xN where N is not null) and/or without defined format (`VX_DF_IMAGE_VIRT`). The undefined property of the virtual object at creation time is undefined with regard to the graph and mutable at graph verification time; it will be automatically adjusted at each graph verification, deduced from the node that outputs the virtual object. Dimensions and format properties that are well defined at virtual object creation time are immutable and can’t be adjusted automatically at graph verification time.
- Attributes - Even if a given Virtual data object does not have its dimensionality or format completely defined, these attributes may still be queried. If queried before the object participates in a graph verification, the attribute value returned is what the user provided (e.g., “0” for the dimension). If queried after graph verification (or re-verification), the attribute value returned will be the value determined by the graph verification rules.
- The Dimensionless or Formatless aspect of virtual data is a commodity that allows creating graphs generic with regard to dimensions or format, but there are restrictions:
  a. Nodes may require the dimensions and/or the format to be defined for a virtual output object when it can’t be deduced from its other parameters. For example, a Scale node requires well defined dimensions for the output image, while ColorConvert and ChannelCombine nodes require a well defined format for the output image.
  b. An image created from ROI must always be well defined (`vx_rectangle_t` parameter) and can’t be created from a dimensionless virtual image.
  c. A ROI of a formatless virtual image shouldn’t be a node output.
  d. A tensor created from View must always be well defined and can’t be created from a dimensionless virtual tensor.
  e. A view of a formatless virtual tensor shouldn’t be a node output.
  f. Levels of a dimensionless or formatless virtual pyramid shouldn’t be a node output.

- Inheritance - A sub-object inherits from the virtual property of its parent. A sub-object also inherits from the Dimensionless or Formatless property of its parent with restrictions:
  a. it is adjusted automatically at graph verification when the parent properties are adjusted (the parent is the output of a node)
  b. it can't be adjusted at graph verification when the sub-object is itself the output of a node.
- Optimizations - Virtual data objects do not have to be created during Graph validation and execution and therefore may be of zero *size*.

These restrictions enable vendors the ability to optimize some aspects of the data object or its usage. Some vendors may not allocate such objects, some may create intermediate sub-objects of the object, and some may allocate the object on remote, inaccessible memories. OpenVX does not proscribe *which* optimization the vendor does, merely that it *may* happen.

2.8.3. Node Parameters

Parameters to node creation functions are defined as either atomic types, such as `vx_int32`, `vx_enum`, or as objects, such as `vx_scalar`, `vx_image`. The atomic variables of the Node creation functions shall be converted by the framework into `vx_scalar` references for use by the Nodes. A node parameter of type `vx_scalar` can be changed during the graph execution; whereas, a node parameter of an atomic type (`vx_int32` etc.) require at least a graph revalidation if changed. All node parameter objects may be modified by retrieving the reference to the `vx_parameter` via `vxGetParameterByIndex`, and then passing that to `vxQueryParameter` to retrieve the reference to the object.

```
vx_parameter param = vxGetParameterByIndex(node, p);
vx_reference ref;
vxQueryParameter(param, VX_PARAMETER_REF, &ref, sizeof(ref));
```

If the type of the parameter is unknown, it may be retrieved with the same function.

```
vx_enum type;
vxQueryParameter(param, VX_PARAMETER_TYPE, &type, sizeof(type));
/* cast the ref to the correct vx_<type>. Atomics are now vx_scalar */
```

2.8.4. Graph Parameters

Parameters may exist on Graphs, as well. These parameters are defined by the author of the Graph and each Graph parameter is defined as a specific parameter from a Node within the Graph using `vxAddParameterToGraph`. Graph parameters communicate to the implementation that there are specific Node parameters that may be modified by the client between Graph executions. Additionally, they are parameters that the client may set without the reference to the Node but with the reference to the Graph using `vxSetGraphParameterByIndex`. This allows for the Graph authors to construct *Graph Factories*. How these factories work falls outside the scope of this document.

See Framework: Graph Parameters.

2.8.5. Execution Model

Graphs must execute in both:

- *Synchronous blocking mode* (in that `vxProcessGraph` will block until the graph has completed), and in
- *Asynchronous single-issue-per-reference mode* (via `vxScheduleGraph` and `vxWaitGraph`).

Asynchronous Mode

In asynchronous mode, Graphs must be single-issue-per-reference. This means that given a constructed graph reference G, it may be scheduled multiple times but only executes sequentially with respect to itself. Multiple graphs references given to the asynchronous graph interface do not have a defined behavior and may execute in parallel or in series based on the behavior or the vendor's implementation.

2.8.6. Graph Formalisms

To use graphs several rules must be put in place to allow deterministic execution of Graphs. The behavior of a `processGraph`(G) call is determined by the structure of the Processing Graph G. The Processing Graph is a bipartite graph consisting of a set of Nodes N_1 … N_n and a set of data objects d_1 … d_i. Each edge (N_x,D_y) in the graph represents a data object D_y that is written by Node N_x and each edge (D_x,N_y) represents a data object D_x that is read by Node N_y. Each edge e has a name `Name`(e), which gives the parameter name of the node that references the corresponding data object. Each Node Parameter also has a type `Type(node, name)` in `{INPUT, OUTPUT, INOUT}`. Some data objects are *Virtual*, and some data objects are *Delay*. Delay data objects are just collections of data objects with indexing (like an image list) and known linking points in a graph. A node may be classified as a *head node*, which has no backward dependency. Alternatively, a node may be a *dependent node*, which has a backward dependency to the head node. In addition, the Processing Graph has several restrictions:

1. *Output typing* - Every output edge (N_x,D_y) requires `Type`(N_x, `Name`(N_x,D_y)) in `{OUTPUT, INOUT}`
2. *Input typing* - Every input edge (N_x,D_y) requires `Type`(N_y, `Name`(D_x,N_y)) in `{INPUT}` or `{INOUT}`
3. *Single Writer* - Every data object is the target of at most one output edge.
4. *Broken Cycles* - Every cycle in G must contain at least input edge (D_x,N_y) where D_x is Delay.
5. *Virtual images must have a source* - If D_y is Virtual, then there is at least one output edge that writes D_y(N_x,D_y)
6. *Bidirectional data objects shall not be virtual* - If `Type`(N_x, `Name`(N_x,D_y)) is `INOUT` implies D_y is non-Virtual.
7. *Delay data objects shall not be virtual* - If D_x is Delay then it shall not be Virtual.
8. *A uniform image cannot be output or bidirectional.*

The execution of each node in a graph consists of an atomic operation (sometimes referred to as *firing*) that consumes data representing each input data object, processes it, and produces data representing each output data object. A node may execute when all of its input edges are marked *present*. Before the graph executes, the following initial marking is used:

- All input edges (D_x,N_y) from non-Virtual objects D_x are marked (parameters must be set).
- All input edges (D_x,N_y) with an output edge (N_z,D_x) are unmarked.
- All input edges (D_x,N_y) where D_x is a Delay data object are marked.

Processing a node results in unmarking all the corresponding input edges and marking all its output edges; marking an output edge (N_x,D_y) where D_y is not a Delay results in marking all of the input edges (D_y,N_z). Following these rules, it is possible to statically schedule the nodes in a graph as follows: Construct a precedence graph P, including all the nodes N_1 … N_x, and an edge (N_x,N_z) for every pair of edges (N_x,D_y) and (D_y,N_z) where D_y is not a Delay. Then unconditionally fire each node according to any topological sort of P.

The following assertions should be verified:

- P is a Directed Acyclic Graph (DAG), implied by 4 and the way it is constructed.
- Every data object has a value when it is executed, implied by 5, 6, 7, and the marking.
- Execution is deterministic if the nodes are deterministic, implied by 3, 4, and the marking.
- Every node completes its execution exactly once.

The execution model described here just acts as a formalism. For example, independent processing is allowed across multiple depended and depending nodes and edges, provided that the result is invariant with the execution model described here.

Contained & Overlapping Data Objects

There are cases in which two different data objects referenced by an output parameter of node N_1 and input parameter of node N_2 in a graph induce a dependency between these two nodes: For example, a pyramid and its level images, image and the sub-images created from it by `vxCreateImageFromROI` or `vxCreateImageFromChannel`, or overlapping sub-images of the same image. Following figure show examples of this dependency. To simplify subsequent definitions and requirements a limitation is imposed that if a sub-image $I^{'}$ has been created from image I and sub-image $I^{''}$ has been created from $I^{'}$, then $I^{''}$ is still considered a sub-image of I and not of $I^{'}$. In these cases it is expected that although the two nodes reference two different data objects, any change to one data object might be reflected in the other one. Therefore it implies that N_1 comes before N_2 in the graph’s topological order. To ensure that, following definitions are introduced.

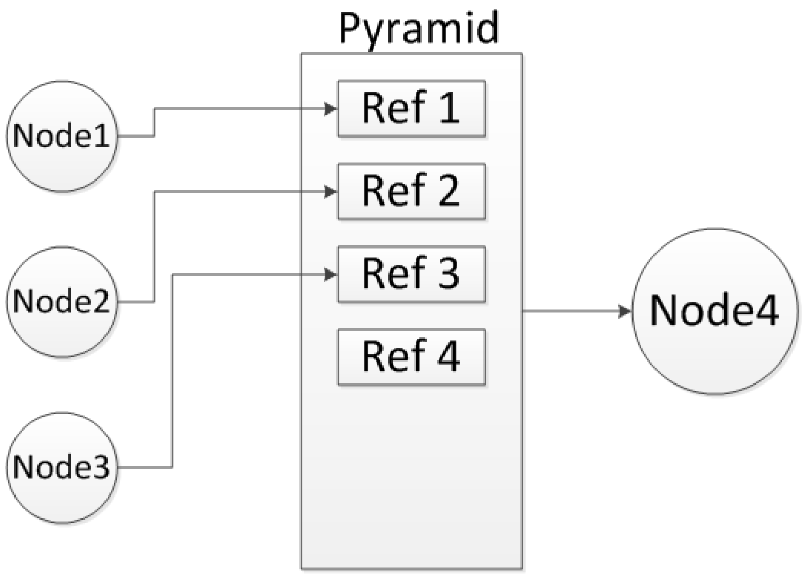


Figure 2. Pyramid Example

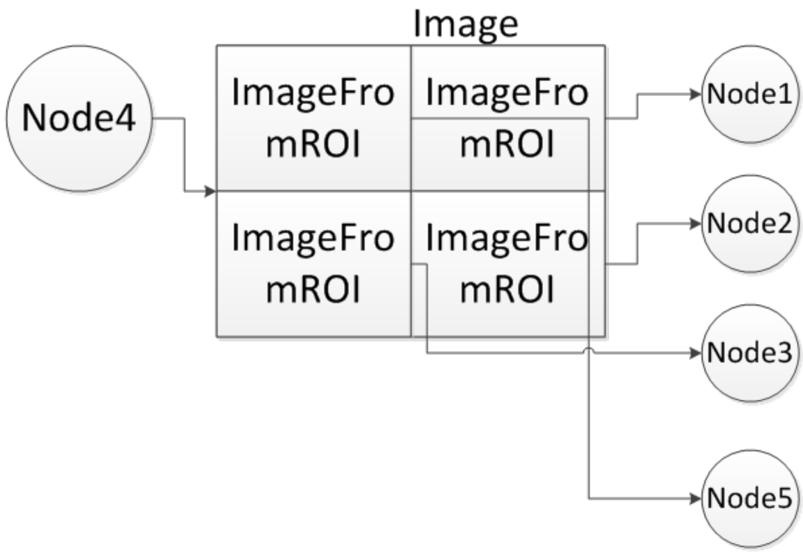


Figure 3. Image Example

1. *Containment Set - C(d)*, the set of recursively contained data objects of *d*, named *Containment Set*, is defined as follows:
   - $C_0(d) = \{d\}$
   - $C_1(d)$ is the set of all data objects that are *directly contained* by *d*:
     - If *d* is an image, all images created from an ROI or channel of *d* are directly contained by *d*.
     - If *d* is a pyramid, all pyramid levels of *d* are directly contained by *d*.
     - If *d* is an object array, all elements of *d* are directly contained by *d*.
     - If *d* is a delay object, all slots of *d* are directly contained by *d*.
   - For i > 1, $C_i(d)$ is the set of all data objects that are contained by *d* at the i^{th} order

$$C_i(d) = \bigcup_{d' \in C_{i-1}(d)} C_1(d')$$

◦ C(*d*) is the set that contains *d* itself, the data objects *contained* by *d*, the data objects that are contained by the data objects contained by *d* and so on. Formally:

$$C(d) = \bigcup_{i=0}^{\infty} C_i(d)$$

2. *I(d)* is a predicate that equals true if and only if *d* is an image.
3. *Overlapping Relationship* - The overlapping relation R_{ov} is a relation defined for images, such that if i_1 and i_2 in *C(i)*, *i* being an image, then i_1 R_{ov} i_2 is true if and only if i_1 and i_2 overlap, i.e there exists a point (x,y) of *i* that is contained in both i_1 and i_2. Note that this relation is reflexive and symmetric, but not transitive: i_1 overlaps i_2 and i_2 overlaps i_3 does not necessarily imply that i_1 overlaps i_3, as illustrated in the following figure:

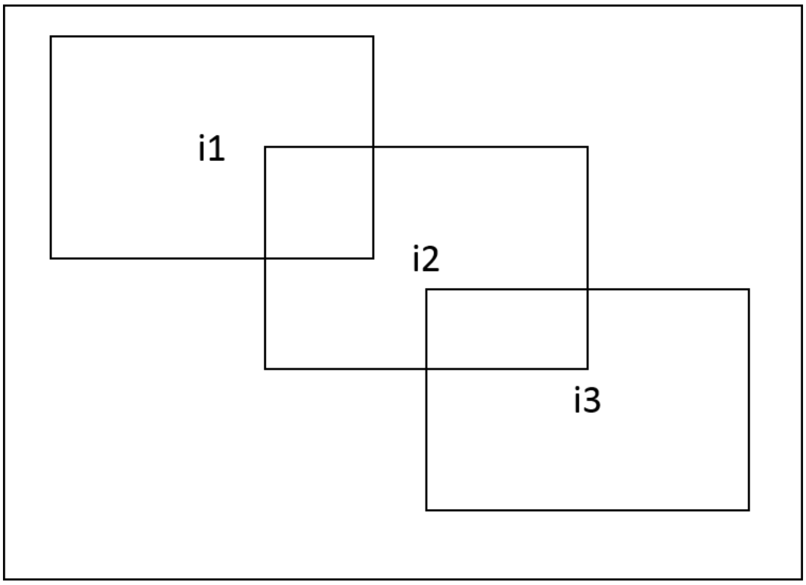


Figure 4. Overlap Example

4. *Dependency Relationship* - The dependency relationship $N_1 \rightarrow N_2$, is a relation defined for nodes. $N_1 \rightarrow N_2$ means that N_2 depends on N_1 and then implies that N_2 must be executed after the completion of N_1.
5. $N_1 \rightarrow N_2$ if N_1 writes to a data object d_1 and N_2 reads from a data object d_2 and:

$$d_1 \in C(d_2) \text{ or } d_2 \in C(d_1) \text{ or } (I(d_1) \text{ and } I(d_2) \text{ and } d_1\ R_{ov}\ d_2)$$

If data object D_y of an output edge (N_x,D_y) overlaps with a data object D_z then the result is implementation defined.

2.8.7. Node Execution Independence

In the following example a client computes the gradient magnitude and gradient phase from a blurred input image. The `vxMagnitudeNode` and `vxPhaseNode` are *independently* computed, in that each does not depend on the output of the other. OpenVX does not mandate that they are run simultaneously or in parallel, but it could be implemented this way by the OpenVX vendor.

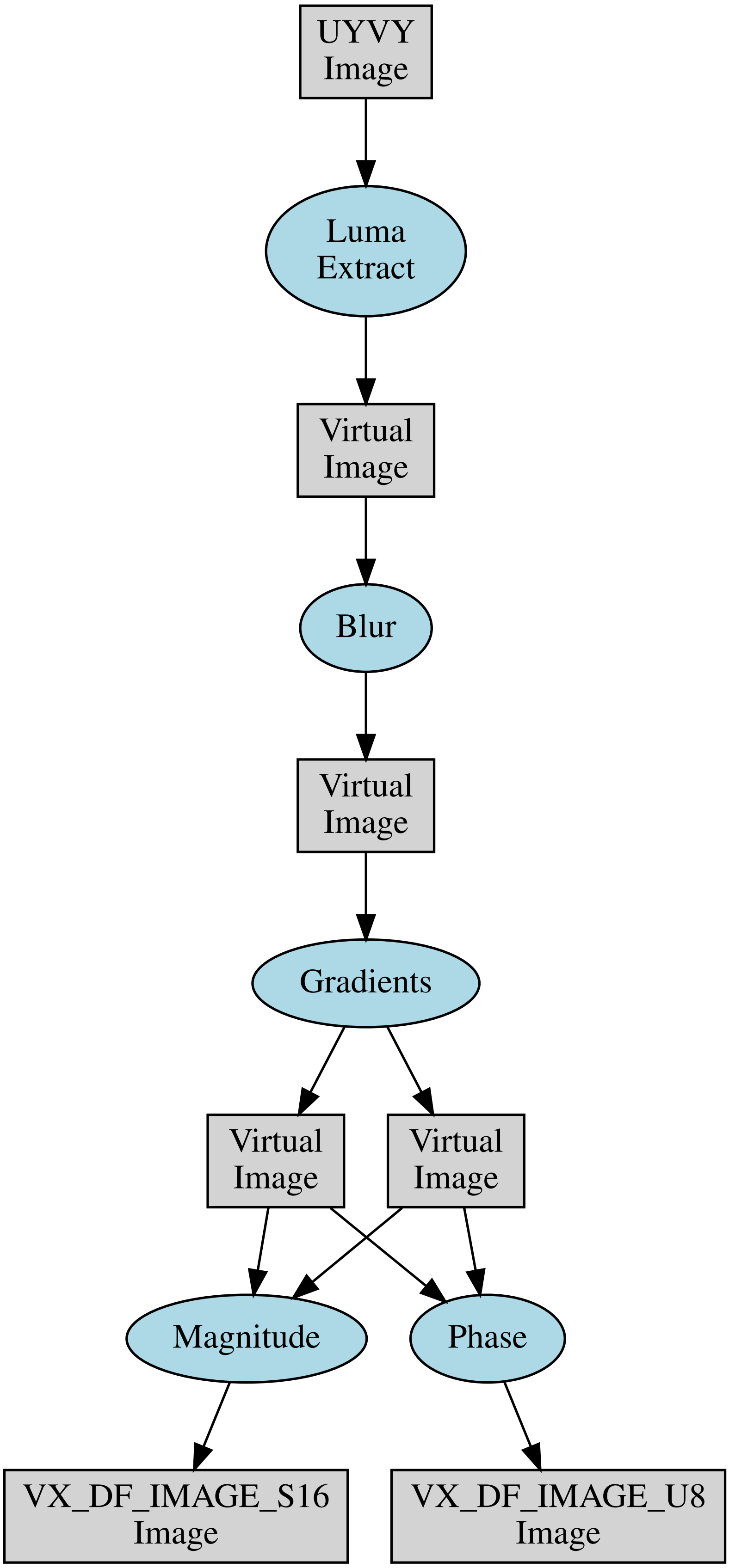


Figure 5. A simple graph with some independent nodes.

The code to construct such a graph can be seen below.

```
vx_context context = vxCreateContext();
vx_image images[] = {
        vxCreateImage(context, 640, 480, VX_DF_IMAGE_UYVY),
        vxCreateImage(context, 640, 480, VX_DF_IMAGE_S16),
        vxCreateImage(context, 640, 480, VX_DF_IMAGE_U8),
};
vx_graph graph = vxCreateGraph(context);
vx_image virts[] = {
        vxCreateVirtualImage(graph, 0, 0, VX_DF_IMAGE_VIRT),
        vxCreateVirtualImage(graph, 0, 0, VX_DF_IMAGE_VIRT),
        vxCreateVirtualImage(graph, 0, 0, VX_DF_IMAGE_VIRT),
        vxCreateVirtualImage(graph, 0, 0, VX_DF_IMAGE_VIRT),
};

vxChannelExtractNode(graph, images[0], VX_CHANNEL_Y, virts[0]),
vxGaussian3x3Node(graph, virts[0], virts[1]),
vxSobel3x3Node(graph, virts[1], virts[2], virts[3]),
vxMagnitudeNode(graph, virts[2], virts[3], images[1]),
vxPhaseNode(graph, virts[2], virts[3], images[2]),

status = vxVerifyGraph(graph);
if (status == VX_SUCCESS)
{
    status = vxProcessGraph(graph);
}
vxReleaseContext(&context); /* this will release everything */
```

2.8.8. Verification

Graphs within OpenVX must go through a rigorous validation process before execution to satisfy the design concept of eliminating run-time overhead (parameter checking) that guarantees safe execution of the graph. OpenVX must check for (but is not limited to) these conditions:

Parameters To Nodes:

- Each required parameter is given to the node (vx_parameter_state_e). Optional parameters may not be present and therefore are not checked when absent. If present, they are checked.
- Each parameter given to a node must be of the right *direction* (a value from `vx_direction_e`).
- Each parameter given to a node must be of the right *object type* (from the object range of `vx_type_e`).
- Each parameter attribute or value must be verified. In the case of a scalar value, it may need to be range checked (e.g., $0.5 \le k \le 1.0$). The implementation is not required to do run-time range checking of scalar values. If the value of the scalar changes at run time to go outside the range, the results are undefined. The rationale is that the potential performance hit for run-time range checking is too large to be enforced. It will still be checked at graph verification time as a time-zero sanity check. If the scalar is an output parameter of another node, it must be initialized to a legal value. In the case of `vxScaleImageNode`, the relation of the input image dimensions to the

output image dimensions determines the scaling factor. These values or attributes of data objects must be checked for compatibility on each platform.

- Graph Connectivity - the `vx_graph` must be a Directed Acyclic Graph (DAG). No cycles or feedback is allowed. The `vx_delay` object has been designed to explicitly address feedback between Graph executions.
- Resolution of Virtual Data Objects - Any changes to *Virtual* data objects from unspecified to specific format or dimensions, as well as the related creation of objects of specific type that are observable at processing time, takes place at Verification time.

The implementation must check that all node parameters are the correct type at node creation time, unless the parameter value is set to `NULL`. Additional checks may also be made on non-`NULL` parameters. The user must be allowed to set parameters to `NULL` at node creation time, even if they are required parameters, in order to create "exemplar" nodes that are not used in graph execution, or to create nodes incrementally. Therefore the implementation must not generate an error at node creation time for parameters that are explicitly set to `NULL`. However, the implementation must check that all required parameters are non-`NULL` and the correct type during `vxVerifyGraph`. Other more complex checks may also be done during `vxVerifyGraph`. The implementation should provide specific error reporting of `NULL` parameters during `vxVerifyGraph`, e.g., "Parameter<parameter> of Node<node> is `NULL`."

2.9. Callbacks

Callbacks are a method to control graph flow and to make decisions based on completed work. The `vxAssignNodeCallback` call takes as a parameter a callback function. This function will be called after the execution of the particular node, but prior to the completion of the graph. If nodes are arranged into independent sets, the order of the callbacks is unspecified. Nodes that are arranged in a serial fashion due to data dependencies perform callbacks in order. The callback function may use the node reference first to extract parameters from the node, and then extract the data references. Data outputs of Nodes with callbacks shall be available (via Map/Unmap/Copy methods) when the callback is called.

2.10. User Kernels

OpenVX supports the concept of *client-defined functions* that shall be executed as *Nodes* from inside the Graph or are Graph *internal*. The purpose of this paradigm is to:

- Further exploit independent operation of nodes within the OpenVX platform.
- Allow componentized functions to be reused elsewhere in OpenVX.
- Formalize strict verification requirements (i.e., Contract Programming).

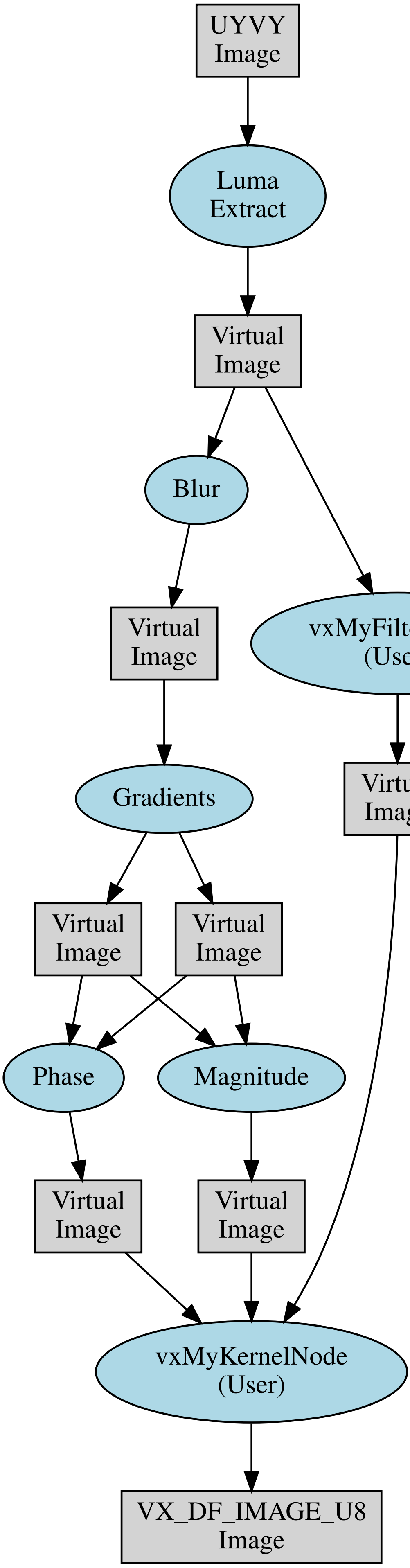


Figure 6. A graph with User Kernel nodes which are independent of the "base" graph with some independent nodes.

In this example, to execute client-supplied functions, the graph does not have to be halted and then resumed. These nodes shall be executed in an independent fashion with respect to independent base nodes within OpenVX. This allows implementations to further minimize execution time if hardware to exploit this property exists.

2.10.1. Parameter Validation

User Kernels must aid in the Graph Verification effort by providing an explicit validation function for each vision function they implement. Each parameter passed to the instanced Node of a User Kernel is validated using the client-supplied validation function. The client must check these attributes and/or values of each parameter:

- Each attribute or value of the parameter must be checked. For example, the size of array, or the value of a scalar to be within a range, or a dimensionality constraint of an image such as width divisibility. (Some implementations may have restrictions, such as an image width be evenly divisible by some fixed number).
- If the output parameters depend on attributes or values from input parameters, those relationships must be checked.

The Meta Format Object

The Meta Format Object is an opaque object used to collect requirements about the output parameter, which then the OpenVX implementation will check. The Client must manually set relevant object attributes to be checked against output parameters, such as dimensionality, format, scaling, etc.

2.10.2. User Kernels Naming Conventions

User Kernels must be exported with a unique name (see Naming Conventions for information on OpenVX conventions) and a unique enumeration. Clients of OpenVX may use either the name or enumeration to retrieve a kernel, so collisions due to non-unique names will cause problems. The kernel enumerations may be extended by following this example:

```
#define VX_KERNEL_NAME_KHR_XYZ "org.khronos.example.xyz"
/*! \brief The XYZ Example Library Set
 * \ingroup group_xyz_ext
 */
#define VX_LIBRARY_XYZ (0x3) // assigned from Khronos, vendors control their own

/*! \brief The list of XYZ Kernels.
 * \ingroup group_xyz_ext
 */
enum vx_kernel_xyz_ext_e {
    /*! \brief The Example User Defined Kernel */
    VX_KERNEL_KHR_XYZ = VX_KERNEL_BASE(VX_ID_DEFAULT, VX_LIBRARY_XYZ) + 0x0,
    // up to 0xFFF kernel enums can be created.
};
```

Each vendor of a vision function or an implementation must apply to Khronos to get a unique identifier (up to a limit of 2^{12} - 1 vendors). Until they obtain a unique ID vendors must use `VX_ID_DEFAULT`.

To construct a kernel enumeration, a vendor must have both their ID and a *library* ID. The library ID's are completely *vendor* defined (however when using the `VX_ID_DEFAULT` ID, many libraries may collide in namespace).

Once both are defined, a kernel enumeration may be constructed using the `VX_KERNEL_BASE` macro and an offset. (The offset is optional, but very helpful for long enumerations.)

2.11. Immediate Mode Functions

OpenVX also contains an interface defined within `<VX/vxu.h>` that allows for immediate execution of vision functions. These interfaces are prefixed with `vxu` to distinguish them from the Node interfaces, which are of the form `vx<Name>Node`. Each of these interfaces replicates a Node interface with some exceptions. Immediate mode functions are defined to *behave* as *Single Node Graphs*, which have no leaking side-effects (e.g., no Log entries) within the Graph Framework after the function returns. The following tables refer to both the Immediate Mode and Graph Mode vision functions. The Module documentation for each vision function draws a distinction on each API by noting that it is either an immediate mode function with the tag `[Immediate]` or it is a Graph mode function by the tag `[Graph]`.

2.12. Targets

A 'Target' specifies a physical or logical devices where a node or an immediate mode function is executed. This allows the use of different implementations of vision functions on different targets. The existence of allowed Targets is exposed to the applications by the use of defined APIs. The choice of a Target allows for different levels of control on where the nodes can be executed. An OpenVX implementation must support at least one target. Additional supported targets are specified using the appropriate enumerations. See `vxSetNodeTarget`, `vxSetImmediateModeTarget`, and `vx_target_e`. An OpenVX implementation must support at least one target `VX_TARGET_ANY` as well as `VX_TARGET_STRING` enumerates. An OpenVX implementation may also support more than these two to indicate the use of specific devices. For example, an implementation may add `VX_TARGET_CPU` and `VX_TARGET_GPU` enumerates to indicate the support of two possible targets to assign a nodes to (or to excute an immediate mode function). Another way an implementation can indicate the existence of multiple targets, for example CPU and GPU, is by specifying the target as `VX_TARGET_STRING` and using strings 'CPU' and 'GPU'. Thus defining targets using names rather than enumerates. The specific naming of string or enumerates is not enforced by the specification and it is up to the vendors to document and communicate the Target naming. Once available in a given implementation Applications can assign a Target to a node to specify the target that must execute that node by using the API `vxSetNodeTarget`. For immediate mode functions the target specifies the physical or logical device where the future execution of that function will be attempted. When an immediate mode function is not supported on the selected target the execution falls back to `VX_TARGET_ANY`.

2.13. Base Vision Functions

OpenVX comes with a standard or *base* set of vision functions. The following table lists the supported set of vision functions, their input types (first table) and output types (second table), and the version of OpenVX in which they are supported.

2.13.1. Inputs

Vision Function	S8	U8	U16	S16	U32	F32	color	other
AbsDiff		1.0		1.0.1				
Accumulate		1.0						
AccumulateSquared		1.0						
AccumulateWeighted		1.0						
Add		1.0		1.0				
And		1.0						
BilateralFilter		1.2		1.2				
Box3x3		1.0						
CannyEdgeDetector		1.0						
ChannelCombine		1.0						
ChannelExtract							1.0	
ColorConvert							1.0	
ConvertDepth		1.0		1.0				
Convolve		1.0						
Data Object Copy								1.2
Dilate3x3		1.0						
EqualizeHistogram		1.0						
Erode3x3		1.0						

Vision Function	S8	U8	U16	S16	U32	F32	color	other
FastCorners		1.0						
Gaussian 3x3		1.0						
Gaussian Pyramid		1.1						
HarrisCorners		1.0						
HalfScale Gaussian		1.0						
Histogram		1.0						
HOGCells		1.2						
HOGFeatures		1.2						
HoughLinesP		1.2						
IntegralImage		1.0						
Laplacian Pyramid		1.1						
Laplacian Reconstruct				1.1				
LBP		1.2						
Magnitude				1.0				
MatchTemplate		1.2						
MeanStdDev		1.0						
Median3x3		1.0						
Max		1.2		1.2				
Min		1.2		1.2				
MinMaxLoc		1.0		1.0				
Multiply		1.0		1.0				
NonLinearFilter		1.1						

Vision Function	S8	U8	U16	S16	U32	F32	color	other
NonMaximaSuppression		1.2		1.2				
Not		1.0						
OpticalFlowPyrLK		1.0						
Or		1.0						
Phase				1.0				
Gaussian Pyramid		1.0						
Remap		1.0						
ScaleImage		1.0						
Sobel3x3		1.0						
Subtract		1.0		1.0				
TableLookup		1.0		1.1				
TensorMultiply	1.2	1.2		1.2				
TensorAdd	1.2	1.2		1.2				
TensorSubtract	1.2	1.2		1.2				
TensorMatrixMultiply	1.2	1.2		1.2				
TensorTableLookup	1.2	1.2		1.2				
TensorTranspose	1.2	1.2		1.2				
Threshold		1.0						
WarpAffine		1.0						
WarpPerspective		1.0						
Xor		1.0						

2.13.2. Outputs

Vision Function	S8	U8	U16	S16	U32	F32	color	other
AbsDiff		1.0		1.0.1				
Accumulate				1.0				
AccumulateSquared				1.0				
AccumulateWeighted		1.0						
Add		1.0		1.0				
And		1.0						
BilateralFilter		1.2		1.2				
Box3x3		1.0						
CannyEdgeDetector		1.0						
ChannelCombine							1.0	
ChannelExtract		1.0						
ColorConvert							1.0	
ConvertDepth		1.0		1.0				
Convolve		1.0		1.0				
Data Object Copy								1.2
Dilate3x3		1.0						
EqualizeHistogram		1.0						
Erode3x3		1.0						
FastCorners		1.0						
Gaussian3x3		1.0						

Vision Function	S8	U8	U16	S16	U32	F32	color	other
Gaussian Pyramid		1.1						
HarrisCorners		1.0						
HalfScale Gaussian		1.0						
Histogram					1.0			
HOGCells	1.2					1.2		
HOGFeatures	1.2					1.2		
HoughLinesP								1.2
IntegralImage					1.0			
Laplacian Pyramid				1.1				
Laplacian Reconstruct		1.1						
LBP		1.2						
Magnitude				1.0				
MatchTemplate		1.2						
MeanStdDev						1.0		
Median3x3		1.0						
Max		1.2		1.2				
Min		1.2		1.2				
MinMaxLoc		1.0		1.0	1.0			
Multiply		1.0		1.0				
NonLinearFilter		1.1						
NonMaximaSuppression		1.2		1.2				
Not		1.0						

Vision Function	S8	U8	U16	S16	U32	F32	color	other
OpticalFlowPyrLK								
Or		1.0						
Phase		1.0						
GaussianPyramid		1.0						
Remap		1.0						
ScaleImage		1.0						
Sobel3x3				1.0				
Subtract		1.0		1.0				
TableLookup		1.0		1.1				
TensorMultiply	1.2	1.2		1.2				
TensorAdd	1.2	1.2		1.2				
TensorSubtract	1.2	1.2		1.2				
TensorMatrixMultiply	1.2	1.2		1.2				
TensorTableLookup	1.2	1.2		1.2				
TensorTranspose	1.2	1.2		1.2				
Threshold		1.0						
WarpAffine		1.0						
WarpPerspective		1.0						
Xor		1.0						

2.13.3. Parameter ordering convention

For vision functions, the input and output parameter ordering convention is:

1. Mandatory inputs
2. Optional inputs

3. Mandatory in/outs
4. Optional in/outs
5. Mandatory outputs
6. Optional outputs

The known exceptions are:

- `vxConvertDepthNode`,
- `vxuConvertDepth`,
- `vxOpticalFlowPyrLKNode`,
- `vxuOpticalFlowPyrLK`,
- `vxScaleImageNode`,
- `vxuScaleImage`.

2.14. Lifecycles

2.14.1. OpenVX Context Lifecycle

The lifecycle of the context is very simple.

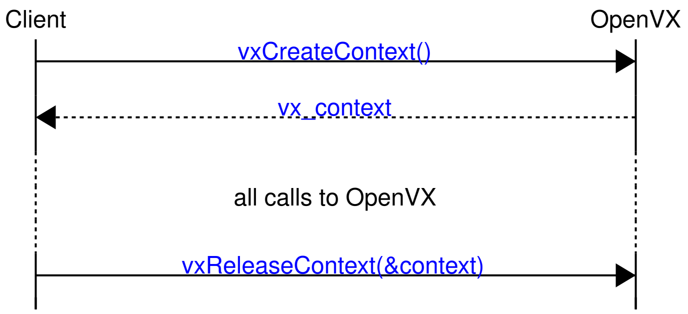


Figure 7. The lifecycle model for an OpenVX Context

2.14.2. Graph Lifecycle

OpenVX has four main phases of graph lifecycle:

- Construction - Graphs are created via `vxCreateGraph`, and Nodes are connected together by data objects.
- Verification - The graphs are checked for consistency, correctness, and other conditions. Memory allocation may occur.
- Execution - The graphs are executed via `vxProcessGraph` or `vxScheduleGraph`. Between executions data may be updated by the client or some other external mechanism. The client of OpenVX may change reference of input data to a graph, but this may require the graph to be validated again by checking `vxIsGraphVerified`.
- Deconstruction - Graphs are released via `vxReleaseGraph`. All Nodes in the Graph are released.

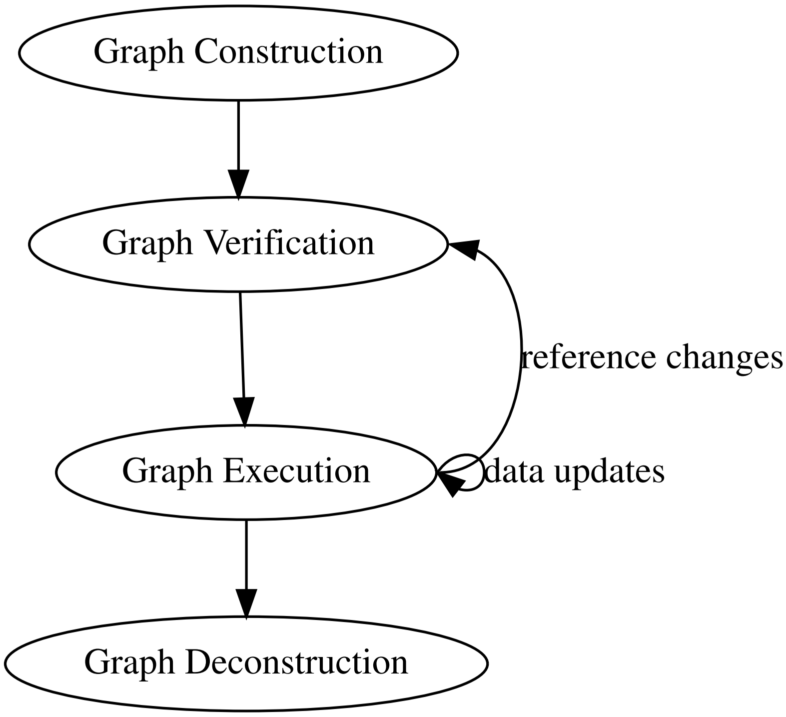


Figure 8. Graph Lifecycle

2.14.3. Data Object Lifecycle

All objects in OpenVX follow a similar lifecycle model. All objects are

- Created via `vxCreate<Object><Method>` or retrieved via `vxGet<Object><Method>` from the parent object if they are internally created.
- Used within Graphs or immediate functions as needed.
- Then objects must be released via `vxRelease<Object>` or via `vxReleaseContext` when all objects are released.

OpenVX Image Lifecycle

This is an example of the Image Lifecycle using the OpenVX Framework API. This would also apply to other data types with changes to the types and function names.

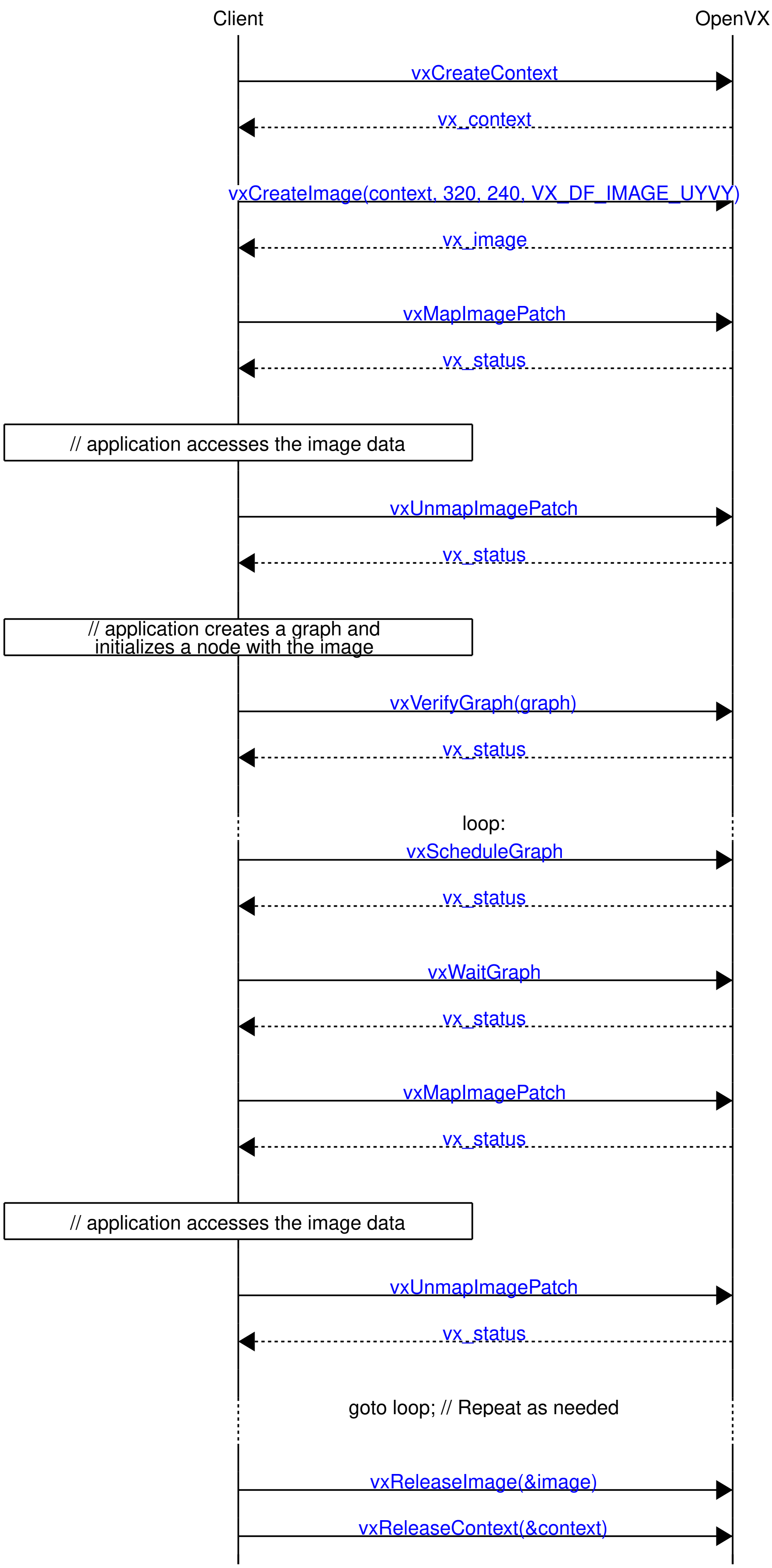


Figure 9. Image Object Lifecycle

2.15. Host Memory Data Object Access Patterns

For objects retrieved from OpenVX that are 2D in nature, such as vx_image, vx_matrix, and vx_convolution, the manner in which the host-side has access to these memory regions is well-defined. OpenVX uses a row-major storage (that is each unit in a column is memory-adjacent to its row adjacent unit). Two-dimensional objects are always created (using vxCreateImage or vxCreateMatrix) in width (columns) by height (rows) notation, with the arguments in that order. When accessing these structures in "C" with two-dimensional arrays of declared size, the user must therefore provide the array dimensions in the reverse of the order of the arguments to the Create function. This layout ensures *row-wise* storage in C on the host. A pointer could also be allocated for the matrix data and would have to be indexed in this row-major method.

2.15.1. Matrix Access Example

```
    const vx_size columns = 3;
    const vx_size rows = 4;
    vx_matrix matrix = vxCreateMatrix(context, VX_TYPE_FLOAT32, columns, rows);
    vx_status status = vxGetStatus((vx_reference)matrix);
    if (status == VX_SUCCESS)
    {
        vx_int32 j, i;
#if defined(OPENVX_USE_C99)
        vx_float32 mat[rows][columns]; /* note: row major */
#else
        vx_float32 *mat = (vx_float32 *)malloc(rows*columns*sizeof(vx_float32));
#endif
        if (vxCopyMatrix(matrix, mat, VX_READ_ONLY, VX_MEMORY_TYPE_HOST) ==
VX_SUCCESS) {
            for (j = 0; j < (vx_int32)rows; j++)
                for (i = 0; i < (vx_int32)columns; i++)
#if defined(OPENVX_USE_C99)
                    mat[j][i] = (vx_float32)rand()/(vx_float32)RAND_MAX;
#else
                    mat[j*columns + i] = (vx_float32)rand()/(vx_float32)RAND_MAX;
#endif
            vxCopyMatrix(matrix, mat, VX_WRITE_ONLY, VX_MEMORY_TYPE_HOST);
        }
#if !defined(OPENVX_USE_C99)
        free(mat);
#endif
    }
```

2.15.2. Image Access Example

Images and Array differ slightly in how they are accessed due to more complex memory layout requirements.

```
vx_status status = VX_SUCCESS;
```

```
void *base_ptr = NULL;
vx_uint32 width = 640, height = 480, plane = 0;
vx_image image = vxCreateImage(context, width, height, VX_DF_IMAGE_U8);
vx_rectangle_t rect;
vx_imagepatch_addressing_t addr;
vx_map_id map_id;

rect.start_x = rect.start_y = 0;
rect.end_x = rect.end_y = PATCH_DIM;

status = vxMapImagePatch(image, &rect, plane, &map_id,
                         &addr, &base_ptr,
                         VX_READ_AND_WRITE, VX_MEMORY_TYPE_HOST, 0);
if (status == VX_SUCCESS)
{
    vx_uint32 x,y,i,j;
    vx_uint8 pixel = 0;

    /* a couple addressing options */

    /* use linear addressing function/macro */
    for (i = 0; i < addr.dim_x*addr.dim_y; i++) {
        vx_uint8 *ptr2 = vxFormatImagePatchAddress1d(base_ptr,
                                                     i, &addr);
        *ptr2 = pixel;
    }

    /* 2d addressing option */
    for (y = 0; y < addr.dim_y; y+=addr.step_y) {
        for (x = 0; x < addr.dim_x; x+=addr.step_x) {
            vx_uint8 *ptr2 = vxFormatImagePatchAddress2d(base_ptr,
                                                         x, y, &addr);
            *ptr2 = pixel;
        }
    }

    /* direct addressing by client
     * for subsampled planes, scale will change
     */
    for (y = 0; y < addr.dim_y; y+=addr.step_y) {
        for (x = 0; x < addr.dim_x; x+=addr.step_x) {
            vx_uint8 *tmp = (vx_uint8 *)base_ptr;
            i = ((addr.stride_y*y*addr.scale_y) /
                  VX_SCALE_UNITY) +
                ((addr.stride_x*x*addr.scale_x) /
                  VX_SCALE_UNITY);
            tmp[i] = pixel;
        }
    }

    /* more efficient direct addressing by client.
```

```
     * for subsampled planes, scale will change.
     */
    for (y = 0; y < addr.dim_y; y+=addr.step_y) {
        j = (addr.stride_y*y*addr.scale_y)/VX_SCALE_UNITY;
        for (x = 0; x < addr.dim_x; x+=addr.step_x) {
            vx_uint8 *tmp = (vx_uint8 *)base_ptr;
            i = j + (addr.stride_x*x*addr.scale_x) /
                VX_SCALE_UNITY;
            tmp[i] = pixel;
        }
    }

    /* this commits the data back to the image.
     */
    status = vxUnmapImagePatch(image, map_id);
}
vxReleaseImage(&image);
```

2.15.3. Array Access Example

Arrays only require a single value, the stride, instead of the entire addressing structure that images need.

```
vx_size i, stride = sizeof(vx_size);
void *base = NULL;
vx_map_id map_id;
/* access entire array at once */
vxMapArrayRange(array, 0, num_items, &map_id, &stride, &base, VX_READ_AND_WRITE,
VX_MEMORY_TYPE_HOST, 0);
for (i = 0; i < num_items; i++)
{
    vxArrayItem(mystruct, base, i, stride).some_uint += i;
    vxArrayItem(mystruct, base, i, stride).some_double = 3.14f;
}
vxUnmapArrayRange(array, map_id);
```

Map/Unmap pairs can also be called on individual elements of array using a method similar to this:

```
/* access each array item individually */
for (i = 0; i < num_items; i++)
{
    mystruct *myptr = NULL;
    vxMapArrayRange(array, i, i+1, &map_id, &stride, (void **)&myptr,
VX_READ_AND_WRITE, VX_MEMORY_TYPE_HOST, 0);
    myptr->some_uint += 1;
    myptr->some_double = 3.14f;
    vxUnmapArrayRange(array, map_id);
}
```

2.16. Concurrent Data Object Access

Accessing OpenVX data-objects using the functions Map, Copy, Read concurrently to an execution of a graph that is accessing the same data objects is permitted only if all accesses are read-only. That is, for Map, Copy to have a read-only access mode and for nodes in the graph to have that data-object as an input parameter only. In all other cases, including write or read-write modes and Write access function, as well as a graph nodes having the data-object as output or bidirectional, the application must guarantee that the access is not performed concurrently with the graph execution. That can be achieved by calling un-map following a map before calling `vxScheduleGraph` or `vxProcessGraph`. In addition, the application must call `vxWaitGraph` after `vxScheduleGraph` before calling Map, Read, Write or Copy to avoid restricted concurrent access. An application that fails to follow the above might encounter an undefined behavior and/or data loss without being notified by the OpenVX framework. Accessing images created from ROI (`vxCreateImageFromROI`) or created from a channel (`vxCreateImageFromChannel`) must be treated as if the entire image is being accessed.

- Setting an attribute is considered as writing to a data object in this respect.
- For concurrent execution of several graphs please see Execution Model
- Also see the graph formalism section for guidance on accessing ROIs of the same image within a graph.

2.17. Valid Image Region

The valid region mechanism informs the application as to which pixels of the output images of a graph's execution have valid values (see valid pixel definition below). The mechanism also applies to immediate mode (VXU) calls, and supports the communication of the valid region between different graph executions. Some vision functions, mainly those providing statistics and summarization of image information, use the valid region to ignore pixels that are not valid on their inputs (potentially bad or unstable pixel values). A good example of such a function is Min/Max Location. Formalization of the valid region mechanism is given below.

- Valid Pixels - All output pixels of an OpenVX function are considered valid by default, unless their calculation depends on input pixels that are not valid. An input pixel is not valid in one of two situations:
  a. The pixel is outside of the image border and the border mode in use is `VX_BORDER_UNDEFINED`
  b. The pixel is outside the valid region of the input image.
- Valid Region - The region in the image that contains all the valid pixels. Theoretically this can be of any shape. OpenVX currently only supports rectangular valid regions. In subsequent text the term 'valid rectangle' denotes a valid region that is rectangular in shape.
- Valid Rectangle Reset - In some cases it is not possible to calculate a valid rectangle for the output image of a vision function (for example, warps and remap). In such cases, the vision function is said to reset the valid Region to the entire image. The attribute `VX_NODE_VALID_RECT_RESET` is a read only attribute and is used to communicate valid rectangle reset behavior to the application. When it is set to `vx_true_e` for a given node the valid rectangle of the output images will reset to the full image upon execution of the node, when it is set to `vx_false_e` the valid rectangle will be calculated. All standard OpenVX functions will have this

attribute set to vx_false_e by default, except for Warp and Remap where it will be set to vx_true_e.

- Valid Rectangle Initialization - Upon the creation of an image, its valid rectangle is the entire image. One exception to this is when creating an image via vxCreateImageFromROI; in that case, the valid region of the ROI image is the subset of the valid region of the parent image that is within the ROI. In other words, the valid region of an image created using an ROI is the largest rectangle that contains valid pixels in the parent image.
- Valid Rectangle Calculation - The valid rectangle of an image changes as part of the graph execution, the correct value is guaranteed only when the execution finishes. The valid rectangle of an image remains unchanged between graph executions and persists between graph executions as long as the application doesn't explicitly change the valid region via vxSetImageValidRectangle. Notice that using vxMapImagePatch, vxUnmapImagePatch or vxSwapImageHandle does not change the valid region of an image. If a non-UNDEFINED border mode is used on an image where the valid region is not the full image, the results at the border and resulting size of the valid region are implementation-dependent. This case can occur when mixing UNDEFINED and other border mode, which is not recommended.
- Valid Rectangle for Immediate mode (VXU) - VXU is considered a single node graph execution, thus the valid rectangle of an output of VXU will be propagated for an input to a consequent VXU call (when using the same output image from one call as input to the consecutive call).
- Valid Region Usage - For all standard OpenVX functions, the framework must guarantee that all pixel values inside the valid rectangle of the output images are valid. The framework does not guarantee that input pixels outside of the valid rectangle are processed. For the following vision functions, the framework guarantees that pixels outside of the valid rectangle do not participate in calculating the vision function result: Equalize Histogram, Integral Image, Fast Corners, Histogram, Mean and Standard Deviation, Min Max Location, Optical Flow Pyramid (LK) and Canny Edge Detector. An application can get the valid rectangle of an image by using vxGetValidRegionImage.
- User kernels - User kernels may change the valid rectangles of their output images. To change the valid rectangle, the programmer of the user kernel must provide a call-back function that sets the valid rectangle. The output validator of the user kernel must provide this callback by setting the value of the vx_meta_format attribute VX_VALID_RECT_CALLBACK during the output validator. The callback function must be callable by the OpenVX framework during graph validation and execution. Assumptions must not be made regarding the order and the frequency by which the valid rectangle callback is called. The framework will recalculate the valid region when a change in the input valid regions is detected. For user nodes, the default value of VX_NODE_VALID_RECT_RESET is vx_true_e. Setting VX_VALID_RECT_CALLBACK during parameter validation to a value other than NULL will result in setting VX_NODE_VALID_RECT_RESET to vx_false_e. Note: the above means that when VX_VALID_RECT_CALLBACK is not set or set to NULL the user-node will reset the valid rectangle to the entire image.
- In addition, valid rectangle reset occurs in the following scenarios:
  a. A reset of the valid rectangle of a parent image when a node writes to one of its ROIs. The only case where the reset does not occur is when the child ROI image is identical to the parent image.
  b. For nodes that have the VX_NODE_VALID_RECT_RESET set to vx_true_e

2.18. Extending OpenVX

Beyond User Kernels there are other mechanisms for vendors to extend features in OpenVX. These mechanisms are not available to User Kernels. Each OpenVX official extension has a unique identifier, comprised of capital letters, numbers and the underscore character, prefixed with "KHR_", for example "KHR_NEW_FEATURE".

2.18.1. Extending Attributes

When extending attributes, vendors *must* use their assigned ID from `vx_vendor_id_e` in conjunction with the appropriate macros for creating new attributes with `VX_ATTRIBUTE_BASE`. The typical mechanism to extend a new attribute for some object type (for example a `vx_node` attribute from `VX_ID_TI`) would look like this:

```
enum {
   VX_NODE_TI_NEWTHING = VX_ATTRIBUTE_BASE(VX_ID_TI, VX_TYPE_NODE) + 0x0,
};
```

2.18.2. Vendor Custom Kernels

Vendors wanting to add more kernels to the base set supplied to OpenVX should provide a header of the form

```
#include <VX/vx_ext_<vendor>.h>
```

that contains definitions of each of the following.

- New Node Creation Function Prototype per function.

```
/*! \brief [Graph] This is an example ISV or OEM provided node which executes
 * in the Graph to call the XYZ kernel.
 * \param [in] graph The handle to the graph in which to instantiate the node.
 * \param [in] input The input image.
 * \param [in] value The input scalar value
 * \param [out] output The output image.
 * \param [in,out] temp A temp array for some data which is needed for
 * every iteration.
 * \ingroup group_example_kernel
 */
vx_node vxXYZNode(vx_graph graph, vx_image input, vx_uint32 value, vx_image output,
vx_array temp);
```

- A new Kernel Enumeration(s) and Kernel String per function.

```
#define VX_KERNEL_NAME_KHR_XYZ "org.khronos.example.xyz"
/*! \brief The XYZ Example Library Set
 * \ingroup group_xyz_ext
 */
#define VX_LIBRARY_XYZ (0x3) // assigned from Khronos, vendors control their own

/*! \brief The list of XYZ Kernels.
 * \ingroup group_xyz_ext
 */
enum vx_kernel_xyz_ext_e {
    /*! \brief The Example User Defined Kernel */
    VX_KERNEL_KHR_XYZ = VX_KERNEL_BASE(VX_ID_DEFAULT, VX_LIBRARY_XYZ) + 0x0,
    // up to 0xFFF kernel enums can be created.
};
```

- [Optional] A new VXU Function per function.

```
/*! \brief [Immediate] This is an example of an immediate mode version of the XYZ
node.
 * \param [in] context The overall context of the implementation.
 * \param [in] input The input image.
 * \param [in] value The input scalar value
 * \param [out] output The output image.
 * \param [in,out] temp A temp array for some data which is needed for
 * every iteration.
 * \ingroup group_example_kernel
 */
vx_status vxuXYZ(vx_context context, vx_image input, vx_uint32 value, vx_image
output, vx_array temp);
```

This should come with good documentation for each new part of the extension. Ideally, these sorts of extensions should not require linking to new objects to facilitate usage.

2.18.3. Vendor Custom Extensions

Some extensions affect *base* vision functions and thus may be invisible to most users. In these circumstances, the vendor must report the supported extensions to the base nodes through the `VX_CONTEXT_EXTENSIONS` attribute on the context.

```
vx_char *tmp, *extensions = NULL;
vx_size size = 0;
vxQueryContext(context,VX_CONTEXT_EXTENSIONS_SIZE,&size,sizeof(size));
extensions = malloc(size);
vxQueryContext(context,VX_CONTEXT_EXTENSIONS,
               extensions, size);
```

Extensions in this list are dependent on the extension itself; they may or may not have a header and new kernels or framework feature or data objects. The common feature is that they are implemented and supported by the implementation vendor.

2.18.4. Hinting

The specification defines a Hinting API that allows Clients to feed information to the implementation for *optional* behavior changes. See Framework: Hints. It is assumed that most of the hints will be vendor- or implementation-specific. Check with the OpenVX implementation vendor for information on vendor-specific extensions.

2.18.5. Directives

The specification defines a Directive API to control implementation behavior. See Framework: Directives. This *may* allow things like disabling parallelism for debugging, enabling cache writing-through for some buffers, or any implementation-specific optimization.

Chapter 3. Vision Functions

These are the base vision functions supported.

These functions were chosen as a subset of a larger pool of possible functions that fall under the following criteria:

- Applicable to Acceleration Hardware
- Very Common Usage
- Encumbrance Free

Modules

Absolute Difference	Accumulate	Accumulate Squared
Accumulate Weighted	Arithmetic Addition	Arithmetic Subtraction
Bilateral Filter	Bitwise AND	Bitwise EXCLUSIVE OR
Bitwise INCLUSIVE OR	Bitwise NOT	Box Filter
Canny Edge Detector	Channel Combine	Channel Extract
Color Convert	Control Flow	Convert Bit Depth
Custom Convolution	Data Object Copy	Dilate Image
Equalize Histogram	Erode Image	Fast Corners
Gaussian Filter	Gaussian Image Pyramid	HOG
Harris Corners	Histogram	HoughLinesP
Integral Image	LBP	Laplacian Image Pyramid
Magnitude	MatchTemplate	Max
Mean and Standard Deviation	Median Filter	Min
Min, Max Location	Non Linear Filter	Non-Maxima Suppression
Optical Flow Pyramid (LK)	Phase	Pixel-wise Multiplication
Reconstruction from a Laplacian Image Pyramid	Remap	Scale Image
Sobel 3x3	TableLookup	Tensor Add
Tensor Convert Bit-Depth	Tensor Matrix Multiply	Tensor Multiply
Tensor Subtract	Tensor TableLookUp	Tensor Transpose
Thresholding	Warp Affine	Warp Perspective

3.1. Absolute Difference

Computes the absolute difference between two images. The output image dimensions should be the same as the dimensions of the input images.

Absolute Difference is computed by:

$$out(x,y) = | in_1(x,y) - in_2(x,y) |$$

If one of the input images is of type VX_DF_IMAGE_S16, all values are converted to vx_int32 and the overflow policy VX_CONVERT_POLICY_SATURATE is used.

$$out(x,y) = saturate_{int16} (| (int32)in_1(x,y) - (int32)in_2(x,y) |)$$

The output image can be VX_DF_IMAGE_U8 only if both source images are VX_DF_IMAGE_U8 and the output image is explicitly set to VX_DF_IMAGE_U8. It is otherwise VX_DF_IMAGE_S16.

Functions

- vxAbsDiffNode
- vxuAbsDiff

3.1.1. Functions

vxAbsDiffNode

[Graph] Creates an AbsDiff node.

```
vx_node vxAbsDiffNode(
    vx_graph                                        graph,
    vx_image                                        in1,
    vx_image                                        in2,
    vx_image                                        out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in1* - An input image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.
- [in] *in2* - An input image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.
- [out] *out* - The output image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format, which must have the same dimensions as the input image.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuAbsDiff

[Immediate] Computes the absolute difference between two images.

```
vx_status vxuAbsDiff(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *in1* - An input image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format.
- `[in]` *in2* - An input image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format.
- `[out]` *out* - The output image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.2. Accumulate

Accumulates an input image into output image. The accumulation image dimensions should be the same as the dimensions of the input image.

Accumulation is computed by:

$$accum(x,y) = accum(x,y) + input(x,y)$$

The overflow policy used is `VX_CONVERT_POLICY_SATURATE`.

Functions

- `vxAccumulateImageNode`
- `vxuAccumulateImage`

3.2.1. Functions

vxAccumulateImageNode

[Graph] Creates an accumulate node.

```
vx_node vxAccumulateImageNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    accum);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[inout]` *accum* - The accumulation image in `VX_DF_IMAGE_S16`, which must have the same dimensions as the input image.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuAccumulateImage

[Immediate] Computes an accumulation.

```
vx_status vxuAccumulateImage(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    accum);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[inout]` *accum* - The accumulation image in `VX_DF_IMAGE_S16`

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.3. Accumulate Squared

Accumulates a squared value from an input image to an output image. The accumulation image dimensions should be the same as the dimensions of the input image.

Accumulate squares is computed by:

$$accum(x,y) = saturate_{int16}\ (\ (uint16)\ accum(x,y) + (\ (\ (uint16)(input(x,y)^2)) >> (shift)))$$

Where $0 \le shift \le 15$

The overflow policy used is `VX_CONVERT_POLICY_SATURATE`.

Functions

- vxAccumulateSquareImageNode
- vxuAccumulateSquareImage

3.3.1. Functions

vxAccumulateSquareImageNode

[Graph] Creates an accumulate square node.

```
vx_node vxAccumulateSquareImageNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_scalar                                   shift,
    vx_image                                    accum);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *shift* - The input VX_TYPE_UINT32 with a value in the range of 0 ≤ shift ≤ 15.
- [inout] *accum* - The accumulation image in VX_DF_IMAGE_S16, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuAccumulateSquareImage

[Immediate] Computes a squared accumulation.

```
vx_status vxuAccumulateSquareImage(
    vx_context                                  context,
    vx_image                                    input,
    vx_scalar                                   shift,
    vx_image                                    accum);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *shift* - A VX_TYPE_UINT32 type, the input value with the range 0 ≤ shift ≤ 15.

- [inout] *accum* - The accumulation image in VX_DF_IMAGE_S16

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.4. Accumulate Weighted

Accumulates a weighted value from an input image to an output image. The accumulation image dimensions should be the same as the dimensions of the input image.

Weighted accumulation is computed by:

$$accum(x,y) = (1 - \alpha)\ accum(x,y) + \alpha\ input(x,y)$$

Where $0 \le \alpha \le 1$. Conceptually, the rounding for this is defined as:

$$output(x,y) = uint8(\ (1 - \alpha)\ float32(\ int32(\ output(x,y)\ )\ ) + \alpha\ float32(\ int32(\ input(x,y)\ )\ )\ )$$

Functions

- vxAccumulateWeightedImageNode
- vxuAccumulateWeightedImage

3.4.1. Functions

vxAccumulateWeightedImageNode

[Graph] Creates a weighted accumulate node.

```
vx_node vxAccumulateWeightedImageNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_scalar                                   alpha,
    vx_image                                    accum);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *alpha* - The input VX_TYPE_FLOAT32 scalar value with a value in the range of $0.0 \le \alpha \le 1.0$.
- [inout] *accum* - The VX_DF_IMAGE_U8 accumulation image, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuAccumulateWeightedImage

[Immediate] Computes a weighted accumulation.

```
vx_status vxuAccumulateWeightedImage(
    vx_context                                  context,
    vx_image                                    input,
    vx_scalar                                   alpha,
    vx_image                                    accum);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *alpha* - A VX_TYPE_FLOAT32 type, the input value with the range $0.0 \le \alpha \le 1.0$.
- [inout] *accum* - The VX_DF_IMAGE_U8 accumulation image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.5. Arithmetic Addition

Performs addition between two images. The output image dimensions should be the same as the dimensions of the input images.

Arithmetic addition is performed between the pixel values in two VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 images. The output image can be VX_DF_IMAGE_U8 only if both source images are VX_DF_IMAGE_U8 and the output image is explicitly set to VX_DF_IMAGE_U8. It is otherwise VX_DF_IMAGE_S16. If one of the input images is of type VX_DF_IMAGE_S16, all values are converted to VX_DF_IMAGE_S16. The overflow handling is controlled by an overflow-policy parameter. For each pixel value in the two input images:

$$out(x,y) = in_1(x,y) + in_2(x,y)$$

Functions

- vxAddNode
- vxuAdd

3.5.1. Functions

vxAddNode

[Graph] Creates an arithmetic addition node.

```
vx_node vxAddNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_enum                                     policy,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in1* - An input image, VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *in2* - An input image, VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *policy* - A VX_TYPE_ENUM of the vx_convert_policy_e enumeration.
- [out] *out* - The output image, a VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 image, which must have the same dimensions as the input images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuAdd

[Immediate] Performs arithmetic addition on pixel values in the input images.

```
vx_status vxuAdd(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_enum                                     policy,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - A VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 input image.
- [in] *in2* - A VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 input image.
- [in] *policy* - A vx_convert_policy_e enumeration.

- [out] *out* - The output image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.6. Arithmetic Subtraction

Performs subtraction between two images. The output image dimensions should be the same as the dimensions of the input images.

Arithmetic subtraction is performed between the pixel values in two VX_DF_IMAGE_U8 or two VX_DF_IMAGE_S16 images. The output image can be VX_DF_IMAGE_U8 only if both source images are VX_DF_IMAGE_U8 and the output image is explicitly set to VX_DF_IMAGE_U8. It is otherwise VX_DF_IMAGE_S16. If one of the input images is of type VX_DF_IMAGE_S16, all values are converted to VX_DF_IMAGE_S16. The overflow handling is controlled by an overflow-policy parameter. For each pixel value in the two input images:

$$out(x,y) = in_1(x,y) - in_2(x,y)$$

Functions

- vxSubtractNode
- vxuSubtract

3.6.1. Functions

vxSubtractNode

[Graph] Creates an arithmetic subtraction node.

```
vx_node vxSubtractNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_enum                                     policy,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in1* - An input image, VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16, the minuend.
- [in] *in2* - An input image, VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16, the subtrahend.
- [in] *policy* - A VX_TYPE_ENUM of the vx_convert_policy_e enumeration.

- [out] *out* - The output image, a VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 image, which must have the same dimensions as the input images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuSubtract

[Immediate] Performs arithmetic subtraction on pixel values in the input images.

```
vx_status vxuSubtract(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_enum                                     policy,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - A VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 input image, the minuend.
- [in] *in2* - A VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 input image, the subtrahend.
- [in] *policy* - A vx_convert_policy_e enumeration.
- [out] *out* - The output image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.7. Bilateral Filter

The function applies bilateral filtering to the input tensor.

A bilateral filter is a non-linear, edge-preserving and noise-reducing smoothing filter. The input and output are tensors with the same dimensions and data type. The tensor dimensions are divided to spatial and non spatial dimensions. The spatial dimensions are isometric distance which is Cartesian. And they are the last 2. The non spatial dimension is the first, and we call him the radiometric. The radiometric value at each spatial position is replaced by a weighted average of radiometric values from nearby pixels. This weight can be based on a Gaussian distribution. Crucially, the weights depend not only on Euclidean distance of spatial dimensions, but also on the radiometric differences (e.g. range differences, such as color intensity, depth distance, etc.). This preserves sharp edges by systematically looping through each pixel and adjusting weights to the adjacent pixels accordingly The equations are as follows:

$$h(x, \tau) = \sum f(y, t) g_1(y - x) g_2(t - \tau) dy dt$$

$$g_1 = \frac{1}{\sqrt{2\pi\sigma_y}} \exp\left(-\frac{1}{2}\left(\frac{y^2}{\sigma_y^2}\right)\right)$$

$$g_2(t) = \frac{1}{\sqrt{2\pi\sigma_t}} \exp\left(-\frac{1}{2}\left(\frac{t^2}{\sigma_t^2}\right)\right)$$

where x, y are in the spatial euclidean space. t, τ are vectors in radiometric space. Can be color, depth or movement. In case of 3 dimensions the 1st dimension of the `vx_tensor`. Which can be of size 1 or 2. Or the value in the tensor in the case of tensor with 2 dimensions.

Functions

- `vxBilateralFilterNode`
- `vxuBilateralFilter`

3.7.1. Functions

vxBilateralFilterNode

[Graph] The function applies bilateral filtering to the input tensor.

```
vx_node vxBilateralFilterNode(
    vx_graph                                    graph,
    vx_tensor                                   src,
    vx_int32                                    diameter,
    vx_float32                                  sigmaSpace,
    vx_float32                                  sigmaValues,
    vx_tensor                                   dst);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *src* - The input data, a `vx_tensor`. maximum 3 dimension and minimum 2. The tensor is of type `VX_TYPE_UINT8` or `VX_TYPE_INT16`. Dimensions are [radiometric,width,height] or [width,height].See `vxCreateTensor` and `vxCreateVirtualTensor`.
- `[in]` *diameter* - of each pixel neighbourhood that is used during filtering. Values of *diameter* must be odd. Bigger then 3 and smaller then 10.
- `[in]` *sigmaValues* - Filter sigma in the radiometric space. Supported values are bigger then 0 and smaller or equal 20.
- `[in]` *sigmaSpace* - Filter sigma in the spatial space. Supported values are bigger then 0 and smaller or equal 20.
- `[out]` *dst* - The output data, a `vx_tensor` of type `VX_TYPE_UINT8` or `VX_TYPE_INT16`. Must be the same

type and size of the input.

> *Note*
>
> The border modes VX_NODE_BORDER value VX_BORDER_REPLICATE and VX_BORDER_CONSTANT are supported.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuBilateralFilter

[Immediate] The function applies bilateral filtering to the input tensor.

```
vx_status vxuBilateralFilter(
    vx_context                                  context,
    vx_tensor                                   src,
    vx_int32                                    diameter,
    vx_float32                                  sigmaSpace,
    vx_float32                                  sigmaValues,
    vx_tensor                                   dst);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *src* - The input data, a vx_tensor. maximum 3 dimension and minimum 2. The tensor is of type VX_TYPE_UINT8 or VX_TYPE_INT16. dimensions are [radiometric,width,height] or [width,height]
- [in] *diameter* - of each pixel neighbourhood that is used during filtering. Values of *diameter* must be odd. Bigger then 3 and smaller then 10.
- [in] *sigmaValues* - Filter sigma in the radiometric space. Supported values are bigger then 0 and smaller or equal 20.
- [in] *sigmaSpace* - Filter sigma in the spatial space. Supported values are bigger then 0 and smaller or equal 20.
- [out] *dst* - The output data, a vx_tensor of type VX_TYPE_UINT8 or VX_TYPE_INT16. Must be the same type and size of the input.

> *Note*
>
> The border modes VX_NODE_BORDER value VX_BORDER_REPLICATE and VX_BORDER_CONSTANT are supported.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.8. Bitwise AND

Performs a *bitwise AND* operation between two VX_DF_IMAGE_U8 images. The output image dimensions should be the same as the dimensions of the input images.

Bitwise AND is computed by the following, for each bit in each pixel in the input images:

$$out(x,y) = in_1(x,y) \wedge in_2(x,y)$$

Or expressed as C code:

```
out(x,y) = in_1(x,y) & in_2(x,y)
```

Functions

- vxAndNode
- vxuAnd

3.8.1. Functions

vxAndNode

[Graph] Creates a bitwise AND node.

```
vx_node vxAndNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in1* - A VX_DF_IMAGE_U8 input image.
- [in] *in2* - A VX_DF_IMAGE_U8 input image.
- [out] *out* - The VX_DF_IMAGE_U8 output image, which must have the same dimensions as the input images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuAnd

[Immediate] Computes the bitwise and between two images.

```
vx_status vxuAnd(
    vx_context                                          context,
    vx_image                                            in1,
    vx_image                                            in2,
    vx_image                                            out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - A VX_DF_IMAGE_U8 input image
- [in] *in2* - A VX_DF_IMAGE_U8 input image
- [out] *out* - The VX_DF_IMAGE_U8 output image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.9. Bitwise EXCLUSIVE OR

Performs a *bitwise EXCLUSIVE OR* (XOR) operation between two VX_DF_IMAGE_U8 images. The output image dimensions should be the same as the dimensions of the input images.

Bitwise XOR is computed by the following, for each bit in each pixel in the input images:

$$out(x,y) = in_1(x,y) \oplus in_2(x,y)$$

Or expressed as C code:

```
out(x,y) = in_1(x,y) ^ in_2(x,y)
```

Functions

- vxXorNode
- vxuXor

3.9.1. Functions

vxXorNode

[Graph] Creates a bitwise EXCLUSIVE OR node.

```
vx_node vxXorNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in1* - A VX_DF_IMAGE_U8 input image.
- [in] *in2* - A VX_DF_IMAGE_U8 input image.
- [out] *out* - The VX_DF_IMAGE_U8 output image, which must have the same dimensions as the input images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuXor

[Immediate] Computes the bitwise exclusive-or between two images.

```
vx_status vxuXor(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - A VX_DF_IMAGE_U8 input image
- [in] *in2* - A VX_DF_IMAGE_U8 input image
- [out] *out* - The VX_DF_IMAGE_U8 output image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.10. Bitwise INCLUSIVE OR

Performs a *bitwise INCLUSIVE OR* operation between two VX_DF_IMAGE_U8 images. The output image dimensions should be the same as the dimensions of the input images.

Bitwise INCLUSIVE OR is computed by the following, for each bit in each pixel in the input images:

$$out(x,y) = in_1(x,y) \vee in_2(x,y)$$

Or expressed as C code:

```
out(x,y) = in_1(x,y) | in_2(x,y)
```

Functions

- vxOrNode
- vxuOr

3.10.1. Functions

vxOrNode

[Graph] Creates a bitwise INCLUSIVE OR node.

```
vx_node vxOrNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in1* - A VX_DF_IMAGE_U8 input image.
- [in] *in2* - A VX_DF_IMAGE_U8 input image.
- [out] *out* - The VX_DF_IMAGE_U8 output image, which must have the same dimensions as the input images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuOr

[Immediate] Computes the bitwise inclusive-or between two images.

```
vx_status vxuOr(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - A VX_DF_IMAGE_U8 input image
- [in] *in2* - A VX_DF_IMAGE_U8 input image
- [out] *out* - The VX_DF_IMAGE_U8 output image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.11. Bitwise NOT

Performs a *bitwise NOT* operation on a VX_DF_IMAGE_U8 input image. The output image dimensions should be the same as the dimensions of the input image.

Bitwise NOT is computed by the following, for each bit in each pixel in the input image:

$$out(x, y) = \overline{in(x, y)}$$

Or expressed as C code:

```
out(x,y) = ~in_1(x,y)
```

Functions

- vxNotNode
- vxuNot

3.11.1. Functions

vxNotNode

[Graph] Creates a bitwise NOT node.

```
vx_node vxNotNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - A VX_DF_IMAGE_U8 input image.
- [out] *output* - The VX_DF_IMAGE_U8 output image, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuNot

[Immediate] Computes the bitwise not of an image.

```
vx_status vxuNot(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The VX_DF_IMAGE_U8 input image
- [out] *output* - The VX_DF_IMAGE_U8 output image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.12. Box Filter

Computes a Box filter over a window of the input image. The output image dimensions should be the same as the dimensions of the input image.

This filter uses the following convolution matrix:

$$\mathbf{K}_{box} = \frac{1}{9} \times \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

Functions

- vxBox3x3Node
- vxuBox3x3

3.12.1. Functions

vxBox3x3Node

[Graph] Creates a Box Filter Node.

```
vx_node vxBox3x3Node(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuBox3x3

[Immediate] Computes a box filter on the image by a 3x3 window.

```
vx_status vxuBox3x3(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` format.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` format.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.13. Canny Edge Detector

Provides a Canny edge detector kernel. The output image dimensions should be the same as the dimensions of the input image.

This function implements an edge detection algorithm similar to that described in [Canny1986]. The main components of the algorithm are:

- Gradient magnitude and orientation computation using a noise resistant operator (Sobel).
- Non-maximum suppression of the gradient magnitude, using the gradient orientation information.
- Tracing edges in the modified gradient image using hysteresis thresholding to produce a binary result.

The details of each of these steps are described below.

Gradient Computation: Conceptually, the input image is convolved with vertical and horizontal Sobel kernels of the size indicated by the *gradient_size* parameter. The Sobel kernels used for the gradient computation shall be as shown below. The two resulting directional gradient images (dx and dy) are then used to compute a gradient magnitude image and a gradient orientation image. The norm used to compute the gradient magnitude is indicated by the *norm_type* parameter, so the magnitude may be $|dx| + |dy|$ for `VX_NORM_L1` or $\sqrt{dx^2 + dy^2}$ for `VX_NORM_L2`. The gradient orientation image is quantized into 4 values: 0, 45, 90, and 135 degrees.

- For gradient size 3:

$$\mathbf{sobel}_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

$$\mathbf{sobel}_y = transpose(sobel_x) = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

- For gradient size 5:

$$\mathbf{sobel}_x = \begin{bmatrix} -1 & -2 & 0 & 2 & 1 \\ -4 & -8 & 0 & 8 & 4 \\ -6 & -12 & 0 & 12 & 6 \\ -4 & -8 & 0 & 8 & 4 \\ -1 & -2 & 0 & 2 & 1 \end{bmatrix}$$

$\mathbf{sobel}_y = \text{transpose}(\mathbf{sobel}_x)$

- For gradient size 7:

$$\mathbf{sobel}_x = \begin{bmatrix} -1 & -4 & -5 & 0 & 5 & 4 & 1 \\ -6 & -24 & -30 & 0 & 30 & 24 & 6 \\ -15 & -60 & -75 & 0 & 75 & 60 & 15 \\ -20 & -80 & -100 & 0 & 100 & 80 & 20 \\ -15 & -60 & -75 & 0 & 75 & 60 & 15 \\ -6 & -24 & -30 & 0 & 30 & 24 & 6 \\ -1 & -4 & -5 & 0 & 5 & 4 & 1 \end{bmatrix}$$

$\mathbf{sobel}_y = \text{transpose}(\mathbf{sobel}_x)$

Non-Maximum Suppression: This is then applied such that a pixel is retained as a potential edge pixel if and only if its magnitude is greater than or equal to the pixels in the direction perpendicular to its edge orientation. For example, if the pixel's orientation is 0 degrees, it is only retained if its gradient magnitude is larger than that of the pixels at 90 and 270 degrees to it. If a pixel is suppressed via this condition, it must not appear as an edge pixel in the final output, i.e., its value must be 0 in the final output.

Edge Tracing: The final edge pixels in the output are identified via a double thresholded hysteresis procedure. All retained pixels with magnitude above the *high* threshold are marked as known edge pixels (valued 255) in the final output image. All pixels with magnitudes less than or equal to the *low* threshold must not be marked as edge pixels in the final output. For the pixels in between the thresholds, edges are traced and marked as edges (255) in the output. This can be done by starting at the known edge pixels and moving in all eight directions recursively until the gradient magnitude is less than or equal to the low threshold.

Caveats: The intermediate results described above are conceptual only; so for example, the implementation may not actually construct the gradient images and non-maximum-suppressed images. Only the final binary (0 or 255 valued) output image must be computed so that it matches the result of a final image constructed as described above.

Enumerations

- `vx_norm_type_e`

Functions

- `vxCannyEdgeDetectorNode`
- `vxuCannyEdgeDetector`

3.13.1. Enumerations

vx_norm_type_e

A normalization type.

```
enum vx_norm_type_e {
    VX_NORM_L1 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_NORM_TYPE) + 0x0,
    VX_NORM_L2 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_NORM_TYPE) + 0x1,
};
```

See also: Canny Edge Detector

Enumerator

- `VX_NORM_L1` - The L1 normalization.
- `VX_NORM_L2` - The L2 normalization.

3.13.2. Functions

vxCannyEdgeDetectorNode

[Graph] Creates a Canny Edge Detection Node.

```
vx_node vxCannyEdgeDetectorNode(
    vx_graph                                            graph,
    vx_image                                            input,
    vx_threshold                                        hyst,
    vx_int32                                            gradient_size,
    vx_enum                                             norm_type,
    vx_image                                            output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[in]` *hyst* - The double threshold for hysteresis. The `VX_THRESHOLD_INPUT_FORMAT` shall be either `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16`. The `VX_THRESHOLD_OUTPUT_FORMAT` is ignored.
- `[in]` *gradient_size* - The size of the Sobel filter window, must support at least 3, 5, and 7.
- `[in]` *norm_type* - A flag indicating the norm used to compute the gradient, `VX_NORM_L1` or `VX_NORM_L2`.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` format with values either 0 or 255.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuCannyEdgeDetector

[Immediate] Computes Canny Edges on the input image into the output image.

```
vx_status vxuCannyEdgeDetector(
    vx_context                                  context,
    vx_image                                    input,
    vx_threshold                                hyst,
    vx_int32                                    gradient_size,
    vx_enum                                     norm_type,
    vx_image                                    output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[in]` *hyst* - The double threshold for hysteresis. The `VX_THRESHOLD_INPUT_FORMAT` shall be either `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16`. The `VX_THRESHOLD_OUTPUT_FORMAT` is ignored.
- `[in]` *gradient_size* - The size of the Sobel filter window, must support at least 3, 5 and 7.
- `[in]` *norm_type* - A flag indicating the norm used to compute the gradient, `VX_NORM_L1` or `VX_NORM_L2`.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` format with values either 0 or 255.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.14. Channel Combine

Implements the Channel Combine Kernel.

This kernel takes multiple `VX_DF_IMAGE_U8` planes to recombine them into a multi-planar or interleaved format from `vx_df_image_e`. The user must specify only the number of channels that are appropriate for the combining operation. If a user specifies more channels than necessary, the operation results in an error. For the case where the destination image is a format with subsampling, the input channels are expected to have been subsampled before combining (by stretching and resizing).

Functions

- `vxChannelCombineNode`
- `vxuChannelCombine`

3.14.1. Functions

vxChannelCombineNode

[Graph] Creates a channel combine node.

```
vx_node vxChannelCombineNode(
    vx_graph                                    graph,
    vx_image                                    plane0,
    vx_image                                    plane1,
    vx_image                                    plane2,
    vx_image                                    plane3,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The graph reference.
- `[in]` *plane0* - The plane that forms channel 0. Must be `VX_DF_IMAGE_U8`.
- `[in]` *plane1* - The plane that forms channel 1. Must be `VX_DF_IMAGE_U8`.
- `[in]` *plane2* - [optional] The plane that forms channel 2. Must be `VX_DF_IMAGE_U8`.
- `[in]` *plane3* - [optional] The plane that forms channel 3. Must be `VX_DF_IMAGE_U8`.
- `[out]` *output* - The output image. The format of the image must be defined, even if the image is virtual. Must have the same dimensions as the input images

See also: `VX_KERNEL_CHANNEL_COMBINE`

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuChannelCombine

[Immediate] Invokes an immediate Channel Combine.

```
vx_status vxuChannelCombine(
    vx_context                                  context,
    vx_image                                    plane0,
    vx_image                                    plane1,
    vx_image                                    plane2,
    vx_image                                    plane3,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *plane0* - The plane that forms channel 0. Must be VX_DF_IMAGE_U8.
- [in] *plane1* - The plane that forms channel 1. Must be VX_DF_IMAGE_U8.
- [in] *plane2* - [optional] The plane that forms channel 2. Must be VX_DF_IMAGE_U8.
- [in] *plane3* - [optional] The plane that forms channel 3. Must be VX_DF_IMAGE_U8.
- [out] *output* - The output image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.15. Channel Extract

Implements the Channel Extraction Kernel.

This kernel removes a single VX_DF_IMAGE_U8 channel (plane) from a multi-planar or interleaved image format from vx_df_image_e.

Functions

- vxChannelExtractNode
- vxuChannelExtract

3.15.1. Functions

vxChannelExtractNode

[Graph] Creates a channel extract node.

```
vx_node vxChannelExtractNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_enum                                     channel,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image. Must be one of the defined vx_df_image_e multi-channel formats.
- [in] *channel* - The vx_channel_e channel to extract.
- [out] *output* - The output image. Must be VX_DF_IMAGE_U8, and must have the same dimensions as the input image.

See also: VX_KERNEL_CHANNEL_EXTRACT

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuChannelExtract

[Immediate] Invokes an immediate Channel Extract.

```
vx_status vxuChannelExtract(
    vx_context                                  context,
    vx_image                                    input,
    vx_enum                                     channel,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image. Must be one of the defined vx_df_image_e multi-channel formats.
- [in] *channel* - The vx_channel_e enumeration to extract.
- [out] *output* - The output image. Must be VX_DF_IMAGE_U8.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.16. Color Convert

Implements the Color Conversion Kernel. The output image dimensions should be the same as the dimensions of the input image.

This kernel converts an image of a designated vx_df_image_e format to another vx_df_image_e format for those combinations listed in the below table, where the columns are output types and the rows are input types. The API version first supporting the conversion is also listed.

I/O	RGB	RGBX	NV12	NV21	UYVY	YUYV	IYUV	YUV4
RGB		1.0	1.0				1.0	1.0
RGBX	1.0		1.0				1.0	1.0
NV12	1.0	1.0					1.0	1.0

I/O	RGB	RGBX	NV12	NV21	UYVY	YUYV	IYUV	YUV4
NV21	1.0	1.0					1.0	1.0
UYVY	1.0	1.0	1.0				1.0	
YUYV	1.0	1.0	1.0				1.0	
IYUV	1.0	1.0	1.0					1.0
YUV4								

The `vx_df_image_e` encoding, held in the `VX_IMAGE_FORMAT` attribute, describes the data layout. The interpretation of the colors is determined by the `VX_IMAGE_SPACE` (see `vx_color_space_e`) and `VX_IMAGE_RANGE` (see `vx_channel_range_e`) attributes of the image. Implementations are required only to support images of `VX_COLOR_SPACE_BT709` and `VX_CHANNEL_RANGE_FULL`.

If the channel range is defined as `VX_CHANNEL_RANGE_FULL`, the conversion between the real number and integer quantizations of color channels is defined for red, green, blue, and Y as:

$$value_{real} = value_{integer} / 256.0$$

$$value_{integer} = max(0, min(255, floor(value_{real} \times 256.0)))$$

For the U and V channels, the conversion between real number and integer quantizations is:

$$value_{real} = (value_{integer} - 128.0) / 256.0$$

$$value_{integer} = max(0, min(255, floor(value_{real} \times 256.0 + 128)))$$

If the channel range is defined as `VX_CHANNEL_RANGE_RESTRICTED`, the conversion between the integer quantizations of color channels and the continuous representations is defined for red, green, blue, and Y as:

$$value_{real} = (value_{integer} - 16.0) / 219.0$$

$$value_{integer} = max(0, min(255, floor(value_{real} \times 219.0 + 16.5)))$$

For the U and V channels, the conversion between real number and integer quantizations is:

$$value_{real} = (value_{integer} - 128.0) / 224.0$$

$$value_{integer} = max(0, min(255, floor(value_{real} \times 224.0 + 128.5)))$$

The conversions between nonlinear-intensity $Y'P_bP_r$ and $R'G'B'$ real numbers are:

$$R' = Y' + 2\,(1 - K_r)\,P_r$$

$$B' = Y' + 2\,(1 - K_b)\,P_b$$

$$G' = Y' - (\,2(K_r\,(1 - K_r)\,P_r + K_b\,(1 - K_b)\,P_b)\,) / (1 - K_r - K_b)$$

$Y' = (K_r R') + (K_b B') + (1 - K_r - K_b)G'$

$P_b = B' / 2 - ((R' K_r) + G'(1 - K_r - K_b)) / (2 (1 - K_b))$

$P_r = R' / 2 - ((B' K_b) + G'(1 - K_r - K_b)) / (2 (1 - K_r))$

The means of reconstructing P_b and P_r values from chroma-downsampled formats is implementation-defined.

In VX_COLOR_SPACE_BT601_525 or VX_COLOR_SPACE_BT601_625:

$K_r = 0.299$

$K_b = 0.114$

In VX_COLOR_SPACE_BT709:

$K_r = 0.2126$

$K_b = 0.0722$

In all cases, for the purposes of conversion, these colour representations are interpreted as nonlinear in intensity, as defined by the BT.601, BT.709, and sRGB specifications. That is, the encoded colour channels are nonlinear R', G' and B', Y', P_b, and P_r.

Each channel of the $R'G'B'$ representation can be converted to and from a linear-intensity RGB channel by these formulae:

$$value_{nonlinear} = \begin{cases} 1.099 value_{linear}^{0.45} - 0.099 & 1 \geq value_{linear} \geq 0.018 \\ 4.500 value_{linear} & 0.018 > value_{linear} \geq 0 \end{cases}$$

$$value_{linear} = \begin{cases} \left(\dfrac{value_{nonlinear} + 0.099}{1.099}\right)^{\frac{1}{0.45}} & 1 \geq value_{nonlinear} > 0.081 \\ \dfrac{value_{nonlinear}}{4.5} & 0.081 \geq value_{nonlinear} \geq 0 \end{cases}$$

As the different color spaces have different RGB primaries, a conversion between them must transform the color coordinates into the new RGB space. Working with linear RGB values, the conversion formulae are:

$R_{BT601\_525} = R_{BT601\_625} \times 1.112302 + G_{BT601\_625} \times -0.102441 + B_{BT601\_625} \times -0.009860$

$G_{BT601\_525} = R_{BT601\_625} \times -0.020497 + G_{BT601\_625} \times 1.037030 + B_{BT601\_625} \times -0.016533$

$B_{BT601\_525} = R_{BT601\_625} \times 0.001704 + G_{BT601\_625} \times 0.016063 + B_{BT601\_625} \times 0.982233$

$R_{BT601\_525} = R_{BT709} \times 1.065379 + G_{BT709} \times -0.055401 + B_{BT709} \times -0.009978$

$G_{BT601\_525} = R_{BT709} \times -0.019633 + G_{BT709} \times 1.036363 + B_{BT709} \times -0.016731$

$B_{BT601\_525} = R_{BT709} \times 0.001632 + G_{BT709} \times 0.004412 + B_{BT709} \times 0.993956$

$R_{BT601\_625} = R_{BT601\_525} \times 0.900657 + G_{BT601\_525} \times 0.088807 + B_{BT601\_525} \times 0.010536$

$G_{BT601\_625} = R_{BT601\_525} \times 0.017772 + G_{BT601\_525} \times 0.965793 + B_{BT601\_525} \times 0.016435$

$B_{BT601\_625} = R_{BT601\_525} \times -0.001853 + G_{BT601\_525} \times -0.015948 + B_{BT601\_525} \times 1.017801$

$R_{BT601\_625} = R_{BT709} \times 0.957815 + G_{BT709} \times 0.042185$

$G_{BT601\_625} = G_{BT709}$

$B_{BT601\_625} = G_{BT709} \times -0.011934 + B_{BT709} \times 1.011934$

$R_{BT709} = R_{BT601\_525} \times 0.939542 + G_{BT601\_525} \times 0.050181 + B_{BT601\_525} \times 0.010277$

$G_{BT709} = R_{BT601\_525} \times 0.017772 + G_{BT601\_525} \times 0.965793 + B_{BT601\_525} \times 0.016435$

$B_{BT709} = R_{BT601\_525} \times -0.001622 + G_{BT601\_525} \times -0.004370 + B_{BT601\_525} \times 1.005991$

$R_{BT709} = R_{BT601\_625} \times 1.044043 + G_{BT601\_625} \times -0.044043$

$G_{BT709} = G_{BT601\_625}$

$B_{BT709} = G_{BT601\_625} \times 0.011793 + B_{BT601\_625} \times 0.988207$

A conversion between one YUV color space and another may therefore consist of the following transformations:

1. Convert quantized $Y'C_bC_r$ ("YUV") to continuous, nonlinear $Y'P_bP_r$.
2. Convert continuous $Y'P_bP_r$ to continuous, nonlinear $R'G'B'$.
3. Convert nonlinear $R'G'B'$ to linear-intensity RGB (gamma-correction).
4. Convert linear RGB from the first color space to linear RGB in the second color space.
5. Convert linear RGB to nonlinear $R'G'B'$ (gamma-conversion).
6. Convert nonlinear $R'G'B'$ to $Y'P_bP_r$.
7. Convert continuous $Y'P_bP_r$ to quantized $Y'C_bC_r$ ("YUV").

The above formulae and constants are defined in the ITU BT.601 and BT.709 specifications. The formulae for converting between RGB primaries can be derived from the specified primary chromaticity values and the specified white point by solving for the relative intensity of the primaries.

Functions

- `vxColorConvertNode`
- `vxuColorConvert`

3.16.1. Functions

vxColorConvertNode

[Graph] Creates a color conversion node.

```
vx_node vxColorConvertNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image from which to convert.
- `[out]` *output* - The output image to which to convert, which must have the same dimensions as the input image.

See also: `VX_KERNEL_COLOR_CONVERT`

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuColorConvert

[Immediate] Invokes an immediate Color Conversion.

```
vx_status vxuColorConvert(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image.
- `[out]` *output* - The output image.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success

- * - An error occurred. See vx_status_e.

3.17. Control Flow

Defines the predicated execution model of OpenVX.

These features allow for conditional graph flow in OpenVX, via support for a variety of operations between two scalars. The supported scalar data types VX_TYPE_BOOL, VX_TYPE_INT8, VX_TYPE_UINT8, VX_TYPE_INT16, VX_TYPE_UINT16, VX_TYPE_INT32, VX_TYPE_UINT32, VX_TYPE_SIZE, VX_TYPE_FLOAT32 are supported.

Table 1. Summary of logical operations

Scalar Operation	Equation	Data Types
VX_SCALAR_OP_AND	output = (a&b)	bool = bool op bool
VX_SCALAR_OP_OR	output = (a|b)	bool = bool op bool
VX_SCALAR_OP_XOR	output = (a^b)	bool = bool op bool
VX_SCALAR_OP_NAND	output = !(a&b)	bool = bool op bool

Table 2. Summary of comparison operations

Scalar Operation	Equation	Data Types
VX_SCALAR_OP_EQUAL	output = (a == b)	bool = num op num
VX_SCALAR_OP_NOTEQUAL	output = (a != b)	bool = num op num
VX_SCALAR_OP_LESS	output = (a < b)	bool = num op num
VX_SCALAR_OP_LESSEQ	output = (a ≤ b)	bool = num op num
VX_SCALAR_OP_GREATER	output = (a > b)	bool = num op num
VX_SCALAR_OP_GREATEREQ	output = (a ≥ b)	bool = num op num

Table 3. Summary of arithmetic operations

Scalar Operation	Equation	Data Types
VX_SCALAR_OP_ADD	output = (a+b)	num = num op num
VX_SCALAR_OP_SUBTRACT	output = (a-b)	num = num op num
VX_SCALAR_OP_MULTIPLY	output = (a*b)	num = num op num
VX_SCALAR_OP_DIVIDE	output = (a/b)	num = num op num
VX_SCALAR_OP_MODULUS	output = (a%b)	num = num op num
VX_SCALAR_OP_MIN	output = min(a,b)	num = num op num
VX_SCALAR_OP_MAX	output = max(a,b)	num = num op num

Please note that in the above tables:

- bool denotes a scalar of data type VX_TYPE_BOOL
- num denotes supported scalar data types are VX_TYPE_INT8, VX_TYPE_UINT8, VX_TYPE_INT16, VX_TYPE_UINT16, VX_TYPE_INT32, VX_TYPE_UINT32, VX_SIZE, and VX_FLOAT32.

- The VX_SCALAR_OP_MODULUS operation supports integer operands.
- The results of VX_SCALAR_OP_DIVIDE and VX_SCALAR_OP_MODULUS operations with the second argument as zero, must be defined by the implementation.
- For arithmetic and comparison operations with mixed input data types, the results will be mathematically accurate without the side effects of internal data representations.
- If the operation result can not be stored in output data type without data and/or precision loss, the following rules shall be applied:
    a. If the operation result is integer and output is floating-point, the operation result is promoted to floating-point.
    b. If the operation result is floating-point and output is an integer, the operation result is converted to integer with rounding policy VX_ROUND_POLICY_TO_ZERO and conversion policy VX_CONVERT_POLICY_SATURATE.
    c. If both operation result and output are integers, the result is converted to output data type with VX_CONVERT_POLICY_WRAP conversion policy.

Functions

- vxScalarOperationNode
- vxSelectNode

3.17.1. Functions

vxScalarOperationNode

[Graph] Creates a scalar operation node.

```
vx_node vxScalarOperationNode(
    vx_graph                                    graph,
    vx_enum                                     scalar_operation,
    vx_scalar                                   a,
    vx_scalar                                   b,
    vx_scalar                                   output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *scalar_operation* - A VX_TYPE_ENUM of the vx_scalar_operation_e enumeration.
- [in] *a* - First scalar operand.
- [in] *b* - Second scalar operand.
- [out] *output* - Result of the scalar operation.

Returns: vx_node.

Return Values

* vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxSelectNode

[Graph] Selects one of two data objects depending on the the value of a condition (boolean scalar), and copies its data into another data object.

```
vx_node vxSelectNode(
    vx_graph                                          graph,
    vx_scalar                                         condition,
    vx_reference                                      true_value,
    vx_reference                                      false_value,
    vx_reference                                      output);
```

This node supports predicated execution flow within a graph. All the data objects passed to this kernel shall have the same object type and meta data. It is important to note that an implementation may optimize away the select and copy when virtual data objects are used.

If there is a kernel node that contribute only into virtual data objects during the graph execution due to certain data path being eliminated by not taken argument of select node, then the OpenVX implementation guarantees that there will not be any side effects to graph execution and node state.

If the path to a select node contains non-virtual objects, user nodes, or nodes with completion callbacks, then that path may not be "optimized out" because the callback must be executed and the non-virtual objects must be modified.

Parameters

* [in] *graph* - The reference to the graph.
* [in] *condition* - VX_TYPE_BOOL predicate variable.
* [in] *true_value* - Data object for true.
* [in] *false_value* - Data object for false.
* [out] *output* - Output data object.

Returns: vx_node.

Return Values

* vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

3.18. Convert Bit Depth

Converts image bit depth. The output image dimensions should be the same as the dimensions of the input image.

This kernel converts an image from some source bit-depth to another bit-depth as described by the table below. If the input value is unsigned the shift must be in zeros. If the input value is signed, the shift used must be an arithmetic shift. The columns in the table below are the output types and the rows are the input types. The API version on which conversion is supported is also listed. (An *X* denotes an invalid operation.)

I/O	U8	U16	S16	U32	S32
U8	X		1.0		
U16		X	X		
S16	1.0	X	X		
U32				X	X
S32				X	X

Conversion Type: The table below identifies the conversion types for the allowed bith depth conversions.

From	To	Conversion Type
U8	S16	Up-conversion
S16	U8	Down-conversion

Convert Policy: Down-conversions with `VX_CONVERT_POLICY_WRAP` follow this equation:

```
output(x,y) = ((uint8)(input(x,y) >> shift));
```

Down-conversions with `VX_CONVERT_POLICY_SATURATE` follow this equation:

```
int16 value = input(x,y) >> shift;
value = value < 0 ? 0 : value;
value = value > 255 ? 255 : value;
output(x,y) = (uint8)value;
```

Up-conversions ignore the policy and perform this operation:

```
output(x,y) = ((int16)input(x,y)) << shift;
```

The valid values for 'shift' are as specified below, all other values produce undefined behavior.

```
0 <= shift < 8;
```

Functions

- `vxConvertDepthNode`
- `vxuConvertDepth`

3.18.1. Functions

vxConvertDepthNode

[Graph] Creates a bit-depth conversion node.

```
vx_node vxConvertDepthNode(
    vx_graph                                     graph,
    vx_image                                     input,
    vx_image                                     output,
    vx_enum                                      policy,
    vx_scalar                                    shift);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image.
- `[out]` *output* - The output image with the same dimensions of the input image.
- `[in]` *policy* - A `VX_TYPE_ENUM` of the `vx_convert_policy_e` enumeration.
- `[in]` *shift* - A scalar containing a `VX_TYPE_INT32` of the shift value.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuConvertDepth

[Immediate] Converts the input images bit-depth into the output image.

```
vx_status vxuConvertDepth(
    vx_context                                   context,
    vx_image                                     input,
    vx_image                                     output,
    vx_enum                                      policy,
    vx_int32                                     shift);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image.
- `[out]` *output* - The output image.
- `[in]` *policy* - A `VX_TYPE_ENUM` of the `vx_convert_policy_e` enumeration.

- [in] *shift* - A scalar containing a VX_TYPE_INT32 of the shift value.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e..

3.19. Custom Convolution

Convolves the input with the client supplied convolution matrix. The output image dimensions should be the same as the dimensions of the input image.

The client can supply a vx_int16 typed convolution matrix $C_{m,n}$. Outputs will be in the VX_DF_IMAGE_S16 format unless a VX_DF_IMAGE_U8 image is explicitly provided. If values would have been out of range of U8 for VX_DF_IMAGE_U8, the values are clamped to 0 or 255.

$$k_0 = \frac{m}{2}$$

$$l_0 = \frac{n}{2}$$

$$sum = \sum_{k=0,\ l=0}^{k=m-1,\ l=n-1} input(x + k_0 - k,\ y + l_0 - l) C_{k,\ l}$$

> *Note*
>
> The above equation for this function is different than an equivalent operation suggested by the OpenCV Filter2D function.

This translates into the C declaration:

```
// A horizontal Scharr gradient operator with different scale.
vx_int16 gx[3][3] = {
    {  3, 0, -3},
    { 10, 0,-10},
    {  3, 0, -3},
};
vx_uint32 scale = 8;
vx_convolution scharr_x = vxCreateConvolution(context, 3, 3);
vxCopyConvolutionCoefficients(scharr_x, (vx_int16*)gx, VX_WRITE_ONLY,
VX_MEMORY_TYPE_HOST);
vxSetConvolutionAttribute(scharr_x, VX_CONVOLUTION_SCALE, &scale, sizeof(scale));
```

For VX_DF_IMAGE_U8 output, an additional step is taken:

$$output(x,\ y) = \begin{cases} 0 & sum < 0 \\ 255 & sum\ /\ scale > 255 \\ sum\ /\ scale & \text{otherwise} \end{cases}$$

For VX_DF_IMAGE_S16 output, the summation is simply set to the output

output(x,y) = sum / scale

The overflow policy used is VX_CONVERT_POLICY_SATURATE.

Functions

- vxConvolveNode
- vxuConvolve

3.19.1. Functions

vxConvolveNode

[Graph] Creates a custom convolution node.

```
vx_node vxConvolveNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_convolution                              conv,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [in] *conv* - The vx_int16 convolution matrix.
- [out] *output* - The output image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuConvolve

[Immediate] Computes a convolution on the input image with the supplied matrix.

```
vx_status vxuConvolve(
    vx_context                                  context,
    vx_image                                    input,
    vx_convolution                              conv,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [in] *conv* - The vx_int16 convolution matrix.
- [out] *output* - The output image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.20. Data Object Copy

Copy a data object to another.

Copy data from an input data object into another data object. The input and output object must have the same object type and meta data. If these objects are object arrays, or pyramids then a deep copy shall be performed.

Functions

- vxCopyNode
- vxuCopy

3.20.1. Functions

vxCopyNode

Copy data from one object to another.

```
vx_node vxCopyNode(
    vx_graph                                    graph,
    vx_reference                                input,
    vx_reference                                output);
```

Note

An implementation may optimize away the copy when virtual data objects are used.

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input data object.
- [out] *output* - The output data object with meta-data identical to the input data object.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuCopy

[Immediate] Copy data from one object to another.

```
vx_status vxuCopy(
    vx_context                                   context,
    vx_reference                                 input,
    vx_reference                                 output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input data object.
- [out] *output* - The output data object.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.21. Dilate Image

Implements Dilation, which *grows* the white space in a VX_DF_IMAGE_U8 Boolean image. The output image dimensions should be the same as the dimensions of the input image.

This kernel uses a 3x3 box around the output pixel used to determine value.

$$dst(x, y) = \max_{\substack{x-1 \leq x' \leq x+1 \\ y-1 \leq y' \leq y+1}} src(x', y')$$

> *Note*
>
> For kernels that use other structuring patterns than 3x3 see vxNonLinearFilterNode or vxuNonLinearFilter.

Functions

- vxDilate3x3Node
- vxuDilate3x3

3.21.1. Functions

vxDilate3x3Node

[Graph] Creates a Dilation Image Node.

```
vx_node vxDilate3x3Node(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuDilate3x3

[Immediate] Dilates an image by a 3x3 window.

```
vx_status vxuDilate3x3(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.22. Equalize Histogram

Equalizes the histogram of a grayscale image. The output image dimensions should be the same as the dimensions of the input image.

This kernel uses Histogram Equalization to modify the values of a grayscale image so that it will automatically have a standardized brightness and contrast.

Functions

- vxEqualizeHistNode
- vxuEqualizeHist

3.22.1. Functions

vxEqualizeHistNode

[Graph] Creates a Histogram Equalization node.

```
vx_node vxEqualizeHistNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The grayscale input image in VX_DF_IMAGE_U8.
- [out] *output* - The grayscale output image of type VX_DF_IMAGE_U8 with equalized brightness and contrast and same size as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuEqualizeHist

[Immediate] Equalizes the Histogram of a grayscale image.

```
vx_status vxuEqualizeHist(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The grayscale input image in VX_DF_IMAGE_U8
- [out] *output* - The grayscale output image of type VX_DF_IMAGE_U8 with equalized brightness and contrast.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.23. Erode Image

Implements Erosion, which *shrinks* the white space in a VX_DF_IMAGE_U8 Boolean image. The output image dimensions should be the same as the dimensions of the input image.

This kernel uses a 3x3 box around the output pixel used to determine value.

$$dst(x, y) = \min_{\substack{x-1 \le x' \le x+1 \\ y-1 \le y' \le y+1}} src(x', y')$$

Note

For kernels that use other structuring patterns than 3x3 see vxNonLinearFilterNode or vxuNonLinearFilter.

Functions

- vxErode3x3Node
- vxuErode3x3

3.23.1. Functions

vxErode3x3Node

[Graph] Creates an Erosion Image Node.

```
vx_node vxErode3x3Node(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format, which must have the same

dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuErode3x3

[Immediate] Erodes an image by a 3x3 window.

```
vx_status vxuErode3x3(
    vx_context                                      context,
    vx_image                                        input,
    vx_image                                        output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.24. Fast Corners

Computes the corners in an image using a method based upon FAST9 algorithm suggested in [Rosten2006] and with some updates from [Rosten2008] with modifications described below.

It extracts corners by evaluating pixels on the Bresenham circle around a candidate point. If N contiguous pixels are brighter than the candidate point by at least a threshold value t or darker by at least t, then the candidate point is considered to be a corner. For each detected corner, its strength is computed. Optionally, a non-maxima suppression step is applied on all detected corners to remove multiple or spurious responses.

3.24.1. Segment Test Detector

The FAST corner detector uses the pixels on a Bresenham circle of radius 3 (16 pixels) to classify whether a candidate point p is actually a corner, given the following variables.

$$\begin{aligned}
I &= \text{input image} \\
p &= \text{candidate point position for a corner} \\
I_p &= \text{image intensity of the candidate point in image } I \\
x &= \text{pixel on the Bresenham circle around the candidate point } p \\
I_x &= \text{image intensity of the candidate point} \\
t &= \text{intensity difference threshold for a corner} \\
N &= \text{minimum number of contiguous pixel to detect a corner} \\
S &= \text{set of contiguous pixel on the Bresenham circle around the candidate point} \\
C_p &= \text{corner response at corner location } p
\end{aligned}$$

The two conditions for FAST corner detection can be expressed as:

- C1: A set of N contiguous pixels S, $\forall$ x in S, $I_x > I_p + t$
- C2: A set of N contiguous pixels S, $\forall$ x in S, $I_x < I_p - t$

So when either of these two conditions is met, the candidate p is classified as a corner.

In this version of the FAST algorithm, the minimum number of contiguous pixels N is 9 (FAST9).

The value of the intensity difference threshold *strength_thresh*. of type `VX_TYPE_FLOAT32` must be within:

`UINT8_MIN` < t < `UINT8_MAX`

These limits are established due to the input data type `VX_DF_IMAGE_U8`.

Corner Strength Computation:

Once a corner has been detected, its strength (response, saliency, or score) shall be computed if *nonmax_suppression* is set to true, otherwise the value of strength is undefined. The corner response C_p function is defined as the largest threshold t for which the pixel p remains a corner.

Non-maximum suppression:

If the *nonmax_suppression* flag is true, a non-maxima suppression step is applied on the detected corners. The corner with coordinates (x,y) is kept if and only if

$$\begin{aligned}
C_p(x, y) \geq C_p(x-1, y-1) \; and \; C_p(x, y) \geq C_p(x, y-1) \; and \\
C_p(x, y) \geq C_p(x+1, y-1) \; and \; C_p(x, y) \geq C_p(x-1, y) \; and \\
C_p(x, y) > C_p(x+1, y) \; and \; C_p(x, y) > C_p(x-1, y+1) \; and \\
C_p(x, y) > C_p(x, y+1) \; and \; C_p(x, y) > C_p(x+1, y+1)
\end{aligned}$$

See http://www.edwardrosten.com/work/fast.html and http://en.wikipedia.org/wiki/Features_from_accelerated_segment_test

Functions

- `vxFastCornersNode`
- `vxuFastCorners`

3.24.2. Functions

vxFastCornersNode

[Graph] Creates a FAST Corners Node.

```
vx_node vxFastCornersNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_scalar                                   strength_thresh,
    vx_bool                                     nonmax_suppression,
    vx_array                                    corners,
    vx_scalar                                   num_corners);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[in]` *strength_thresh* - Threshold on difference between intensity of the central pixel and pixels on Bresenham's circle of radius 3 (`VX_TYPE_FLOAT32` scalar), with a value in the range of 0.0 ≤ strength_thresh < 256.0. Any fractional value will be truncated to an integer.
- `[in]` *nonmax_suppression* - If true, non-maximum suppression is applied to detected corners before being placed in the `vx_array` of `VX_TYPE_KEYPOINT` objects.
- `[out]` *corners* - Output corner `vx_array` of `VX_TYPE_KEYPOINT`. The order of the keypoints in this array is implementation dependent.
- `[out]` *num_corners* - [optional] The total number of detected corners in image. Use a `VX_TYPE_SIZE` scalar.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuFastCorners

[Immediate] Computes corners on an image using FAST algorithm and produces the array of feature points.

```
vx_status vxuFastCorners(
    vx_context                                  context,
    vx_image                                    input,
    vx_scalar                                   strength_thresh,
    vx_bool                                     nonmax_suppression,
    vx_array                                    corners,
    vx_scalar                                   num_corners);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[in]` *strength_thresh* - Threshold on difference between intensity of the central pixel and pixels on Bresenham's circle of radius 3 (`VX_TYPE_FLOAT32` scalar), with a value in the range of 0.0 ≤ strength_thresh < 256.0. Any fractional value will be truncated to an integer.
- `[in]` *nonmax_suppression* - If true, non-maximum suppression is applied to detected corners before being places in the `vx_array` of `VX_TYPE_KEYPOINT` structs.
- `[out]` *corners* - Output corner `vx_array` of `VX_TYPE_KEYPOINT`. The order of the keypoints in this array is implementation dependent.
- `[out]` *num_corners* - [optional] The total number of detected corners in image. Use a `VX_TYPE_SIZE` scalar.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.25. Gaussian Filter

Computes a Gaussian filter over a window of the input image. The output image dimensions should be the same as the dimensions of the input image.

This filter uses the following convolution matrix:

$$\mathbf{K}_{gaussian} = \frac{1}{16} \times \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

Functions

- `vxGaussian3x3Node`
- `vxuGaussian3x3`

3.25.1. Functions

vxGaussian3x3Node

[Graph] Creates a Gaussian Filter Node.

```
vx_node vxGaussian3x3Node(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` format.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` format, which must have the same dimensions as the input image.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuGaussian3x3

[Immediate] Computes a gaussian filter on the image by a 3x3 window.

```
vx_status vxuGaussian3x3(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` format.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` format.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.26. Gaussian Image Pyramid

Computes a Gaussian Image Pyramid from an input image.

This vision function creates the Gaussian image pyramid from the input image using the particular 5x5 Gaussian Kernel:

$$\mathbf{G} = \frac{1}{256} \times \begin{bmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{bmatrix}$$

image to the next level using VX_INTERPOLATION_NEAREST_NEIGHBOR. For the Gaussian pyramid, level 0 shall always have the same resolution and contents as the input image. Pyramids configured with one of the following level scaling must be supported:

- VX_SCALE_PYRAMID_HALF
- VX_SCALE_PYRAMID_ORB

Functions

- vxGaussianPyramidNode
- vxuGaussianPyramid

3.26.1. Functions

vxGaussianPyramidNode

[Graph] Creates a node for a Gaussian Image Pyramid.

```
vx_node vxGaussianPyramidNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_pyramid                                  gaussian);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *gaussian* - The Gaussian pyramid with VX_DF_IMAGE_U8 to construct.

See also: Object: Pyramid

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuGaussianPyramid

[Immediate] Computes a Gaussian pyramid from an input image.

```
vx_status vxuGaussianPyramid(
    vx_context                                  context,
    vx_image                                    input,
    vx_pyramid                                  gaussian);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8
- [out] *gaussian* - The Gaussian pyramid with VX_DF_IMAGE_U8 to construct.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.27. HOG

Extracts Histogram of Oriented Gradients features from the input grayscale image.

The Histogram of Oriented Gradients (HOG) vision function is split into two nodes vxHOGCellsNode and vxHOGFeaturesNode. The specification of these nodes cover a subset of possible HOG implementations. The vxHOGCellsNode calculates the gradient orientation histograms and average gradient magnitudes for each of the cells. The vxHOGFeaturesNode uses the cell histograms and optionally the average gradient magnitude of the cells to produce a HOG feature vector. This involves grouping up the cell histograms into blocks which are then normalized. A moving window is applied to the input image and for each location the block data associated with the window is concatenated to the HOG feature vector.

Data Structures

- vx_hog_t

Functions

- vxHOGCellsNode
- vxHOGFeaturesNode
- vxuHOGCells
- vxuHOGFeatures

3.27.1. Data Structures

vxuHOGFeatures

The HOG descriptor structure.

```
typedef struct _vx_hog_t {
    vx_int32      cell_width;
    vx_int32      cell_height;
    vx_int32      block_width;
    vx_int32      block_height;
    vx_int32      block_stride;
    vx_int32      num_bins;
    vx_int32      window_width;
    vx_int32      window_height;
    vx_int32      window_stride;
    vx_float32    threshold;
} vx_hog_t;
```

3.27.2. Functions

vxHOGCellsNode

[Graph] Performs cell calculations for the average gradient magnitude and gradient orientation histograms.

```
vx_node vxHOGCellsNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_int32                                    cell_width,
    vx_int32                                    cell_height,
    vx_int32                                    num_bins,
    vx_tensor                                   magnitudes,
    vx_tensor                                   bins);
```

Firstly, the gradient magnitude and gradient orientation are computed for each pixel in the input image. Two 1-D centred, point discrete derivative masks are applied to the input image in the horizontal and vertical directions. M_h = [-1, 0, 1] and M_v = ^{T} G_v is the result of applying mask M_v to the input image, and G_h is the result of applying mask M_h to the input image. The border mode used for the gradient calculation is implementation dependent. Its behavior should be similar to VX_BORDER_UNDEFINED. The gradient magnitudes and gradient orientations for each pixel are then calculated in the following manner.

$$G(x,y) = sqrt(G_v(x,y)^2 + G_h(x,y)^2)$$

$$\theta(x,y) = arctan(G_v(x,y), G_h(x,y))$$

where

$$arctan(v, h) = \begin{cases} tan^{-1}(v/h) & h \neq 0 \\ -\frac{\pi}{2} & v<0,\ h = 0 \\ \frac{\pi}{2} & v>0,\ h = 0 \\ 0 & v = 0,\ h = 0 \end{cases}$$

Secondly, the gradient magnitudes and orientations are used to compute the bins output tensor and optional magnitudes output tensor. These tensors are computed on a cell level where the cells are rectangular in shape. The magnitudes tensor contains the average gradient magnitude for each cell.

$$magnitudes(c) = \frac{1}{(cell\_width \times cell\_height)} \sum_{w=0}^{cell\_width} \sum_{h=0}^{cell\_height} G_c(w, h)$$

where G_c is the gradient magnitudes related to cell c. The bins tensor contains histograms of gradient orientations for each cell. The gradient orientations at each pixel range from 0 to 360 degrees. These are quantised into a set of histogram bins based on the num_bins parameter. Each pixel votes for a specific cell histogram bin based on its gradient orientation. The vote itself is the pixel's gradient magnitude.

$$bins(c, n) = \sum_{w=0}^{cell\_width} \sum_{h=0}^{cell\_height} G_c(w, h) \times 1[B_c(w, h, num\_bins) = = n]$$

where B_c produces the histogram bin number based on the gradient orientation of the pixel at location (w,h) in cell c based on the num_bins and

$$1[B_c(w,h,num\_bins) == n]$$

is a delta-function with value 1 when B_c(w,h,num_bins) == n or 0 otherwise.

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image of type `VX_DF_IMAGE_U8`.
- `[in]` *cell_width* - The histogram cell width of type `VX_TYPE_INT32`.
- `[in]` *cell_height* - The histogram cell height of type `VX_TYPE_INT32`.
- `[in]` *num_bins* - The histogram size of type `VX_TYPE_INT32`.
- `[out]` *magnitudes* - (Optional) The output average gradient magnitudes per cell of `vx_tensor` of type `VX_TYPE_INT16` of size [floor($image_{width}$ / $cell_{width}$), floor($image_{height}$ / $cell_{height}$)].
- `[out]` *bins* - The output gradient orientation histograms per cell of `vx_tensor` of type `VX_TYPE_INT16` of size [floor($image_{width}$ / $cell_{width}$), floor($image_{height}$ / $cell_{height}$), num_{bins}].

Returns: `vx_node`.

Return Values

- 0 - Node could not be created.
- * - Node handle.

vxHOGFeaturesNode

[Graph] The node produces HOG features for the W1xW2 window in a sliding window fashion over the whole input image. Each position produces a HOG feature vector.

```
vx_node vxHOGFeaturesNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_tensor                                   magnitudes,
    vx_tensor                                   bins,
    const vx_hog_t*                             params,
    vx_size                                     hog_param_size,
    vx_tensor                                   features);
```

Firstly if a magnitudes tensor is provided the cell histograms in the bins tensor are normalised by the average cell gradient magnitudes.

$$bins(c, n) = \frac{bins(c, n)}{magnitudes(c)}$$

To account for changes in illumination and contrast the cell histograms must be locally normalized which requires grouping the cell histograms together into larger spatially connected blocks. Blocks are rectangular grids represented by three parameters: the number of cells per block, the number of pixels per cell, and the number of bins per cell histogram (num_{bins}). These blocks typically overlap, meaning that each cell histogram contributes more than once to the final descriptor. To normalize a block its cell histograms h are grouped together to form a vector v = [h_1, h_2, h_3, ..., h_n]. This vector is normalised using L2-Hys which means performing L2-norm on this vector; clipping the result (by limiting the maximum values of v to be threshold) and renormalizing again. If the threshold is equal to zero then L2-Hys normalization is not performed.

$$L2norm(v) = \frac{v}{\sqrt{\parallel v \parallel_2^2 + \epsilon^2}}$$

where $||\ v\ ||_k$ be its k-norm for k=1, 2, and ε be a small constant. For a specific window its HOG descriptor is then the concatenated vector of the components of the normalized cell histograms from all of the block regions contained in the window. The W1xW2 window starting position is at coordinates 0x0. If the input image has dimensions that are not an integer multiple of W1xW2 blocks with the specified stride, then the last positions that contain only a partial W1xW2 window will be calculated with the remaining part of the W1xW2 window padded with zeroes. The Window W1xW2 must also have a size so that it contains an integer number of cells, otherwise the node is not well-defined. The final output tensor will contain HOG descriptors equal to the number of windows in the input image. The output features tensor has 3 dimensions, given by:

$$(\quad (I_w - W_w) / W_s \quad + 1,$$

$$(I_h - W_h) / W_s \quad + 1,$$

$$(W_w - B_w) / B_s + 1 \quad \times \quad (W_h - B_h) / B_s + 1 \quad \times ((B_w \times B_h) / (C_w \times C_h)) \times num_{bins})$$

where *I*, *W*, *B*, and *C* refer to the image, window, block, and cell respectively, and the subscripts *w*, *h*, and *s* select the width, height, and stride properties respectively.

See `vxCreateTensor` and `vxCreateVirtualTensor`. We recommend the output tensors always be *virtual* objects, with this node connected directly to the classifier. The output tensor will be very large, and using non-virtual tensors will result in a poorly optimized implementation. Merging of this node with a classifier node such as that described in the classifier extension will result in better performance. Notice that this node creation function has more parameters than the corresponding kernel. Numbering of kernel parameters (required if you create this node using the generic interface) is explicitly specified here.

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image of type `VX_DF_IMAGE_U8`. (Kernel parameter #0)
- `[in]` *magnitudes* - (Optional) The gradient magnitudes per cell of `vx_tensor` of type `VX_TYPE_INT16`. It is the output of `vxHOGCellsNode`. (Kernel parameter #1)
- `[in]` *bins* - The gradient orientation histograms per cell of `vx_tensor` of type `VX_TYPE_INT16`. It is the output of `vxHOGCellsNode`. (Kernel parameter #2)
- `[in]` *params* - The parameters of type `vx_hog_t`. (Kernel parameter #3)
- `[in]` *hog_param_size* - Size of `vx_hog_t` in bytes. Note that this parameter is not counted as one of the kernel parameters.
- `[out]` *features* - The output HOG features of `vx_tensor` of type `VX_TYPE_INT16`. (Kernel parameter #4)

Returns: `vx_node`.

Return Values

- 0 - Node could not be created.
- * - Node handle.

vxuHOGCells

[Immediate] Performs cell calculations for the average gradient magnitude and gradient orientation histograms.

```
vx_status vxuHOGCells(
    vx_context                                  context,
    vx_image                                    input,
    vx_int32                                    cell_size,
    vx_int32                                    num_bins,
    vx_tensor                                   magnitudes,
    vx_tensor                                   bins);
```

Firstly, the gradient magnitude and gradient orientation are computed for each pixel in the input image. Two 1-D centred, point discrete derivative masks are applied to the input image in the horizontal and vertical directions. M_h = [-1, 0, 1] and M_v = ^{T} G_v is the result of applying mask M_v to the input image, and G_h is the result of applying mask M_h to the input image. The border mode used for the gradient calculation is implementation dependent. Its behavior should be similar to `VX_BORDER_UNDEFINED`. The gradient magnitudes and gradient orientations for each pixel are then calculated in the following manner.

$G(x,y) = sqrt(G_v(x,y)^2 + G_h(x,y)^2)$

$\theta(x,y) = arctan(G_v(x,y), G_h(x,y))$

where

$$arctan(v, h) = \begin{cases} tan^{-1}(v/h) & h \neq 0 \\ -\frac{\pi}{2} & v<0,\ h = 0 \\ \frac{\pi}{2} & v>0,\ h = 0 \\ 0 & v = 0,\ h = 0 \end{cases}$$

Secondly, the gradient magnitudes and orientations are used to compute the bins output tensor and optional magnitudes output tensor. These tensors are computed on a cell level where the cells are rectangular in shape. The magnitudes tensor contains the average gradient magnitude for each cell.

$$magnitudes(c) = \frac{1}{(cell\_width \times cell\_height)} \sum_{w=0}^{cell\_width} \sum_{h=0}^{cell\_height} G_c(w, h)$$

where G_c is the gradient magnitudes related to cell c. The bins tensor contains histograms of gradient orientations for each cell. The gradient orientations at each pixel range from 0 to 360 degrees. These are quantised into a set of histogram bins based on the num_bins parameter. Each pixel votes for a specific cell histogram bin based on its gradient orientation. The vote itself is the pixel's gradient magnitude.

$$bins(c, n) = \sum_{w=0}^{cell\_width} \sum_{h=0}^{cell\_height} G_c(w, h) \times 1[B_c(w, h, num\_bins) == n]$$

where B_c produces the histogram bin number based on the gradient orientation of the pixel at location (w,h) in cell c based on the num_bins and

$1[B_c(w,h,num\_bins) == n]$

is a delta-function with value 1 when $B_c(w,h,num\_bins) == n$ or 0 otherwise.

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image of type `VX_DF_IMAGE_U8`.
- `[in]` *cell_width* - The histogram cell width of type `VX_TYPE_INT32`.
- `[in]` *cell_height* - The histogram cell height of type `VX_TYPE_INT32`.
- `[in]` *num_bins* - The histogram size of type `VX_TYPE_INT32`.
- `[out]` *magnitudes* - The output average gradient magnitudes per cell of `vx_tensor` of type `VX_TYPE_INT16` of size $[floor(image_{width} / cell_{width}), floor(image_{height} / cell_{height})]$.
- `[out]` *bins* - The output gradient orientation histograms per cell of `vx_tensor` of type `VX_TYPE_INT16` of size $[floor(image_{width} / cell_{width}), floor(image_{height} / cell_{height}), num_{bins}]$.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

vxuHOGFeatures

[Immediate] Computes Histogram of Oriented Gradients features for the W1xW2 window in a sliding window fashion over the whole input image.

```
vx_status vxuHOGFeatures(
    vx_context                                  context,
    vx_image                                    input,
    vx_tensor                                   magnitudes,
    vx_tensor                                   bins,
    const vx_hog_t*                             params,
    vx_size                                     hog_param_size,
    vx_tensor                                   features);
```

Firstly if a magnitudes tensor is provided the cell histograms in the bins tensor are normalised by the average cell gradient magnitudes.

$$bins(c, n) = \frac{bins(c, n)}{magnitudes(c)}$$

To account for changes in illumination and contrast the cell histograms must be locally normalized which requires grouping the cell histograms together into larger spatially connected blocks. Blocks are rectangular grids represented by three parameters: the number of cells per block, the number of pixels per cell, and the number of bins per cell histogram (num_{bins}). These blocks typically overlap, meaning that each cell histogram contributes more than once to the final descriptor. To normalize a block its cell histograms h are grouped together to form a vector v = [h_1, h_2, h_3, ..., h_n]. This vector is normalised using L2-Hys which means performing L2-norm on this vector; clipping the result (by limiting the maximum values of v to be threshold) and renormalizing again. If the threshold is equal to zero then L2-Hys normalization is not performed.

$$L2norm(v) = \frac{v}{\sqrt{\| v \|_2^2 + \epsilon^2}}$$

where $|| v ||_k$ be its k-norm for k=1, 2, and ε be a small constant. For a specific window its HOG descriptor is then the concatenated vector of the components of the normalized cell histograms from all of the block regions contained in the window. The W1xW2 window starting position is at coordinates 0x0. If the input image has dimensions that are not an integer multiple of W1xW2 blocks with the specified stride, then the last positions that contain only a partial W1xW2 window will be calculated with the remaining part of the W1xW2 window padded with zeroes. The Window W1xW2 must also have a size so that it contains an integer number of cells, otherwise the node is not well-defined. The final output tensor will contain HOG descriptors equal to the number of windows in the input image. The output features tensor has 3 dimensions, given by:

($(I_w - W_w) / W_s$ + 1,

$(I_h - W_h) / W_s$ + 1,

$$(W_w - B_w) / B_s + 1 \quad \times \quad (W_h - B_h) / B_s + 1 \quad \times ((B_w \times B_h) / (C_w \times C_h)) \times num_{bins})$$

where I, W, B, and C refer to the image, window, block, and cell respectively, and the subscripts w, h, and s select the width, height, and stride properties respectively.

See vxCreateTensor and vxCreateVirtualTensor. The output tensor from this function may be very large. For this reason, is it not recommended that this "immediate mode" version of the function be used. The preferred method to perform this function is as graph node with a virtual tensor as the output.

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image of type VX_DF_IMAGE_U8.
- [in] *magnitudes* - The averge gradient magnitudes per cell of vx_tensor of type VX_TYPE_INT16. It is the output of vxuHOGCells.
- [in] *bins* - The gradient orientation histogram per cell of vx_tensor of type VX_TYPE_INT16. It is the output of vxuHOGCells.
- [in] *params* - The parameters of type vx_hog_t.
- [in] *hog_param_size* - Size of vx_hog_t in bytes.
- [out] *features* - The output HOG features of vx_tensor of type VX_TYPE_INT16.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.28. Harris Corners

Computes the Harris Corners of an image.

The Harris Corners are computed with several parameters

$$\begin{aligned} I &= \text{input image} \\ T_c &= \text{corner strength threshold} \\ r &= \text{euclidean radius} \\ k &= \text{sensitivity threshold} \\ w &= \text{window size} \\ b &= \text{block size} \end{aligned}$$

The computation to find the corner values or scores can be summarized as:

$$
\begin{aligned}
G_x &= Sobel_x(w, I)\\
G_y &= Sobel_y(w, I)\\
A &= window_{G_{x,\ y}}(x - b/2,\ y - b/2,\ x + b/2,\ y + b/2)\\
trace(A) &= \sum^{A} G_x^2 + \sum^{A} G_y^2\\
det(A) &= \sum^{A} G_x^2 \sum^{A} G_y^2 - \left(\sum^{A}(G_x G_y)\right)^2\\
M_c(x, y) &= det(A) - k * trace(A)^2\\
V_c(x, y) &= \begin{cases} M_c(x, y) & M_c(x, y) > T_c \\ 0 & \text{otherwise} \end{cases}
\end{aligned}
$$

where V_c is the thresholded corner value.

The normalized Sobel kernels used for the gradient computation shall be as shown below:

- For gradient size 3:

$$
\mathbf{Sobel}_x(Normalized) = \frac{1}{4 \times 255 \times b} \times \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}
$$

$$
\mathbf{Sobel}_y(Normalized) = \frac{1}{4 \times 255 \times b} \times transpose(sobel_x) = \frac{1}{4 \times 255 \times b} \times \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}
$$

- For gradient size 5:

$$
\mathbf{Sobel}_x(Normalized) = \frac{1}{16 \times 255 \times b} \times \begin{bmatrix} -1 & -2 & 0 & 2 & 1 \\ -4 & -8 & 0 & 8 & 4 \\ -6 & -12 & 0 & 12 & 6 \\ -4 & -8 & 0 & 8 & 4 \\ -1 & -2 & 0 & 2 & 1 \end{bmatrix}
$$

$$
\mathbf{Sobel}_y(Normalized) = \frac{1}{16 \times 255 \times b} \times transpose(sobel_x)
$$

- For gradient size 7:

$$
\mathbf{Sobel}_x(Normalized) = \frac{1}{64 \times 255 \times b} \times \begin{bmatrix} -1 & -4 & -5 & 0 & 5 & 4 & 1 \\ -6 & -24 & -30 & 0 & 30 & 24 & 6 \\ -15 & -60 & -75 & 0 & 75 & 60 & 15 \\ -20 & -80 & -100 & 0 & 100 & 80 & 20 \\ -15 & -60 & -75 & 0 & 75 & 60 & 15 \\ -6 & -24 & -30 & 0 & 30 & 24 & 6 \\ -1 & -4 & -5 & 0 & 5 & 4 & 1 \end{bmatrix}
$$

$$
\mathbf{Sobel}_y(Normalized) = \frac{1}{64 * 255 * b} \times transpose(sobel_x)
$$

V_c is then non-maximally suppressed, returning the same results as using the following algorithm:

- Filter the features using the non-maximum suppression algorithm defined for `vxFastCornersNode`.
- Create an array of features sorted by V_c in descending order: $V_c(j) > V_c(j+1)$.
- Initialize an empty feature set F = {}
- For each feature j in the sorted array, while $V_c(j) > T_c$:
  - If there is no feature i in F such that the Euclidean distance between pixels i and j is less

than r, add the feature j to the feature set F.

An implementation shall support all values of Euclidean distance r that satisfy: 0 ≤ max_dist ≤ 30 The feature set F is returned as a `vx_array` of `vx_keypoint_t` structs.

Functions

- `vxHarrisCornersNode`
- `vxuHarrisCorners`

3.28.1. Functions

vxHarrisCornersNode

[Graph] Creates a Harris Corners Node.

```
vx_node vxHarrisCornersNode(
    vx_graph                                      graph,
    vx_image                                      input,
    vx_scalar                                     strength_thresh,
    vx_scalar                                     min_distance,
    vx_scalar                                     sensitivity,
    vx_int32                                      gradient_size,
    vx_int32                                      block_size,
    vx_array                                      corners,
    vx_scalar                                     num_corners);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[in]` *strength_thresh* - The `VX_TYPE_FLOAT32` minimum threshold with which to eliminate Harris Corner scores (computed using the normalized Sobel kernel).
- `[in]` *min_distance* - The `VX_TYPE_FLOAT32` radial Euclidean distance for non-maximum suppression.
- `[in]` *sensitivity* - The `VX_TYPE_FLOAT32` scalar sensitivity threshold k from the Harris-Stephens equation.
- `[in]` *gradient_size* - The gradient window size to use on the input. The implementation must support at least 3, 5, and 7.
- `[in]` *block_size* - The block window size used to compute the Harris Corner score. The implementation must support at least 3, 5, and 7.
- `[out]` *corners* - The array of `VX_TYPE_KEYPOINT` objects. The order of the keypoints in this array is implementation dependent.
- `[out]` *num_corners* - [optional] The total number of detected corners in image. Use a `VX_TYPE_SIZE` scalar.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuHarrisCorners

[Immediate] Computes the Harris Corners over an image and produces the array of scored points.

```
vx_status vxuHarrisCorners(
    vx_context                                      context,
    vx_image                                        input,
    vx_scalar                                       strength_thresh,
    vx_scalar                                       min_distance,
    vx_scalar                                       sensitivity,
    vx_int32                                        gradient_size,
    vx_int32                                        block_size,
    vx_array                                        corners,
    vx_scalar                                       num_corners);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *strength_thresh* - The VX_TYPE_FLOAT32 minimum threshold which to eliminate Harris Corner scores (computed using the normalized Sobel kernel).
- [in] *min_distance* - The VX_TYPE_FLOAT32 radial Euclidean distance for non-maximum suppression.
- [in] *sensitivity* - The VX_TYPE_FLOAT32 scalar sensitivity threshold k from the Harris-Stephens equation.
- [in] *gradient_size* - The gradient window size to use on the input. The implementation must support at least 3, 5, and 7.
- [in] *block_size* - The block window size used to compute the harris corner score. The implementation must support at least 3, 5, and 7.
- [out] *corners* - The array of VX_TYPE_KEYPOINT structs. The order of the keypoints in this array is implementation dependent.
- [out] *num_corners* - [optional] The total number of detected corners in image. Use a VX_TYPE_SIZE scalar

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success

- * - An error occurred. See vx_status_e.

3.29. Histogram

Generates a distribution from an image.

This kernel counts the number of occurrences of each pixel value within the window size of a pre-calculated number of bins. A pixel with intensity I will result in incrementing histogram bin i where

$$i = (I - offset) \times (numBins / range), I \geq offset, I < offset + range$$

Pixels with intensities that don't meet these conditions will have no effect on the histogram. Here offset, range and numBins are values of histogram attributes (see VX_DISTRIBUTION_OFFSET, VX_DISTRIBUTION_RANGE, VX_DISTRIBUTION_BINS).

Functions

- vxHistogramNode
- vxuHistogram

3.29.1. Functions

vxHistogramNode

[Graph] Creates a Histogram node.

```
vx_node vxHistogramNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_distribution                             distribution);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8.
- [out] *distribution* - The output distribution.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuHistogram

[Immediate] Generates a distribution from an image.

```
vx_status vxuHistogram(
    vx_context                                  context,
    vx_image                                    input,
    vx_distribution                             distribution);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8
- [out] *distribution* - The output distribution.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.30. HoughLinesP

Finds the Probabilistic Hough Lines detected in the input binary image.

The node implement the Progressive Probabilistic Hough Transform described in Matas, J. and Galambos, C. and Kittler, J.V., Robust Detection of Lines Using the Progressive Probabilistic Hough Transform. CVIU 78 1, pp 119-137 (2000). The linear Hough transform algorithm uses a two-dimensional array, called an accumulator, to detect the existence of a line described by $r = x \cos \theta + y \sin \theta$. The dimension of the accumulator equals the number of unknown parameters, i.e., two, considering quantized values of r and θ in the pair (r,θ). For each pixel at (x,y) and its neighbourhood, the Hough transform algorithm determines if there is enough evidence of a straight line at that pixel. If so, it will calculate the parameters (r,θ) of that line, and then look for the accumulator's bin that the parameters fall into, and increment the value of that bin.

Algorithm Outline:

1. Check the input image; if it is empty then finish.
2. Update the accumulator with a single pixel randomly selected from the input image.
3. Remove the selected pixel from input image.
4. Check if the highest peak in the accumulator that was modified by the new pixel is higher than threshold. If not then goto 1.
5. Look along a corridor specified by the peak in the accumulator, and find the longest segment that either is continuous or exhibits a gap not exceeding a given threshold.
6. Remove the pixels in the segment from input image.
7. "Unvote" from the accumulator all the pixels from the line that have previously voted.
8. If the line segment is longer than the minimum length add it into the output list.

9. Goto 1

each line is stored in `vx_line2d_t` struct such that $start\_x \leq end\_x$.

Data Structures

- `vx_hough_lines_p_t`

Functions

- `vxHoughLinesPNode`
- `vxuHoughLinesP`

3.30.1. Data Structures

vxuHoughLinesP

Hough lines probability parameters.

```
typedef struct _vx_hough_lines_p_t {
    vx_float32    rho;
    vx_float32    theta;
    vx_int32      threshold;
    vx_int32      line_length;
    vx_int32      line_gap;
    vx_float32    theta_max;
    vx_float32    theta_min;
} vx_hough_lines_p_t;
```

3.30.2. Functions

vxHoughLinesPNode

[Graph] Finds the Probabilistic Hough Lines detected in the input binary image, each line is stored in the output array as a set of points (x1, y1, x2, y2) .

```
vx_node vxHoughLinesPNode(
    vx_graph                                       graph,
    vx_image                                       input,
    const vx_hough_lines_p_t*                      params,
    vx_array                                       lines_array,
    vx_scalar                                      num_lines);
```

Some implementations of the algorithm may have a random or non-deterministic element. If the target application is in a safety-critical environment this should be borne in mind and steps taken in the implementation, the application or both to achieve the level of determinism required by the system design.

Parameters

- [in] *graph* - graph handle
- [in] *input* - 8 bit, single channel binary source image
- [in] *params* - parameters of the struct vx_hough_lines_p_t
- [out] *lines_array* - lines_array contains array of lines, see vx_line2d_t The order of lines in implementation dependent
- [out] *num_lines* - [optional] The total number of detected lines in image. Use a VX_TYPE_SIZE scalar

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuHoughLinesP

[Immediate] Finds the Probabilistic Hough Lines detected in the input binary image, each line is stored in the output array as a set of points (x1, y1, x2, y2) .

```
vx_status vxuHoughLinesP(
    vx_context                                  context,
    vx_image                                    input,
    const vx_hough_lines_p_t*                   params,
    vx_array                                    lines_array,
    vx_scalar                                   num_lines);
```

Some implementations of the algorithm may have a random or non-deterministic element. If the target application is in a safety-critical environment this should be borne in mind and steps taken in the implementation, the application or both to achieve the level of determinism required by the system design.

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - 8 bit, single channel binary source image
- [in] *params* - parameters of the struct vx_hough_lines_p_t
- [out] *lines_array* - lines_array contains array of lines, see vx_line2d_t The order of lines in implementation dependent
- [out] *num_lines* - [optional] The total number of detected lines in image. Use a VX_TYPE_SIZE scalar.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.31. Integral Image

Computes the integral image of the input. The output image dimensions should be the same as the dimensions of the input image.

Each output pixel is the sum of the corresponding input pixel and all other pixels above and to the left of it.

dst(x,y) = sum(x,y)

where, for x ≥ 0 and y ≥ 0

sum(x,y) = src(x,y) + sum(x-1,y) + sum(x,y-1) - sum(x-1,y-1)

otherwise,

sum(x,y) = 0

The overflow policy used is VX_CONVERT_POLICY_WRAP.

Functions

- vxIntegralImageNode
- vxuIntegralImage

3.31.1. Functions

vxIntegralImageNode

[Graph] Creates an Integral Image Node.

```
vx_node vxIntegralImageNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U32 format, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuIntegralImage

[Immediate] Computes the integral image of the input.

```
vx_status vxuIntegralImage(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U32 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.32. LBP

Extracts LBP image from an input image. The output image dimensions should be the same as the dimensions of the input image.

The function calculates one of the following LBP descriptors: Local Binary Pattern, Modified Local Binary Pattern, or Uniform Local Binary Pattern.

Local binary pattern is defined as: Each pixel (y,x) generate an 8 bit value describing the local binary pattern around the pixel, by comparing the pixel value with its 8 neighbours (selected neighbours of the 3x3 or 5x5 window).

We will define the pixels for the 3x3 neighbourhood as:

$$
\begin{aligned}
g_0 &= SrcImg[y-1,\ x-1] \\
g_1 &= SrcImg[y-1,\ x] \\
g_2 &= SrcImg[y-1,\ x+1] \\
g_3 &= SrcImg[y,\ x+1] \\
g_4 &= SrcImg[y+1,\ x+1] \\
g_5 &= SrcImg[y+1,\ x] \\
g_6 &= SrcImg[y+1,\ x-1] \\
g_7 &= SrcImg[y,\ x-1] \\
g_c &= SrcImg[y,\ x]
\end{aligned}
$$

and the pixels in a 5x5 neighbourhood as:

$$\begin{aligned}
g_0 &= SrcImg[y-1,\ x-1]\\
g_1 &= SrcImg[y-2,\ x]\\
g_2 &= SrcImg[y-1,\ x+1]\\
g_3 &= SrcImg[y,\ x+2]\\
g_4 &= SrcImg[y+1,\ x+1]\\
g_5 &= SrcImg[y+2,\ x]\\
g_6 &= SrcImg[y+1,\ x-1]\\
g_7 &= SrcImg[y,\ x-2]\\
g_c &= SrcImg[y,\ x]
\end{aligned}$$

We also define the sign difference function:

$$s(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x<0 \end{cases}$$

Using the above definitions. The LBP image is defined in the following equation:

$$DstImg[y,\ x] = \sum_{p=0}^{7} s(g_p - g_c)2^p$$

For modified local binary pattern. Each pixel (y,x) generate an 8 bit value describing the modified local binary pattern around the pixel, by comparing the average of 8 neighbour pixels with its 8 neighbours (5x5 window).

$$\begin{aligned}
Avg[y,\ x] = &((SrcImg[y-2,\ x-2])\\
+ &(SrcImg[y-2,\ x])\\
+ &(SrcImg[y-2,\ x+2])\\
+ &(SrcImg[y,\ x+2])\\
+ &(SrcImg[y+2,\ x+2])\\
+ &(SrcImg[y+2,\ x])\\
+ &(SrcImg[y+2,\ x-2])\\
+ &(SrcImg[y,\ x-2])+1)/8
\end{aligned}$$

$$\begin{aligned}
DstImg[y,\ x] = &((SrcImg[y-2,\ x-2]>Avg[y,\ x]))\\
\mid &((SrcImg[y-2,\ x]>Avg[y,\ x])<<1)\\
\mid &((SrcImg[y-2,\ x+2]>Avg[y,\ x])<<2)\\
\mid &((SrcImg[y,\ x+2]>Avg[y,\ x])<<3)\\
\mid &((SrcImg[y+2,\ x+2]>Avg[y,\ x])<<4)\\
\mid &((SrcImg[y+2,\ x]>Avg[y,\ x])<<5)\\
\mid &((SrcImg[y+2,\ x-2]>Avg[y,\ x])<<6)\\
\mid &((SrcImg[y,\ x-2]>Avg[y,\ x])<<7)
\end{aligned}$$

The uniform LBP patterns refer to the patterns which have limited transition or discontinuities (smaller then 2 or equal) in the circular binary presentation.

For each pixel (y,x) a value is generated, describing the transition around the pixel (If there are up to 2 transitions between 0 to 1 or 1 to 0). And an additional value for all other local binary pattern values. We can define the function that measure transition as:

$$U = |s(g_7 - g_c) - s(g_0 - g_c)| + \sum_{p=1}^{7} |s(g_p - g_c) - s(g_{p-1} - g_c)|$$

With the above definitions, the unified LBP equation is defined as.

$$DstImg[y,x] = \begin{cases} \sum_{p=0}^{7} s(g_p - g_c)2^p & U \leq 2 \\ 9 & otherwise \end{cases}$$

Enumerations

- vx_lbp_format_e

Functions

- vxLBPNode
- vxuLBP

3.32.1. Enumerations

vx_lbp_format_e

Local binary pattern supported.

```
enum vx_lbp_format_e {
    VX_LBP = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_LBP_FORMAT ) + 0x0,
    VX_MLBP = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_LBP_FORMAT ) + 0x1,
    VX_ULBP = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_LBP_FORMAT ) + 0x2,
};
```

Enumerator

- VX_LBP - local binary pattern
- VX_MLBP - Modified Local Binary Patterns.
- VX_ULBP - Uniform local binary pattern.

3.32.2. Functions

vxLBPNode

[Graph] Creates a node that extracts LBP image from an input image

```
vx_node vxLBPNode(
    vx_graph                                    graph,
    vx_image                                    in,
    vx_enum                                     format,
    vx_int8                                     kernel_size,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in* - An input image in vx_image. Or SrcImg in the equations. The image is of type

VX_DF_IMAGE_U8

- [in] *format* - A variation of LBP like original LBP and mLBP. See vx_lbp_format_e
- [in] *kernel_size* - Kernel size. Only size of 3 and 5 are supported
- [out] *out* - An output image in vx_image. Or DstImg in the equations. The image is of type VX_DF_IMAGE_U8 with the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuLBP

[Immediate] The function extracts LBP image from an input image

```
vx_status vxuLBP(
    vx_context                                  context,
    vx_image                                    in,
    vx_enum                                     format,
    vx_int8                                     kernel_size,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in* - An input image in vx_image. Or SrcImg in the equations. the image is of type VX_DF_IMAGE_U8
- [in] *format* - A variation of LBP like original LBP and mLBP. see vx_lbp_format_e
- [in] *kernel_size* - Kernel size. Only size of 3 and 5 are supported
- [out] *out* - An output image in vx_image. Or DstImg in the equations. The image is of type VX_DF_IMAGE_U8

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.33. Laplacian Image Pyramid

Computes a Laplacian Image Pyramid from an input image.

This vision function creates the Laplacian image pyramid from the input image. First, a Gaussian pyramid is created with the scale attribute VX_SCALE_PYRAMID_HALF and the number of levels equal to

N+1, where N is the number of levels in the laplacian pyramid. The border mode for the Gaussian pyramid calculation should be `VX_BORDER_REPLICATE`. Then, for each i = 0 ... N-1, the Laplacian level L_i is computed as:

$L_i = G_i - UpSample(G_{i+1})$.

Here G_i is the i-th level of the Gaussian pyramid.

UpSample(I) is computed by injecting even zero rows and columns and then convolves the result with the Gaussian 5x5 filter multiplied by 4.

$$UpSample(I)_{x,y} = 4\sum_{k=-2}^{2}\sum_{l=-2}^{2} I'_{x-k,y-l} W_{k+2,l+2}$$

$$I'_{x,y} = \begin{cases} I_{\frac{x}{2},\frac{y}{2}} & \text{if x and y are even} \\ 0 & \text{otherwise} \end{cases}$$

$$\mathbf{W} = \frac{1}{256} \times \begin{bmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{bmatrix}$$

L_0 shall always have the same resolution as the input image. The output image is equal to G_N.

The border mode for the UpSample calculation should be `VX_BORDER_REPLICATE`.

Functions

- `vxLaplacianPyramidNode`
- `vxuLaplacianPyramid`

3.33.1. Functions

vxLaplacianPyramidNode

[Graph] Creates a node for a Laplacian Image Pyramid.

```
vx_node vxLaplacianPyramidNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_pyramid                                  laplacian,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format.
- `[out]` *laplacian* - The Laplacian pyramid with `VX_DF_IMAGE_S16` to construct.
- `[out]` *output* - The lowest resolution image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format necessary to reconstruct the input image from the pyramid. The output image format should be

same as input image format.

See also: Object: Pyramid

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuLaplacianPyramid

[Immediate] Computes a Laplacian pyramid from an input image.

```
vx_status vxuLaplacianPyramid(
    vx_context                                      context,
    vx_image                                        input,
    vx_pyramid                                      laplacian,
    vx_image                                        output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.
- [out] *laplacian* - The Laplacian pyramid with VX_DF_IMAGE_S16 to construct.
- [out] *output* - The lowest resolution image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format necessary to reconstruct the input image from the pyramid. The output image format should be same as input image format.

See also: Object: Pyramid

Returns: A vx_status enumeration.

Return Values

- VX_SUCCESS - Success.
- * - An error occured. See vx_status_e

3.34. Magnitude

Implements the Gradient Magnitude Computation Kernel. The output image dimensions should be the same as the dimensions of the input images.

This kernel takes two gradients in VX_DF_IMAGE_S16 format and computes the VX_DF_IMAGE_S16 normalized magnitude. Magnitude is computed as:

$$mag(x, y) = \sqrt{grad_x(x, y)^2 + grad_y(x, y)^2}$$

The conceptual definition describing the overflow is given as:

```
uint16 z = uint16( sqrt( double( uint32( int32(x) * int32(x) ) + uint32( int32(y) *
int32(y) ) ) ) + 0.5);

int16 mag = z > 32767 ? 32767 : z;
```

Functions

- vxMagnitudeNode
- vxuMagnitude

3.34.1. Functions

vxMagnitudeNode

[Graph] Create a Magnitude node.

```
vx_node vxMagnitudeNode(
    vx_graph                                    graph,
    vx_image                                    grad_x,
    vx_image                                    grad_y,
    vx_image                                    mag);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *grad_x* - The input x image. This must be in VX_DF_IMAGE_S16 format.
- [in] *grad_y* - The input y image. This must be in VX_DF_IMAGE_S16 format.
- [out] *mag* - The magnitude image. This is in VX_DF_IMAGE_S16 format. Must have the same dimensions as the input image.

See also: VX_KERNEL_MAGNITUDE

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuMagnitude

[Immediate] Invokes an immediate Magnitude.

```
vx_status vxuMagnitude(
    vx_context                                  context,
    vx_image                                    grad_x,
    vx_image                                    grad_y,
    vx_image                                    mag);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *grad_x* - The input x image. This must be in VX_DF_IMAGE_S16 format.
- [in] *grad_y* - The input y image. This must be in VX_DF_IMAGE_S16 format.
- [out] *mag* - The magnitude image. This will be in VX_DF_IMAGE_S16 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.35. MatchTemplate

Compares an image template against overlapped image regions.

The detailed equation to the matching can be found in vx_comp_metric_e. The output of the template matching node is a comparison map. The output comparison map should be the same size as the input image. The template image size (width*height) shall not be larger than 65535. If the valid region of the template image is smaller than the entire template image, the result in the destination image is implementation-dependent.

Enumerations

- vx_comp_metric_e

Functions

- vxMatchTemplateNode
- vxuMatchTemplate

3.35.1. Enumerations

vx_comp_metric_e

comparing metrics.

```
enum vx_comp_metric_e {
    VX_COMPARE_HAMMING = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_COMP_METRIC ) + 0x0,
    VX_COMPARE_L1 = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_COMP_METRIC ) + 0x1,
    VX_COMPARE_L2 = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_COMP_METRIC ) + 0x2,
    VX_COMPARE_CCORR = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_COMP_METRIC ) + 0x3,
    VX_COMPARE_L2_NORM = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_COMP_METRIC ) + 0x4,
    VX_COMPARE_CCORR_NORM = VX_ENUM_BASE( VX_ID_KHRONOS, VX_ENUM_COMP_METRIC ) + 0x5,
};
```

In all the equations below w and h are width and height of the template image respectively. R is the compare map. T is the template image. I is the image on which the template is searched.

Enumerator

- `VX_COMPARE_HAMMING` - hamming distance
  $R(x, y) = \frac{1}{w*h}\sum_{\grave{x}, \grave{y}}^{w, h} XOR(T(\grave{x}, \grave{y}), I(x+\grave{x}, y+\grave{y}))$
- `VX_COMPARE_L1` - L1 distance
  $R(x, y) = \frac{1}{w*h}\sum_{\grave{x}, \grave{y}}^{w, h} ABS(T(\grave{x}, \grave{y}) - I(x+\grave{x}, y+\grave{y}))$.
- `VX_COMPARE_L2` - L2 distance, normalized by image size
  $R(x, y) = \frac{1}{w*h}\sum_{\grave{x}, \grave{y}}^{w, h} (T(\grave{x}, \grave{y}) - I(x+\grave{x}, y+\grave{y}))^2$.
- `VX_COMPARE_CCORR` - cross correlation distance
  $R(x, y) = \frac{1}{w*h}\sum_{\grave{x}, \grave{y}}^{w, h} (T(\grave{x}, \grave{y}) * I(x+\grave{x}, y+\grave{y}))$
- `VX_COMPARE_L2_NORM` - L2 normalized distance
  $R(x, y) = \frac{\sum_{\grave{x}, \grave{y}}^{w, h} (T(\grave{x}, \grave{y}) - I(x+\grave{x}, y+\grave{y}))^2}{\sqrt{\sum_{\grave{x}, \grave{y}}^{w, h} T(\grave{x}, \grave{y})^2 * I(x+\grave{x}, y+\grave{y})^2}}$.
- `VX_COMPARE_CCORR_NORM` - cross correlation normalized distance
  $R(x, y) = \frac{\sum_{\grave{x}, \grave{y}}^{w, h} T(\grave{x}, \grave{y}) * I(x+\grave{x}, y+\grave{y}) * 2^{15}}{\sqrt{\sum_{\grave{x}, \grave{y}}^{w, h} T(\grave{x}, \grave{y})^2 * I(x+\grave{x}, y+\grave{y})^2}}$

3.35.2. Functions

vxMatchTemplateNode

[Graph] The Node Compares an image template against overlapped image regions.

```
vx_node vxMatchTemplateNode(
    vx_graph                                   graph,
    vx_image                                   src,
    vx_image                                   templateImage,
    vx_enum                                    matchingMethod,
    vx_image                                   output);
```

The detailed equation to the matching can be found in `vx_comp_metric_e`. The output of the template matching node is a comparison map as described in `vx_comp_metric_e`. The Node have a limitation on the template image size (width*height). It should not be larger then 65535. If the valid region of the template image is smaller than the entire template image, the result in the destination image is implementation-dependent.

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *src* - The input image of type `VX_DF_IMAGE_U8`.
- `[in]` *templateImage* - Searched template of type `VX_DF_IMAGE_U8`.
- `[in]` *matchingMethod* - attribute specifying the comparison method `vx_comp_metric_e`. This function support only `VX_COMPARE_CCORR_NORM` and `VX_COMPARE_L2`.
- `[out]` *output* - Map of comparison results. The output is an image of type `VX_DF_IMAGE_S16`.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuMatchTemplate

[Immediate] The function compares an image template against overlapped image regions.

```
vx_status vxuMatchTemplate(
    vx_context                                  context,
    vx_image                                    src,
    vx_image                                    templateImage,
    vx_enum                                     matchingMethod,
    vx_image                                    output);
```

The detailed equation to the matching can be found in `vx_comp_metric_e`. The output of the template matching node is a comparison map as described in `vx_comp_metric_e`. The Node have a limitation on the template image size (width*height). It should not be larger then 65535. If the valid region of the template image is smaller than the entire template image, the result in the destination image is implementation-dependent.

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *src* - The input image of type `VX_DF_IMAGE_U8`.
- `[in]` *templateImage* - Searched template of type `VX_DF_IMAGE_U8`.
- `[in]` *matchingMethod* - attribute specifying the comparison method `vx_comp_metric_e`. This function support only `VX_COMPARE_CCORR_NORM` and `VX_COMPARE_L2`.
- `[out]` *output* - Map of comparison results. The output is an image of type `VX_DF_IMAGE_S16`

Returns: A `vx_status_e` enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.36. Max

Implements a pixel-wise maximum kernel. The output image dimensions should be the same as the dimensions of the input image.

Performing a pixel-wise maximum on a VX_DF_IMAGE_U8 images or VX_DF_IMAGE_S16. All data types of the input and output images must match.

out[i,j] = (in1[i,j] > in2[i,j] ? in1[i,j] : in2[i,j])

Functions

- vxMaxNode
- vxuMax

3.36.1. Functions

vxMaxNode

[Graph] Creates a pixel-wise maximum kernel.

```
vx_node vxMaxNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph where to create the node.
- [in] *in1* - The first input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *in2* - The second input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [out] *out* - The output image which will hold the result of max and will have the same type and dimensions of the imput images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuMax

[Immediate] Computes pixel-wise maximum values between two images.

```
vx_status vxuMax(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - The first input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *in2* - The second input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [out] *out* - The output image which will hold the result of max.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.37. Mean and Standard Deviation

Computes the mean pixel value and the standard deviation of the pixels in the input image (which has a dimension width and height).

The mean value is computed as:

$$\mu = \frac{\left(\sum_{y=0}^{h} \sum_{x=0}^{w} src(x, y)\right)}{(width \times height)}$$

The standard deviation is computed as:

$$\sigma = \sqrt{\frac{\left(\sum_{y=0}^{h} \sum_{x=0}^{w} (\mu - src(x, y))^2\right)}{(width \times height)}}$$

Functions

- vxMeanStdDevNode
- vxuMeanStdDev

3.37.1. Functions

vxMeanStdDevNode

[Graph] Creates a mean value and optionally, a standard deviation node.

```
vx_node vxMeanStdDevNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_scalar                                   mean,
    vx_scalar                                   stddev);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image. `VX_DF_IMAGE_U8` is supported.
- `[out]` *mean* - The `VX_TYPE_FLOAT32` average pixel value.
- `[out]` *stddev* - [optional] The `VX_TYPE_FLOAT32` standard deviation of the pixel values.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuMeanStdDev

[Immediate] Computes the mean value and optionally the standard deviation.

```
vx_status vxuMeanStdDev(
    vx_context                                  context,
    vx_image                                    input,
    vx_float32*                                 mean,
    vx_float32*                                 stddev);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image. `VX_DF_IMAGE_U8` is supported.
- `[out]` *mean* - The average pixel value.
- `[out]` *stddev* - [optional] The standard deviation of the pixel values.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.38. Median Filter

Computes a median pixel value over a window of the input image. The output image dimensions should be the same as the dimensions of the input image.

The median is the middle value over an odd-numbered, sorted range of values.

> *Note*
>
> For kernels that use other structuring patterns than 3x3 see `vxNonLinearFilterNode` or `vxuNonLinearFilter`.

Functions

- `vxMedian3x3Node`
- `vxuMedian3x3`

3.38.1. Functions

vxMedian3x3Node

[Graph] Creates a Median Image Node.

```
vx_node vxMedian3x3Node(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` format.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` format, which must have the same dimensions as the input image.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuMedian3x3

[Immediate] Computes a median filter on the image by a 3x3 window.

```
vx_status vxuMedian3x3(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.39. Min

Implements a pixel-wise minimum kernel. The output image dimensions should be the same as the dimensions of the input image.

Performing a pixel-wise minimum on a VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 images. All data types of the input and output images must match.

$$out[i,j] = (in1[i,j] < in2[i,j] \ ? \ in1[i,j] : in2[i,j])$$

Functions

- vxMinNode
- vxuMin

3.39.1. Functions

vxMinNode

[Graph] Creates a pixel-wise minimum kernel.

```
vx_node vxMinNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph where to create the node.
- [in] *in1* - The first input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *in2* - The second input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [out] *out* - The output image which will hold the result of min and will have the same type and dimensions of the imput images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuMin

[Immediate] Computes pixel-wise minimum values between two images.

```
vx_status vxuMin(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - The first input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *in2* - The second input image. Must be of type VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [out] *out* - The output image which will hold the result of min.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.40. Min, Max Location

Finds the minimum and maximum values in an image and a location for each.

If the input image has several minimums/maximums, the kernel returns all of them.

$$minVal = \min_{\substack{0 \le x' \le width \\ 0 \le y' \le height}} src(x', y')$$

$$maxVal = \max_{\substack{0 \le x' \le width \\ 0 \le y' \le height}} src(x', y')$$

Functions

- vxMinMaxLocNode
- vxuMinMaxLoc

3.40.1. Functions

vxMinMaxLocNode

[Graph] Creates a min,max,loc node.

```
vx_node vxMinMaxLocNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_scalar                                   minVal,
    vx_scalar                                   maxVal,
    vx_array                                    minLoc,
    vx_array                                    maxLoc,
    vx_scalar                                   minCount,
    vx_scalar                                   maxCount);
```

Parameters

- [in] *graph* - The reference to create the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.
- [out] *minVal* - The minimum value in the image, which corresponds to the type of the input.
- [out] *maxVal* - The maximum value in the image, which corresponds to the type of the input.
- [out] *minLoc* - [optional] The minimum VX_TYPE_COORDINATES2D locations. If the input image has several minimums, the kernel will return up to the capacity of the array.
- [out] *maxLoc* - [optional] The maximum VX_TYPE_COORDINATES2D locations. If the input image has several maximums, the kernel will return up to the capacity of the array.
- [out] *minCount* - [optional] The total number of detected minimums in image. Use a VX_TYPE_SIZE scalar.
- [out] *maxCount* - [optional] The total number of detected maximums in image. Use a VX_TYPE_SIZE scalar.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuMinMaxLoc

[Immediate] Computes the minimum and maximum values of the image.

```
vx_status vxuMinMaxLoc(
    vx_context                                  context,
    vx_image                                    input,
    vx_scalar                                   minVal,
    vx_scalar                                   maxVal,
    vx_array                                    minLoc,
    vx_array                                    maxLoc,
    vx_scalar                                   minCount,
    vx_scalar                                   maxCount);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format.
- `[out]` *minVal* - The minimum value in the image, which corresponds to the type of the input.
- `[out]` *maxVal* - The maximum value in the image, which corresponds to the type of the input.
- `[out]` *minLoc* - [optional] The minimum `VX_TYPE_COORDINATES2D` locations. If the input image has several minimums, the kernel will return up to the capacity of the array.
- `[out]` *maxLoc* - [optional] The maximum `VX_TYPE_COORDINATES2D` locations. If the input image has several maximums, the kernel will return up to the capacity of the array.
- `[out]` *minCount* - [optional] The total number of detected minimums in image. Use a `VX_TYPE_SIZE` scalar.
- `[out]` *maxCount* - [optional] The total number of detected maximums in image. Use a `VX_TYPE_SIZE` scalar.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.41. Non Linear Filter

Computes a non-linear filter over a window of the input image. The output image dimensions should be the same as the dimensions of the input image.

The attribute `VX_CONTEXT_NONLINEAR_MAX_DIMENSION` enables the user to query the largest nonlinear filter supported by the implementation of vxNonLinearFilterNode. The implementation must support all dimensions (height or width, not necessarily the same) up to the value of this attribute. The lowest value that must be supported for this attribute is 9.

Functions

- vxNonLinearFilterNode
- vxuNonLinearFilter

3.41.1. Functions

vxNonLinearFilterNode

[Graph] Creates a Non-linear Filter Node.

```
vx_node vxNonLinearFilterNode(
    vx_graph                                      graph,
    vx_enum                                       function,
    vx_image                                      input,
    vx_matrix                                     mask,
    vx_image                                      output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *function* - The non-linear filter function. See vx_non_linear_filter_e.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [in] *mask* - The mask to be applied to the Non-linear function. VX_MATRIX_ORIGIN attribute is used to place the mask appropriately when computing the resulting image. See vxCreateMatrixFromPattern.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format, which must have the same dimensions as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuNonLinearFilter

[Immediate] Performs Non-linear Filtering.

```
vx_status vxuNonLinearFilter(
    vx_context                                    context,
    vx_enum                                       function,
    vx_image                                      input,
    vx_matrix                                     mask,
    vx_image                                      output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *function* - The non-linear filter function. See vx_non_linear_filter_e.
- [in] *input* - The input image in VX_DF_IMAGE_U8 format.
- [in] *mask* - The mask to be applied to the non-linear function. VX_MATRIX_ORIGIN attribute is used to place the mask appropriately when computing the resulting image. See vxCreateMatrixFromPattern and vxCreateMatrixFromPatternAndOrigin.
- [out] *output* - The output image in VX_DF_IMAGE_U8 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.42. Non-Maxima Suppression

Find local maxima in an image, or otherwise suppress pixels that are not local maxima.

The input to the Non-Maxima Suppressor is either a VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 image. In the case of a VX_DF_IMAGE_S16 image, suppressed pixels shall take the value of INT16_MIN.

An optional mask image may be used to restrict the suppression to a region-of-interest. If a mask pixel is non-zero, then the associated pixel in the input is completely ignored and not considered during suppression; that is, it is not suppressed and not considered as part of any suppression window.

A pixel with coordinates (x,y) is kept if and only if it is greater than or equal to its top left neighbours; and greater than its bottom right neighbours. For example, for a window size of 3, P(x,y) is retained if the following condition holds:

$$\begin{gathered} P(x,\ y) \geq P(x-1,\ y-1)\ and\ P(x,\ y) \geq P(x,\ y-1)\ and \\ P(x,\ y) \geq P(x+1,\ y-1)\ and\ P(x,\ y) \geq P(x-1,\ y)\ and \\ P(x,\ y) > P(x+1,\ y)\ and\ P(x,\ y) > P(x-1,\ y+1)\ and \\ P(x,\ y) > P(x,\ y+1)\ and\ P(x,\ y) > P(x+1,\ y+1) \end{gathered}$$

Functions

- vxNonMaxSuppressionNode
- vxuNonMaxSuppression

3.42.1. Functions

vxNonMaxSuppressionNode

[Graph] Creates a Non-Maxima Suppression node.

```
vx_node vxNonMaxSuppressionNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    mask,
    vx_int32                                    win_size,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format.
- `[in]` *mask* - [optional] Constrict suppression to a ROI. The mask image is of type `VX_DF_IMAGE_U8` and must be the same dimensions as the input image.
- `[in]` *win_size* - The size of window over which to perform the localized non-maxima suppression. Must be odd, and less than or equal to the smallest dimension of the input image.
- `[out]` *output* - The output image, of the same type and size as the input, that has been non-maxima suppressed.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuNonMaxSuppression

[Immediate] Performs Non-Maxima Suppression on an image, producing an image of the same type.

```
vx_status vxuNonMaxSuppression(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    mask,
    vx_int32                                    win_size,
    vx_image                                    output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format.
- `[in]` *mask* - [optional] Constrict suppression to a ROI. The mask image is of type `VX_DF_IMAGE_U8` and must be the same dimensions as the input image.
- `[in]` *win_size* - The size of window over which to perform the localized non-maxima suppression. Must be odd, and less than or equal to the smallest dimension of the input image.

- [out] *output* - The output image, of the same type as the input, that has been non-maxima suppressed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.43. Optical Flow Pyramid (LK)

Computes the optical flow using the Lucas-Kanade method between two pyramid images.

The function is an implementation of the algorithm described in [Bouguet2000]. The function inputs are two vx_pyramid objects, old and new, along with a vx_array of vx_keypoint_t structs to track from the old vx_pyramid. Both pyramids old and new pyramids must have the same dimensionality. VX_SCALE_PYRAMID_HALF pyramidal scaling must be supported.

The function outputs a vx_array of vx_keypoint_t structs that were tracked from the old vx_pyramid to the new vx_pyramid. Each element in the vx_array of vx_keypoint_t structs in the new array may be valid or not. The implementation shall return the same number of vx_keypoint_t structs in the new vx_array that were in the older vx_array.

In more detail: The Lucas-Kanade method finds the affine motion vector V for each point in the old image tracking points array, using the following equation:

$$\begin{bmatrix} V_x \\ V_y \end{bmatrix} = \begin{bmatrix} \sum_i I_x^2 & \sum_i I_x \times I_y \\ \sum_i I_x \times I_y & \sum_i I_y^2 \end{bmatrix}^{-1} \begin{bmatrix} -\sum_i I_x \times I_t \\ -\sum_i I_y \times I_t \end{bmatrix}$$

Where I_x and I_y are obtained using the Scharr gradients on the input image:

$$G_x = \begin{bmatrix} +3 & 0 & -3 \\ +10 & 0 & -10 \\ +3 & 0 & -3 \end{bmatrix}$$

$$G_y = \begin{bmatrix} +3 & +10 & +3 \\ 0 & 0 & 0 \\ -3 & -10 & -3 \end{bmatrix}$$

I_t is obtained by a simple difference between the same pixel in both images. I is defined as the adjacent pixels to the point p(x,y) under consideration. With a given window size of M, I is M^2 points. The pixel p(x,y) is centered in the window. In practice, to get an accurate solution, it is necessary to iterate multiple times on this scheme (in a Newton-Raphson fashion) until:

- the residual of the affine motion vector is smaller than a threshold
- And/or maximum number of iteration achieved.

Each iteration, the estimation of the previous iteration is used by changing I_t to be the difference between the old image and the pixel with the estimated coordinates in the new image. Each iteration the function checks if the pixel to track was lost. The criteria for lost tracking is that the matrix above is invertible. (The determinant of the matrix is less than a threshold : 10^{-7}.) Or the minimum eigenvalue of the matrix is smaller then a threshold (10^{-4}). Also lost tracking happens when the point tracked coordinate is outside the image coordinates. When `vx_true_e` is given as the input to *use_initial_estimates*, the algorithm starts by calculating I_t as the difference between the old image and the pixel with the initial estimated coordinates in the new image. The input `vx_array` of `vx_keypoint_t` structs with *tracking_status* set to zero (lost) are copied to the new `vx_array`.

Clients are responsible for editing the output `vx_array` of `vx_keypoint_t` structs array before applying it as the input `vx_array` of `vx_keypoint_t` structs for the next frame. For example, `vx_keypoint_t` structs with *tracking_status* set to zero may be removed by a client for efficiency.

This function changes just the *x*, *y*, and *tracking_status* members of the `vx_keypoint_t` structure and behaves as if it copied the rest from the old tracking `vx_keypoint_t` to new image `vx_keypoint_t`.

Functions

- `vxOpticalFlowPyrLKNode`
- `vxuOpticalFlowPyrLK`

3.43.1. Functions

vxOpticalFlowPyrLKNode

[Graph] Creates a Lucas Kanade Tracking Node.

```
vx_node vxOpticalFlowPyrLKNode(
    vx_graph                                    graph,
    vx_pyramid                                  old_images,
    vx_pyramid                                  new_images,
    vx_array                                    old_points,
    vx_array                                    new_points_estimates,
    vx_array                                    new_points,
    vx_enum                                     termination,
    vx_scalar                                   epsilon,
    vx_scalar                                   num_iterations,
    vx_scalar                                   use_initial_estimate,
    vx_size                                     window_dimension);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *old_images* - Input of first (old) image pyramid in `VX_DF_IMAGE_U8`.
- `[in]` *new_images* - Input of destination (new) image pyramid `VX_DF_IMAGE_U8`.
- `[in]` *old_points* - An array of key points in a `vx_array` of `VX_TYPE_KEYPOINT`; those key points are defined at the *old_images* high resolution pyramid.
- `[in]` *new_points_estimates* - An array of estimation on what is the output key points in a `vx_array` of `VX_TYPE_KEYPOINT`; those keypoints are defined at the *new_images* high resolution pyramid.

- [out] *new_points* - An output array of key points in a vx_array of VX_TYPE_KEYPOINT; those key points are defined at the *new_images* high resolution pyramid.
- [in] *termination* - The termination can be VX_TERM_CRITERIA_ITERATIONS or VX_TERM_CRITERIA_EPSILON or VX_TERM_CRITERIA_BOTH.
- [in] *epsilon* - The vx_float32 error for terminating the algorithm.
- [in] *num_iterations* - The number of iterations. Use a VX_TYPE_UINT32 scalar.
- [in] *use_initial_estimate* - Use a VX_TYPE_BOOL scalar.
- [in] *window_dimension* - The size of the window on which to perform the algorithm. See VX_CONTEXT_OPTICAL_FLOW_MAX_WINDOW_DIMENSION

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuOpticalFlowPyrLK

[Immediate] Computes an optical flow on two images.

```
vx_status vxuOpticalFlowPyrLK(
    vx_context                                  context,
    vx_pyramid                                  old_images,
    vx_pyramid                                  new_images,
    vx_array                                    old_points,
    vx_array                                    new_points_estimates,
    vx_array                                    new_points,
    vx_enum                                     termination,
    vx_scalar                                   epsilon,
    vx_scalar                                   num_iterations,
    vx_scalar                                   use_initial_estimate,
    vx_size                                     window_dimension);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *old_images* - Input of first (old) image pyramid in VX_DF_IMAGE_U8.
- [in] *new_images* - Input of destination (new) image pyramid in VX_DF_IMAGE_U8
- [in] *old_points* - an array of key points in a vx_array of VX_TYPE_KEYPOINT those key points are defined at the old_images high resolution pyramid
- [in] *new_points_estimates* - an array of estimation on what is the output key points in a vx_array of VX_TYPE_KEYPOINT those keypoints are defined at the new_images high resolution pyramid
- [out] *new_points* - an output array of key points in a vx_array of VX_TYPE_KEYPOINT those key points are defined at the new_images high resolution pyramid

- `[in]` *termination* - termination can be `VX_TERM_CRITERIA_ITERATIONS` or `VX_TERM_CRITERIA_EPSILON` or `VX_TERM_CRITERIA_BOTH`
- `[in]` *epsilon* - is the `vx_float32` error for terminating the algorithm
- `[in]` *num_iterations* - is the number of iterations. Use a `VX_TYPE_UINT32` scalar.
- `[in]` *use_initial_estimate* - Can be set to either `vx_false_e` or `vx_true_e`.
- `[in]` *window_dimension* - The size of the window on which to perform the algorithm. See `VX_CONTEXT_OPTICAL_FLOW_MAX_WINDOW_DIMENSION`

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.44. Phase

Implements the Gradient Phase Computation Kernel. The output image dimensions should be the same as the dimensions of the input images.

This kernel takes two gradients in `VX_DF_IMAGE_S16` format and computes the angles for each pixel and stores this in a `VX_DF_IMAGE_U8` image.

$\varphi = \tan^{-1} (grad\_y(x,y) / grad\_x(x,y))$

Where φ is then translated to $0 \leq \varphi < 2\pi$. Each φ value is then mapped to the range 0 to 255 inclusive.

Functions

- `vxPhaseNode`
- `vxuPhase`

3.44.1. Functions

vxPhaseNode

[Graph] Creates a Phase node.

```
vx_node vxPhaseNode(
    vx_graph                                    graph,
    vx_image                                    grad_x,
    vx_image                                    grad_y,
    vx_image                                    orientation);
```

Parameters

- `[in]` *graph* - The reference to the graph.

- [in] *grad_x* - The input x image. This must be in VX_DF_IMAGE_S16 format.
- [in] *grad_y* - The input y image. This must be in VX_DF_IMAGE_S16 format.
- [out] *orientation* - The phase image. This is in VX_DF_IMAGE_U8 format, and must have the same dimensions as the input images.

See also: VX_KERNEL_PHASE

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuPhase

[Immediate] Invokes an immediate Phase.

```
vx_status vxuPhase(
    vx_context                                  context,
    vx_image                                    grad_x,
    vx_image                                    grad_y,
    vx_image                                    orientation);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *grad_x* - The input x image. This must be in VX_DF_IMAGE_S16 format.
- [in] *grad_y* - The input y image. This must be in VX_DF_IMAGE_S16 format.
- [out] *orientation* - The phase image. This will be in VX_DF_IMAGE_U8 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.45. Pixel-wise Multiplication

Performs element-wise multiplication between two images and a scalar value. The output image dimensions should be the same as the dimensions of the input images.

Pixel-wise multiplication is performed between the pixel values in two VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 images and a scalar floating-point number *scale*. The output image can be VX_DF_IMAGE_U8 only if both source images are VX_DF_IMAGE_U8 and the output image is explicitly set to VX_DF_IMAGE_U8. It is otherwise VX_DF_IMAGE_S16. If one of the input images is of type

VX_DF_IMAGE_S16, all values are converted to VX_DF_IMAGE_S16.

The scale with a value of $1 / 2^n$, where n is an integer and $0 \le n \le 15$, and 1/255 (0x1.010102p-8 C99 float hex) must be supported. The support for other values of scale is not prohibited. Furthermore, for scale with a value of 1/255 the rounding policy of VX_ROUND_POLICY_TO_NEAREST_EVEN must be supported whereas for the scale with value of $\frac{1}{2^n}$ the rounding policy of VX_ROUND_POLICY_TO_ZERO must be supported. The support of other rounding modes for any values of scale is not prohibited.

The rounding policy VX_ROUND_POLICY_TO_ZERO for this function is defined as:

reference(x,y,scale) = truncate(((int32_t)in_1(x,y)) × ((int32_t)in_2(x,y)) × (double)scale)

The rounding policy VX_ROUND_POLICY_TO_NEAREST_EVEN for this function is defined as:

reference(x,y,scale) = round_to_nearest_even(((int32_t)in_1(x,y)) × ((int32_t)in_2(x,y)) × (double)scale)

The overflow handling is controlled by an overflow-policy parameter. For each pixel value in the two input images:

$out(x,y) = in_1(x,y) \times in_2(x,y) \times scale$

Functions

- vxMultiplyNode
- vxuMultiply

3.45.1. Functions

vxMultiplyNode

[Graph] Creates an pixelwise-multiplication node.

```
vx_node vxMultiplyNode(
    vx_graph                                    graph,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_scalar                                   scale,
    vx_enum                                     overflow_policy,
    vx_enum                                     rounding_policy,
    vx_image                                    out);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *in1* - An input image, VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *in2* - An input image, VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *scale* - A non-negative VX_TYPE_FLOAT32 multiplied to each product before overflow

handling.

- [in] *overflow_policy* - A VX_TYPE_ENUM of the vx_convert_policy_e enumeration.
- [in] *rounding_policy* - A VX_TYPE_ENUM of the vx_round_policy_e enumeration.
- [out] *out* - The output image, a VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 image. Must have the same type and dimensions of the imput images.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuMultiply

[Immediate] Performs elementwise multiplications on pixel values in the input images and a scale.

```
vx_status vxuMultiply(
    vx_context                                  context,
    vx_image                                    in1,
    vx_image                                    in2,
    vx_float32                                  scale,
    vx_enum                                     overflow_policy,
    vx_enum                                     rounding_policy,
    vx_image                                    out);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *in1* - A VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 input image.
- [in] *in2* - A VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 input image.
- [in] *scale* - A non-negative VX_TYPE_FLOAT32 multiplied to each product before overflow handling.
- [in] *overflow_policy* - A vx_convert_policy_e enumeration.
- [in] *rounding_policy* - A vx_round_policy_e enumeration.
- [out] *out* - The output image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16 format.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.46. Reconstruction from a Laplacian Image Pyramid

Reconstructs the original image from a Laplacian Image Pyramid.

This vision function reconstructs the image of the highest possible resolution from a Laplacian pyramid. The upscaled input image is added to the last level of the Laplacian pyramid L_{N-1}:

$$I_{N-1} = \text{UpSample}(\text{input}) + L_{N-1}$$

For the definition of the UpSample function please see vxLaplacianPyramidNode. Correspondingly, for each pyramid level i = 0 … N-2:

$$I_i = \text{UpSample}(I_{i+1}) + L_i$$

Finally, the output image is:

$$\text{output} = I_0$$

Functions

- vxLaplacianReconstructNode
- vxuLaplacianReconstruct

3.46.1. Functions

vxLaplacianReconstructNode

[Graph] Reconstructs an image from a Laplacian Image pyramid.

```
vx_node vxLaplacianReconstructNode(
    vx_graph                                    graph,
    vx_pyramid                                  laplacian,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *laplacian* - The Laplacian pyramid with `VX_DF_IMAGE_S16` format.
- `[in]` *input* - The lowest resolution image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format for the Laplacian pyramid.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format with the highest possible resolution reconstructed from the Laplacian pyramid. The output image format should be same as input image format.

See also: Object: Pyramid

Returns: `vx_node`.

Return Values

- 0 - Node could not be created.
- * - Node handle.

vxuLaplacianReconstruct

[Immediate] Reconstructs an image from a Laplacian Image pyramid.

```
vx_status vxuLaplacianReconstruct(
    vx_context                                  context,
    vx_pyramid                                  laplacian,
    vx_image                                    input,
    vx_image                                    output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *laplacian* - The Laplacian pyramid with `VX_DF_IMAGE_S16` format.
- `[in]` *input* - The lowest resolution image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format for the Laplacian pyramid.
- `[out]` *output* - The output image in `VX_DF_IMAGE_U8` or `VX_DF_IMAGE_S16` format with the highest possible resolution reconstructed from the Laplacian pyramid. The output image format should be same as input image format.

See also: Object: Pyramid

Returns: A `vx_status` enumeration.

Return Values

- `VX_SUCCESS` - Success.
- * - An error occured. See `vx_status_e`

3.47. Remap

Maps output pixels in an image from input pixels in an image.

Remap takes a remap table object `vx_remap` to map a set of output pixels back to source input pixels. A remap is typically defined as:

output(x,y) = input(mapx(x,y),mapy(x,y))

for every (x,y) in the destination image

However, the mapping functions are contained in the `vx_remap` object.

Functions

- vxRemapNode
- vxuRemap

3.47.1. Functions

vxRemapNode

[Graph] Creates a Remap Node.

```
vx_node vxRemapNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_remap                                    table,
    vx_enum                                     policy,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph that will contain the node.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *table* - The remap table object.
- [in] *policy* - An interpolation type from vx_interpolation_type_e. VX_INTERPOLATION_AREA is not supported.
- [out] *output* - The output VX_DF_IMAGE_U8 image with the same dimensions as the input image.

> *Note*
>
> The border modes VX_NODE_BORDER value VX_BORDER_UNDEFINED and VX_BORDER_CONSTANT are supported.

Returns: A vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuRemap

[Immediate] Remaps an output image from an input image.

```
vx_status vxuRemap(
    vx_context                                  context,
    vx_image                                    input,
    vx_remap                                    table,
    vx_enum                                     policy,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *table* - The remap table object.
- [in] *policy* - The interpolation policy from vx_interpolation_type_e. VX_INTERPOLATION_AREA is not supported.
- [out] *output* - The output VX_DF_IMAGE_U8 image.

Returns: A vx_status_e enumeration.

3.48. Scale Image

Implements the Image Resizing Kernel.

This kernel resizes an image from the source to the destination dimensions. The supported interpolation types are currently:

- VX_INTERPOLATION_NEAREST_NEIGHBOR
- VX_INTERPOLATION_AREA
- VX_INTERPOLATION_BILINEAR

The sample positions used to determine output pixel values are generated by scaling the outside edges of the source image pixels to the outside edges of the destination image pixels. As described in the documentation for vx_interpolation_type_e, samples are taken at pixel centers. This means that, unless the scale is 1:1, the sample position for the top left destination pixel typically does not fall exactly on the top left source pixel but will be generated by interpolation.

That is, the sample positions corresponding in source and destination are defined by the following equations:

$$x_{input} = ((x_{output} + 0.5) \times (width_{input} / width_{output})) - 0.5$$

$$y_{input} = ((y_{output} + 0.5) \times (height_{input} / height_{output})) - 0.5$$

$$x_{output} = ((x_{input} + 0.5) \times (width_{output} / width_{input})) - 0.5$$

$$y_{output} = ((y_{input} + 0.5) \times (height_{output} / height_{input})) - 0.5$$

- For `VX_INTERPOLATION_NEAREST_NEIGHBOR`, the output value is that of the pixel whose centre is closest to the sample point.
- For `VX_INTERPOLATION_BILINEAR`, the output value is formed by a weighted average of the nearest source pixels to the sample point. That is:

  x_{lower} = floor(x_{input})

  y_{lower} = floor(y_{input})

  s = x_{input} - x_{lower}

  t = y_{input} - y_{lower}

  output(x_{input},y_{input}) = (1-s)(1-t) × input(x_{lower},y_{lower}) + s(1-t) × input(x_{lower}+1,y_{lower}) + (1-s)t × input(x_{lower},y_{lower}+1) + s × t × input(x_{lower}+1,y_{lower}+1)

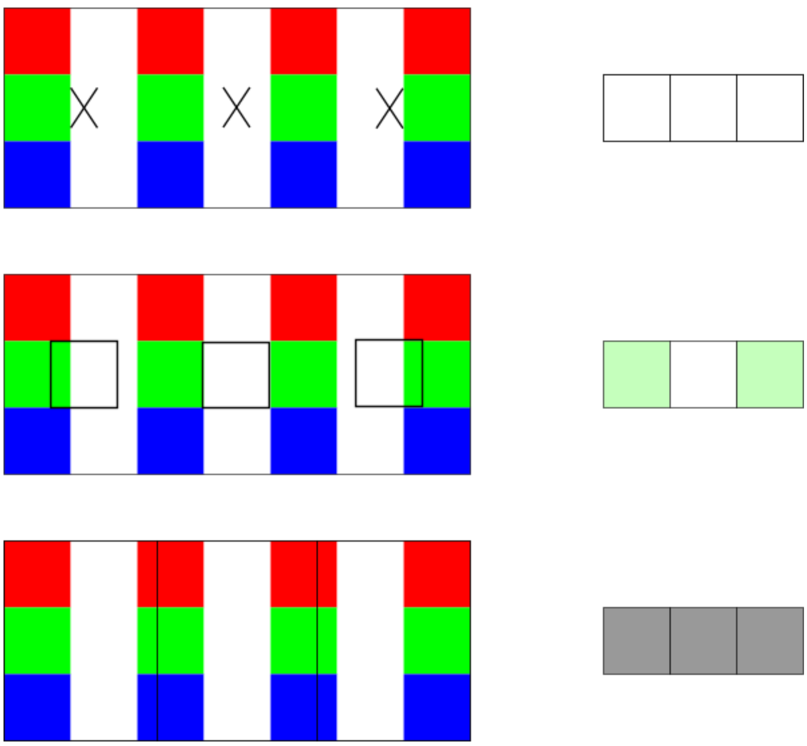
- For `VX_INTERPOLATION_AREA`, the implementation is expected to generate each output pixel by sampling all the source pixels that are at least partly covered by the area bounded by:

$$\left(x_{output} \times \frac{width_{input}}{width_{output}}\right) - 0.5, \left(y_{output} \times \frac{height_{input}}{height_{output}}\right) - 0.5$$

and

$$\left((x_{output} + 1) \times \frac{width_{input}}{width_{output}}\right) - 0.5, \left((y_{output} + 1) \times \frac{height_{input}}{height_{output}}\right) - 0.5$$

The details of this sampling method are implementation-defined. The implementation should perform enough sampling to avoid aliasing, but there is no requirement that the sample areas for adjacent output pixels be disjoint, nor that the pixels be weighted evenly.



The above diagram shows three sampling methods used to shrink a 7x3 image to 3x1.

The topmost image pair shows nearest-neighbor sampling, with crosses on the left image marking the sample positions in the source that are used to generate the output image on the right. As the pixel centre closest to the sample position is white in all cases, the resulting 3x1 image is white.

The middle image pair shows bilinear sampling, with black squares on the left image showing the region in the source being sampled to generate each pixel on the destination image on the right. This sample area is always the size of an input pixel. The outer destination pixels partly sample from the outermost green pixels, so their resulting value is a weighted average of white and green.

The bottom image pair shows area sampling. The black rectangles in the source image on the left show the bounds of the projection of the destination pixels onto the source. The destination pixels on the right are formed by averaging at least those source pixels whose areas are wholly or partly contained within those rectangles. The manner of this averaging is implementation-defined; the example shown here weights the contribution of each source pixel by the amount of that pixel's area contained within the black rectangle.

Functions

- `vxHalfScaleGaussianNode`
- `vxScaleImageNode`
- `vxuHalfScaleGaussian`
- `vxuScaleImage`

3.48.1. Functions

vxHalfScaleGaussianNode

[Graph] Performs a Gaussian Blur on an image then half-scales it. The interpolation mode used is nearest-neighbor.

```
vx_node vxHalfScaleGaussianNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output,
    vx_int32                                    kernel_size);
```

The output image size is determined by:

$$W_{output} = (W_{input} + 1) / 2$$

$$H_{output} = (H_{input} + 1) / 2$$

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.

* [out] *output* - The output VX_DF_IMAGE_U8 image.
* [in] *kernel_size* - The input size of the Gaussian filter. Supported values are 1, 3 and 5.

Returns: vx_node.

Return Values

* vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxScaleImageNode

[Graph] Creates a Scale Image Node.

```
vx_node vxScaleImageNode(
    vx_graph                                      graph,
    vx_image                                      src,
    vx_image                                      dst,
    vx_enum                                       type);
```

Parameters

* [in] *graph* - The reference to the graph.
* [in] *src* - The source image of type VX_DF_IMAGE_U8.
* [out] *dst* - The destination image of type VX_DF_IMAGE_U8.
* [in] *type* - The interpolation type to use.

See also: vx_interpolation_type_e.

> *Note*
>
> The destination image must have a defined size and format. The border modes VX_NODE_BORDER value VX_BORDER_UNDEFINED, VX_BORDER_REPLICATE and VX_BORDER_CONSTANT are supported.

Returns: vx_node.

Return Values

* vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuHalfScaleGaussian

[Immediate] Performs a Gaussian Blur on an image then half-scales it. The interpolation mode used is nearest-neighbor.

```
vx_status vxuHalfScaleGaussian(
    vx_context                                          context,
    vx_image                                            input,
    vx_image                                            output,
    vx_int32                                            kernel_size);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [out] *output* - The output VX_DF_IMAGE_U8 image.
- [in] *kernel_size* - The input size of the Gaussian filter. Supported values are 1, 3 and 5.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

vxuScaleImage

[Immediate] Scales an input image to an output image.

```
vx_status vxuScaleImage(
    vx_context                                          context,
    vx_image                                            src,
    vx_image                                            dst,
    vx_enum                                             type);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *src* - The source image of type VX_DF_IMAGE_U8.
- [out] *dst* - The destintation image of type VX_DF_IMAGE_U8.
- [in] *type* - The interpolation type.

See also: vx_interpolation_type_e.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.49. Sobel 3x3

Implements the Sobel Image Filter Kernel. The output images dimensions should be the same as the dimensions of the input image.

This kernel produces two output planes (one can be omitted) in the x and y plane. The Sobel Operators G_x, G_y are defined as:

$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix}, \mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix}$$

Functions

- `vxSobel3x3Node`
- `vxuSobel3x3`

3.49.1. Functions

vxSobel3x3Node

[Graph] Creates a Sobel3x3 node.

```
vx_node vxSobel3x3Node(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_image                                    output_x,
    vx_image                                    output_y);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` format.
- `[out]` *output_x* - [optional] The output gradient in the x direction in `VX_DF_IMAGE_S16`. Must have the same dimensions as the input image.
- `[out]` *output_y* - [optional] The output gradient in the y direction in `VX_DF_IMAGE_S16`. Must have the same dimensions as the input image.

See also: `VX_KERNEL_SOBEL_3x3`

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuSobel3x3

[Immediate] Invokes an immediate Sobel 3x3.

```
vx_status vxuSobel3x3(
    vx_context                                  context,
    vx_image                                    input,
    vx_image                                    output_x,
    vx_image                                    output_y);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input image in `VX_DF_IMAGE_U8` format.
- `[out]` *output_x* - [optional] The output gradient in the x direction in `VX_DF_IMAGE_S16`.
- `[out]` *output_y* - [optional] The output gradient in the y direction in `VX_DF_IMAGE_S16`.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.50. TableLookup

Implements the Table Lookup Image Kernel. The output image dimensions should be the same as the dimensions of the input image.

This kernel uses each pixel in an image to index into a LUT and put the indexed LUT value into the output image. The formats supported are `VX_DF_IMAGE_U8` and `VX_DF_IMAGE_S16`.

Functions

- `vxTableLookupNode`
- `vxuTableLookup`

3.50.1. Functions

vxTableLookupNode

[Graph] Creates a Table Lookup node. If a value from the input image is not present in the lookup table, the result is undefined.

```
vx_node vxTableLookupNode(
    vx_graph                                      graph,
    vx_image                                      input,
    vx_lut                                        lut,
    vx_image                                      output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *lut* - The LUT which is of type VX_TYPE_UINT8 if input image is VX_DF_IMAGE_U8 or VX_TYPE_INT16 if input image is VX_DF_IMAGE_S16.
- [out] *output* - The output image of the same type and size as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxuTableLookup

[Immediate] Processes the image through the LUT.

```
vx_status vxuTableLookup(
    vx_context                                    context,
    vx_image                                      input,
    vx_lut                                        lut,
    vx_image                                      output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image in VX_DF_IMAGE_U8 or VX_DF_IMAGE_S16.
- [in] *lut* - The LUT which is of type VX_TYPE_UINT8 if input image is VX_DF_IMAGE_U8 or VX_TYPE_INT16 if input image is VX_DF_IMAGE_S16.
- [out] *output* - The output image of the same type as the input image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.51. Tensor Add

Performs arithmetic addition on element values in the input tensor data.

Functions

- vxTensorAddNode
- vxuTensorAdd

3.51.1. Functions

vxTensorAddNode

[Graph] Performs arithmetic addition on element values in the input tensor data.

```
vx_node vxTensorAddNode(
    vx_graph                                    graph,
    vx_tensor                                   input1,
    vx_tensor                                   input2,
    vx_enum                                     policy,
    vx_tensor                                   output);
```

Parameters

- `[in]` *graph* - The handle to the graph.
- `[in]` *input1* - Input tensor data. Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8` and `VX_TYPE_INT8`, with fixed_point_position 0.
- `[in]` *input2* - Input tensor data. The dimensions and sizes of *input2* match those of *input1*, unless the `vx_tensor` of one or more dimensions in *input2* is 1. In this case, those dimensions are treated as if this tensor was expanded to match the size of the corresponding dimension of *input1*, and data was duplicated on all terms in that dimension. After this expansion, the dimensions will be equal. The data type must match the data type of *input1*.
- `[in]` *policy* - A `vx_convert_policy_e` enumeration.
- `[out]` *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: `vx_node`.

Returns: A node reference `vx_node`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxuTensorAdd

[Immediate] Performs arithmetic addition on element values in the input tensor data.

```
vx_status vxuTensorAdd(
    vx_context                                  context,
    vx_tensor                                   input1,
    vx_tensor                                   input2,
    vx_enum                                     policy,
    vx_tensor                                   output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input1* - Input tensor data. Implementations must support input tensor data type VX_TYPE_INT16 with fixed_point_position 8, and tensor data types VX_TYPE_UINT8 and VX_TYPE_INT8, with fixed_point_position 0.
- [in] *input2* - Input tensor data. The dimensions and sizes of *input2* match those of *input1*, unless the vx_tensor of one or more dimensions in *input2* is 1. In this case, those dimensions are treated as if this tensor was expanded to match the size of the corresponding dimension of *input1*, and data was duplicated on all terms in that dimension. After this expansion, the dimensions will be equal. The data type must match the data type of *input1*.
- [in] *policy* - A vx_convert_policy_e enumeration.
- [out] *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.52. Tensor Convert Bit-Depth

Creates a bit-depth conversion node.

Convert tensor from a specific data type and fixed point position to another data type and fixed point position. The equation for the conversion is as follows:

$$output = \frac{\left(\frac{input}{2^{input\_fixed\_point\_position}} - offset\right)}{norm} \times 2^{output\_fixed\_point\_position}$$

Where offset and norm are the input parameters in vx_float32. input_fixed_point_position and output_fixed_point_position are the fixed point positions of the input and output respectivly. Is case input or output tensors are of VX_TYPE_FLOAT32 fixed point position 0 is used.

Functions

- vxTensorConvertDepthNode
- vxuTensorConvertDepth

3.52.1. Functions

vxTensorConvertDepthNode

[Graph] Creates a bit-depth conversion node.

```
vx_node vxTensorConvertDepthNode(
    vx_graph                                    graph,
    vx_tensor                                   input,
    vx_enum                                     policy,
    vx_scalar                                   norm,
    vx_scalar                                   offset,
    vx_tensor                                   output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input tensor. Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8` and `VX_TYPE_INT8`, with fixed_point_position 0.
- `[in]` *policy* - A `VX_TYPE_ENUM` of the `vx_convert_policy_e` enumeration.
- `[in]` *norm* - A scalar containing a `VX_TYPE_FLOAT32` of the normalization value.
- `[in]` *offset* - A scalar containing a `VX_TYPE_FLOAT32` of the offset value subtracted before normalization.
- `[out]` *output* - The output tensor. Implementations must support input tensor data type `VX_TYPE_INT16`. with fixed_point_position 8. And `VX_TYPE_UINT8` with fixed_point_position 0.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuTensorConvertDepth

[Immediate] Performs a bit-depth conversion.

```
vx_status vxuTensorConvertDepth(
    vx_context                                  context,
    vx_tensor                                   input,
    vx_enum                                     policy,
    vx_scalar                                   norm,
    vx_scalar                                   offset,
    vx_tensor                                   output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input tensor. Implementations must support input tensor data type VX_TYPE_INT16 with fixed_point_position 8, and tensor data types VX_TYPE_UINT8 and VX_TYPE_INT8, with fixed_point_position 0.
- [in] *policy* - A VX_TYPE_ENUM of the vx_convert_policy_e enumeration.
- [in] *norm* - A scalar containing a VX_TYPE_FLOAT32 of the normalization value.
- [in] *offset* - A scalar containing a VX_TYPE_FLOAT32 of the offset value subtracted before normalization.
- [out] *output* - The output tensor. Implementations must support input tensor data type VX_TYPE_INT16. with fixed_point_position 8. And VX_TYPE_UINT8 with fixed_point_position 0.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.53. Tensor Matrix Multiply

Creates a generalized matrix multiplication node.

Performs:

output = T1(input1) T2(input2)) + T3(input3)

Where matrix multiplication is defined as:

$$C[i*L+j] = saturate(truncate(round(\sum_{k=1}^{M}(C[i*L+j]+((int)A[i*M+k])*((int)B[k*L+j])))))$$

where i,j are indexes from 1 to N,L respectively. C matrix is of size NxL. A matrix is of size NxM and B matrix is of size MxL. For signed integers, a fixed point calculation is performed with round, truncate and saturate according to the number of accumulator bits. round: rounding to nearest on the fractional part. truncate: at every multiplication result of 32bit is truncated after rounding. saturate: a saturation if performed on the accumulation and after the truncation, meaning no saturation is performed on the multiplication result.

Data Structures

- vx_tensor_matrix_multiply_params_t

Functions

- vxTensorMatrixMultiplyNode
- vxuTensorMatrixMultiply

3.53.1. Data Structures

vxuTensorMatrixMultiply

Matrix Multiply Parameters.

```
typedef struct _vx_tensor_matrix_multiply_params_t {
    vx_bool     transpose_input1;
    vx_bool     transpose_input2;
    vx_bool     transpose_input3;
} vx_tensor_matrix_multiply_params_t;
```

- *transpose_input1*, *transpose_input2*, *transpose_input3* - if True, the corresponding matrix is transposed before the operation, otherwise the matrix is used as is.

3.53.2. Functions

vxTensorMatrixMultiplyNode

[Graph] Creates a generalized matrix multiplication node.

```
vx_node vxTensorMatrixMultiplyNode(
    vx_graph                                    graph,
    vx_tensor                                   input1,
    vx_tensor                                   input2,
    vx_tensor                                   input3,
    const vx_tensor_matrix_multiply_params_t*   matrix_multiply_params,
    vx_tensor                                   output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input1* - The first input 2D tensor of type `VX_TYPE_INT16` with fixed_point_pos 8, or tensor data types `VX_TYPE_UINT8` or `VX_TYPE_INT8`, with fixed_point_pos 0.
- `[in]` *input2* - The second 2D tensor. Must be in the same data type as *input1*.
- `[in]` *input3* - The third 2D tensor. Must be in the same data type as *input1*. [optional].
- `[in]` *matrix_multiply_params* - Matrix multiply parameters, see `vx_tensor_matrix_multiply_params_t`.
- `[out]` *output* - The output 2D tensor. Must be in the same data type as *input1*. Output dimension must agree the formula in the description.

Returns: `vx_node`.

Returns: A node reference `vx_node`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxuTensorMatrixMultiply

[Immediate] Performs a generalized matrix multiplication.

```
vx_status vxuTensorMatrixMultiply(
    vx_context                              context,
    vx_tensor                               input1,
    vx_tensor                               input2,
    vx_tensor                               input3,
    const vx_tensor_matrix_multiply_params_t*   matrix_multiply_params,
    vx_tensor                               output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input1* - The first input 2D tensor of type `VX_TYPE_INT16` with fixed_point_pos 8, or tensor data types `VX_TYPE_UINT8` or `VX_TYPE_INT8`, with fixed_point_pos 0.
- `[in]` *input2* - The second 2D tensor. Must be in the same data type as *input1*.
- `[in]` *input3* - The third 2D tensor. Must be in the same data type as *input1*. [optional].
- `[in]` *matrix_multiply_params* - Matrix multiply parameters, see `vx_tensor_matrix_multiply_params_t`.
- `[out]` *output* - The output 2D tensor. Must be in the same data type as *input1*. Output dimension must agree the formula in the description.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.54. Tensor Multiply

Performs element wise multiplications on element values in the input tensor data with a scale.

Pixel-wise multiplication is performed between the pixel values in two tensors and a scalar floating-point number *scale*. The scale with a value of $1 / 2^n$, where n is an integer and $0 \le n \le 15$, and 1/255 (0x1.010102p-8 C99 float hex) must be supported. The support for other values of scale is not prohibited. Furthermore, for scale with a value of 1/255 the rounding policy of `VX_ROUND_POLICY_TO_NEAREST_EVEN` must be supported whereas for the scale with value of $1 / 2^n$ the rounding policy of `VX_ROUND_POLICY_TO_ZERO` must be supported. The support of other rounding modes for any values of scale is not prohibited.

Functions

- `vxTensorMultiplyNode`
  `vxuTensorMultiply`

3.54.1. Functions

vxTensorMultiplyNode

[Graph] Performs element wise multiplications on element values in the input tensor data with a scale.

```
vx_node vxTensorMultiplyNode(
    vx_graph                                            graph,
    vx_tensor                                           input1,
    vx_tensor                                           input2,
    vx_scalar                                           scale,
    vx_enum                                             overflow_policy,
    vx_enum                                             rounding_policy,
    vx_tensor                                           output);
```

Parameters

- `[in]` *graph* - The handle to the graph.
- `[in]` *input1* - Input tensor data. Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8` and `VX_TYPE_INT8`, with fixed_point_position 0.
- `[in]` *input2* - Input tensor data. The dimensions and sizes of *input2* match those of *input1*, unless the `vx_tensor` of one or more dimensions in *input2* is 1. In this case, those dimensions are treated as if this tensor was expanded to match the size of the corresponding dimension of *input1*, and data was duplicated on all terms in that dimension. After this expansion, the dimensions will be equal. The data type must match the data type of *input1*.
- `[in]` *scale* - A non-negative `VX_TYPE_FLOAT32` multiplied to each product before overflow handling.
- `[in]` *overflow_policy* - A `vx_convert_policy_e` enumeration.
- `[in]` *rounding_policy* - A `vx_round_policy_e` enumeration.
- `[out]` *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: `vx_node`.

Returns: A node reference `vx_node`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxuTensorMultiply

[Immediate] Performs element wise multiplications on element values in the input tensor data with a scale.

```
vx_status vxuTensorMultiply(
    vx_context                                  context,
    vx_tensor                                   input1,
    vx_tensor                                   input2,
    vx_scalar                                   scale,
    vx_enum                                     overflow_policy,
    vx_enum                                     rounding_policy,
    vx_tensor                                   output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input1* - Input tensor data. Implementations must support input tensor data type VX_TYPE_INT16 with fixed_point_position 8, and tensor data types VX_TYPE_UINT8 and VX_TYPE_INT8, with fixed_point_position 0.
- [in] *input2* - Input tensor data. The dimensions and sizes of *input2* match those of *input1*, unless the vx_tensor of one or more dimensions in *input2* is 1. In this case, those dimensions are treated as if this tensor was expanded to match the size of the corresponding dimension of *input1*, and data was duplicated on all terms in that dimension. After this expansion, the dimensions will be equal. The data type must match the data type of *input1*.
- [in] *scale* - A non-negative VX_TYPE_FLOAT32 multiplied to each product before overflow handling.
- [in] *overflow_policy* - A vx_convert_policy_e enumeration.
- [in] *rounding_policy* - A vx_round_policy_e enumeration.
- [out] *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.55. Tensor Subtract

Performs arithmetic subtraction on element values in the input tensor data.

Functions

- vxTensorSubtractNode
- vxuTensorSubtract

3.55.1. Functions

vxTensorSubtractNode

[Graph] Performs arithmetic subtraction on element values in the input tensor data.

```
vx_node vxTensorSubtractNode(
    vx_graph                                      graph,
    vx_tensor                                     input1,
    vx_tensor                                     input2,
    vx_enum                                       policy,
    vx_tensor                                     output);
```

Parameters

- `[in]` *graph* - The handle to the graph.
- `[in]` *input1* - Input tensor data. Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8` and `VX_TYPE_INT8`, with fixed_point_position 0.
- `[in]` *input2* - Input tensor data. The dimensions and sizes of *input2* match those of *input1*, unless the `vx_tensor` of one or more dimensions in *input2* is 1. In this case, those dimensions are treated as if this tensor was expanded to match the size of the corresponding dimension of *input1*, and data was duplicated on all terms in that dimension. After this expansion, the dimensions will be equal. The data type must match the data type of *input1*.
- `[in]` *policy* - A `vx_convert_policy_e` enumeration.
- `[out]` *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: `vx_node`.

Returns: A node reference `vx_node`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxuTensorSubtract

[Immediate] Performs arithmetic subtraction on element values in the input tensor data.

```
vx_status vxuTensorSubtract(
    vx_context                                    context,
    vx_tensor                                     input1,
    vx_tensor                                     input2,
    vx_enum                                       policy,
    vx_tensor                                     output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input1* - Input tensor data. Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8` and `VX_TYPE_INT8`,

with fixed_point_position 0.

- [in] *input2* - Input tensor data. The dimensions and sizes of *input2* match those of *input1*, unless the vx_tensor of one or more dimensions in *input2* is 1. In this case, those dimensions are treated as if this tensor was expanded to match the size of the corresponding dimension of *input1*, and data was duplicated on all terms in that dimension. After this expansion, the dimensions will be equal. The data type must match the data type of *input1*.
- [in] *policy* - A vx_convert_policy_e enumeration.
- [out] *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.56. Tensor TableLookUp

Performs LUT on element values in the input tensor data.

This kernel uses each element in a tensor to index into a LUT and put the indexed LUT value into the output tensor. The tensor types supported are VX_TYPE_UINT8 and VX_TYPE_INT16. Signed inputs are cast to unsigned before used as input indexes to the LUT.

Functions

- vxTensorTableLookupNode
- vxuTensorTableLookup

3.56.1. Functions

vxTensorTableLookupNode

[Graph] Performs LUT on element values in the input tensor data.

```
vx_node vxTensorTableLookupNode(
    vx_graph                                    graph,
    vx_tensor                                   input1,
    vx_lut                                      lut,
    vx_tensor                                   output);
```

Parameters

- [in] *graph* - The handle to the graph.
- [in] *input1* - Input tensor data. Implementations must support input tensor data type VX_TYPE_INT16 with fixed_point_position 8, and tensor data types VX_TYPE_UINT8, with fixed_point_position 0.

- `[in]` *lut* - The look-up table to use, of type `vx_lut`. The elements of *input1* are treated as unsigned integers to determine an index into the look-up table. The data type of the items in the look-up table must match that of the output tensor.
- `[out]` *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: `vx_node`.

Returns: A node reference `vx_node`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxuTensorTableLookup

[Immediate] Performs LUT on element values in the input tensor data.

```
vx_status vxuTensorTableLookup(
    vx_context                                  context,
    vx_tensor                                   input1,
    vx_lut                                      lut,
    vx_tensor                                   output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input1* - Input tensor data. Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8`, with fixed_point_position 0.
- `[in]` *lut* - The look-up table to use, of type `vx_lut`. The elements of *input1* are treated as unsigned integers to determine an index into the look-up table. The data type of the items in the look-up table must match that of the output tensor.
- `[out]` *output* - The output tensor data with the same dimensions as the input tensor data.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

3.57. Tensor Transpose

Performs transpose on the input tensor.

Functions

- `vxTensorTransposeNode`
- `vxuTensorTranspose`

3.57.1. Functions

vxTensorTransposeNode

[Graph] Performs transpose on the input tensor. The node transpose the tensor according to a specified 2 indexes in the tensor (0-based indexing)

```
vx_node vxTensorTransposeNode(
    vx_graph                                        graph,
    vx_tensor                                       input,
    vx_tensor                                       output,
    vx_size                                         dimension1,
    vx_size                                         dimension2);
```

Parameters

- `[in]` *graph* - The handle to the graph.
- `[in]` *input* - Input tensor data, Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8` and `VX_TYPE_INT8`, with fixed_point_position 0.
- `[out]` *output* - output tensor data,
- `[in]` *dimension1* - Dimension index that is transposed with dim 2.
- `[in]` *dimension2* - Dimension index that is transposed with dim 1.

Returns: `vx_node`.

Returns: A node reference `vx_node`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxuTensorTranspose

[Immediate] Performs transpose on the input tensor. The tensor is transposed according to a specified 2 indexes in the tensor (0-based indexing)

```
vx_status vxuTensorTranspose(
    vx_context                                      context,
    vx_tensor                                       input,
    vx_tensor                                       output,
    vx_size                                         dimension1,
    vx_size                                         dimension2);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - Input tensor data, Implementations must support input tensor data type `VX_TYPE_INT16` with fixed_point_position 8, and tensor data types `VX_TYPE_UINT8` and `VX_TYPE_INT8`,

with fixed_point_position 0.

- [out] *output* - output tensor data,
- [in] *dimension1* - Dimension index that is transposed with dim 2.
- [in] *dimension2* - Dimension index that is transposed with dim 1.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.58. Thresholding

Thresholds an input image and produces an output Boolean image. The output image dimensions should be the same as the dimensions of the input image.

In VX_THRESHOLD_TYPE_BINARY, the output is determined by:

$$dst(x, y) = \begin{cases} true\,value & \text{if } src(x, y) > threshold \\ false\,value & \text{otherwise} \end{cases}$$

In VX_THRESHOLD_TYPE_RANGE, the output is determined by:

$$dst(x, y) = \begin{cases} false\,value & \text{if } src(x, y) > upper \\ false\,value & \text{if } src(x, y) < lower \\ true\,value & \text{otherwise} \end{cases}$$

Where 'false value' and 'true value' are defined by the of the *thresh* parameter dependent upon the threshold output format with default values as discussed in the description of vxCreateThresholdForImage or as set by a call to vxCopyThresholdOutput with the *thresh* parameter as the first argument.

Functions

- vxThresholdNode
- vxuThreshold

3.58.1. Functions

vxThresholdNode

[Graph] Creates a Threshold node and returns a reference to it.

```
vx_node vxThresholdNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_threshold                                thresh,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph in which the node is created.
- [in] *input* - The input image. Only images with format VX_DF_IMAGE_U8 and VX_DF_IMAGE_S16 are supported.
- [in] *thresh* - The thresholding object that defines the parameters of the operation. The VX_THRESHOLD_INPUT_FORMAT must be the same as the input image format and the VX_THRESHOLD_OUTPUT_FORMAT must be the same as the output image format.
- [out] *output* - The output image, that will contain as pixel value true and false values defined by *thresh*. Only images with format VX_DF_IMAGE_U8 are supported. The dimensions are the same as the input image.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuThreshold

[Immediate] Threshold's an input image and produces a VX_DF_IMAGE_U8 boolean image.

```
vx_status vxuThreshold(
    vx_context                                  context,
    vx_image                                    input,
    vx_threshold                                thresh,
    vx_image                                    output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input image. Only images with format VX_DF_IMAGE_U8 and VX_DF_IMAGE_S16 are supported.
- [in] *thresh* - The thresholding object that defines the parameters of the operation. The VX_THRESHOLD_INPUT_FORMAT must be the same as the input image format and the VX_THRESHOLD_OUTPUT_FORMAT must be the same as the output image format.
- [out] *output* - The output image, that will contain as pixel value true and false values defined by *thresh*. Only images with format VX_DF_IMAGE_U8 are supported.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.59. Warp Affine

Performs an affine transform on an image.

This kernel performs an affine transform with a 2x3 Matrix M with this method of pixel coordinate translation:

$$\begin{aligned} x0 &= M_{1,1} * x + M_{1,2} * y + M_{1,3} \\ y0 &= M_{2,1} * x + M_{2,2} * y + M_{2,3} \\ output(x, y) &= input(x0, y0) \end{aligned}$$

This translates into the C declaration:

```
// x0 = a x + b y + c;
// y0 = d x + e y + f;
vx_float32 mat[3][2] = {
    {a, d}, // 'x' coefficients
    {b, e}, // 'y' coefficients
    {c, f}, // 'offsets'
};
vx_matrix matrix = vxCreateMatrix(context, VX_TYPE_FLOAT32, 2, 3);
vxCopyMatrix(matrix, mat, VX_WRITE_ONLY, VX_MEMORY_TYPE_HOST);
```

Functions

- vxWarpAffineNode
- vxuWarpAffine

3.59.1. Functions

vxWarpAffineNode

[Graph] Creates an Affine Warp Node.

```
vx_node vxWarpAffineNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_matrix                                   matrix,
    vx_enum                                     type,
    vx_image                                    output);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *matrix* - The affine matrix. Must be 2x3 of type VX_TYPE_FLOAT32.
- [in] *type* - The interpolation type from vx_interpolation_type_e. VX_INTERPOLATION_AREA is not

supported.

- [out] *output* - The output VX_DF_IMAGE_U8 image and the same dimensions as the input image.

> *Note*
>
> The border modes VX_NODE_BORDER value VX_BORDER_UNDEFINED and VX_BORDER_CONSTANT are supported.

Returns: vx_node.

Return Values

- vx_node - A node reference. Any possible errors preventing a successful creation should be checked using vxGetStatus

vxuWarpAffine

[Immediate] Performs an Affine warp on an image.

```
vx_status vxuWarpAffine(
    vx_context                                   context,
    vx_image                                     input,
    vx_matrix                                    matrix,
    vx_enum                                      type,
    vx_image                                     output);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *input* - The input VX_DF_IMAGE_U8 image.
- [in] *matrix* - The affine matrix. Must be 2x3 of type VX_TYPE_FLOAT32.
- [in] *type* - The interpolation type from vx_interpolation_type_e. VX_INTERPOLATION_AREA is not supported.
- [out] *output* - The output VX_DF_IMAGE_U8 image.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Success
- * - An error occurred. See vx_status_e.

3.60. Warp Perspective

Performs a perspective transform on an image.

This kernel performs an perspective transform with a 3x3 Matrix M with this method of pixel coordinate translation:

$$
\begin{aligned}
x0 &= M_{1,1}x + M_{1,2}y + M_{1,3} \\
y0 &= M_{2,1}x + M_{2,2}y + M_{2,3} \\
z0 &= M_{3,1}x + M_{3,2}y + M_{3,3} \\
output(x, y) &= input(\frac{x0}{z0}, \frac{y0}{z0})
\end{aligned}
$$

This translates into the C declaration:

```
// x0 = a x + b y + c;
// y0 = d x + e y + f;
// z0 = g x + h y + i;
vx_float32 mat[3][3] = {
    {a, d, g}, // 'x' coefficients
    {b, e, h}, // 'y' coefficients
    {c, f, i}, // 'offsets'
};
vx_matrix matrix = vxCreateMatrix(context, VX_TYPE_FLOAT32, 3, 3);
vxCopyMatrix(matrix, mat, VX_WRITE_ONLY, VX_MEMORY_TYPE_HOST);
```

Functions

- `vxWarpPerspectiveNode`
- `vxuWarpPerspective`

3.60.1. Functions

vxWarpPerspectiveNode

[Graph] Creates a Perspective Warp Node.

```
vx_node vxWarpPerspectiveNode(
    vx_graph                                    graph,
    vx_image                                    input,
    vx_matrix                                   matrix,
    vx_enum                                     type,
    vx_image                                    output);
```

Parameters

- `[in]` *graph* - The reference to the graph.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[in]` *matrix* - The perspective matrix. Must be 3x3 of type `VX_TYPE_FLOAT32`.
- `[in]` *type* - The interpolation type from `vx_interpolation_type_e`. `VX_INTERPOLATION_AREA` is not supported.
- `[out]` *output* - The output `VX_DF_IMAGE_U8` image with the same dimensions as the input image.

Note

The border modes `VX_NODE_BORDER` value `VX_BORDER_UNDEFINED` and `VX_BORDER_CONSTANT` are supported.

Returns: `vx_node`.

Return Values

- `vx_node` - A node reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`

vxuWarpPerspective

[Immediate] Performs an Perspective warp on an image.

```
vx_status vxuWarpPerspective(
    vx_context                                  context,
    vx_image                                    input,
    vx_matrix                                   matrix,
    vx_enum                                     type,
    vx_image                                    output);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *input* - The input `VX_DF_IMAGE_U8` image.
- `[in]` *matrix* - The perspective matrix. Must be 3x3 of type `VX_TYPE_FLOAT32`.
- `[in]` *type* - The interpolation type from `vx_interpolation_type_e`. `VX_INTERPOLATION_AREA` is not supported.
- `[out]` *output* - The output `VX_DF_IMAGE_U8` image.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Success
- * - An error occurred. See `vx_status_e`.

Chapter 4. Basic Features

The basic parts of OpenVX needed for computation.

Types in OpenVX intended to be derived from the C99 Section 7.18 standard definition of fixed width types.

Modules

- Objects

Data Structures

- `vx_coordinates2d_t`
- `vx_coordinates2df_t`
- `vx_coordinates3d_t`
- `vx_keypoint_t`
- `vx_line2d_t`
- `vx_rectangle_t`

Macros

- `VX_ATTRIBUTE_BASE`
- `VX_ATTRIBUTE_ID_MASK`
- `VX_DF_IMAGE`
- `VX_ENUM_BASE`
- `VX_ENUM_MASK`
- `VX_ENUM_TYPE`
- `VX_ENUM_TYPE_MASK`
- `VX_FMT_REF`
- `VX_FMT_SIZE`
- `VX_KERNEL_BASE`
- `VX_KERNEL_MASK`
- `VX_LIBRARY`
- `VX_LIBRARY_MASK`
- `VX_MAX_LOG_MESSAGE_LEN`
- `VX_SCALE_UNITY`
- `VX_TYPE`
- `VX_TYPE_MASK`
- `VX_VENDOR`
- `VX_VENDOR_MASK`
- `VX_VERSION`
- `VX_VERSION_1_0`
- `VX_VERSION_1_1`
- `VX_VERSION_1_2`

- VX_VERSION_MAJOR
- VX_VERSION_MINOR

Typedefs

- vx_bool
- vx_char
- vx_df_image
- vx_enum
- vx_float32
- vx_float64
- vx_int16
- vx_int32
- vx_int64
- vx_int8
- vx_size
- vx_status
- vx_uint16
- vx_uint32
- vx_uint64
- vx_uint8

Enumerations

- vx_bool_e
- vx_channel_e
- vx_convert_policy_e
- vx_df_image_e
- vx_enum_e
- vx_interpolation_type_e
- vx_non_linear_filter_e
- vx_pattern_e
- vx_status_e
- vx_target_e
- vx_type_e
- vx_vendor_id_e

Functions

- vxGetStatus

4.1. Data Structures

4.1.1. vx_coordinates2d_t

The 2D Coordinates structure.

```
typedef struct _vx_coordinates2d_t {
    vx_uint32    x;
    vx_uint32    y;
} vx_coordinates2d_t;
```

- x - the X coordinate.
- y - the Y coordinate.

4.1.2. vx_coordinates2df_t

The floating-point 2D Coordinates structure.

```
typedef struct _vx_coordinates2df_t {
    vx_float32    x;
    vx_float32    y;
} vx_coordinates2df_t;
```

- x - the X coordinate.
- y - the Y coordinate.

4.1.3. vx_coordinates3d_t

The 3D Coordinates structure.

```
typedef struct _vx_coordinates3d_t {
    vx_uint32    x;
    vx_uint32    y;
    vx_uint32    z;
} vx_coordinates3d_t;
```

- x - the X coordinate.
- y - the Y coordinate.
- z - the Z coordinate

4.1.4. vx_keypoint_t

The keypoint data structure.

```
typedef struct _vx_keypoint_t {
    vx_int32      x;
    vx_int32      y;
    vx_float32    strength;
    vx_float32    scale;
    vx_float32    orientation;
    vx_int32      tracking_status;
    vx_float32    error;
} vx_keypoint_t;
```

- x - The x coordinate.
- y - The y coordinate.
- strength - The strength of the keypoint. Its definition is specific to the corner detector.
- scale - Initialized to 0 by corner detectors.
- orientation - Initialized to 0 by corner detectors.
- tracking_status - A zero indicates a lost point. Initialized to 1 by corner detectors.
- error - A tracking method specific error. Initialized to 0 by corner detectors.

4.1.5. vx_line2d_t

line struct

```
typedef struct _vx_line2d_t {
    vx_float32    start_x;
    vx_float32    start_y;
    vx_float32    end_x;
    vx_float32    end_y;
} vx_line2d_t;
```

- start_x - x index of line start
- start_y - y index of line start
- end_x - x index of line end
- end_y - y index of line end

4.1.6. vx_rectangle_t

The rectangle data structure that is shared with the users. The area of the rectangle can be computed as (*end_x* - *start_x*) * (*end_y* - *start_y*).

```
typedef struct _vx_rectangle_t {
    vx_uint32    start_x;
    vx_uint32    start_y;
    vx_uint32    end_x;
    vx_uint32    end_y;
} vx_rectangle_t;
```

- start_x - The Start X coordinate.
- start_y - The Start Y coordinate.
- end_x - The End X coordinate.
- end_y - The End Y coordinate.

4.2. Macros

4.2.1. VX_ATTRIBUTE_BASE

Defines the manner in which to combine the Vendor and Object IDs to get the base value of the enumeration.

```
#define VX_ATTRIBUTE_BASE(vendor,object) (((vendor) << 20) | (object << 8))
```

4.2.2. VX_ATTRIBUTE_ID_MASK

An object's attribute ID is within the range of $[0,2^8 - 1]$ (inclusive).

```
#define VX_ATTRIBUTE_ID_MASK              (0x000000FF)
```

4.2.3. VX_DF_IMAGE

Converts a set of four chars into a `uint32_t` container of a `VX_DF_IMAGE` code.

```
#define VX_DF_IMAGE(a,b,c,d) ((a) | (b << 8) | (c << 16) | (d << 24))
```

> *Note*
>
> Use a `vx_df_image` variable to hold the value.

4.2.4. VX_ENUM_BASE

Defines the manner in which to combine the Vendor and Object IDs to get the base value of the enumeration.

```
#define VX_ENUM_BASE(vendor,id) (((vendor) << 20) | (id << 12))
```

From any enumerated value (with exceptions), the vendor, and enumeration type should be extractable. Those types that are exceptions are `vx_vendor_id_e`, `vx_type_e`, `vx_enum_e`, `vx_df_image_e`, and `vx_bool`.

4.2.5. VX_ENUM_MASK

A generic enumeration list can have values between [0,2^{12} - 1] (inclusive).

```
#define VX_ENUM_MASK                          (0x00000FFF)
```

4.2.6. VX_ENUM_TYPE

A macro to extract the enum type from an enumerated value.

```
#define VX_ENUM_TYPE(e) (((vx_uint32)(e) & VX_ENUM_TYPE_MASK) >> 12)
```

4.2.7. VX_ENUM_TYPE_MASK

A type of enumeration. The valid range is between [0,2^8 - 1] (inclusive).

```
#define VX_ENUM_TYPE_MASK                     (0x000FF000)
```

4.2.8. VX_FMT_REF

Use to aid in debugging values in OpenVX.

```
#if defined(_WIN32) || defined(UNDER_CE)
#if defined(_WIN64)
#define VX_FMT_REF  "%I64u"
#else
#define VX_FMT_REF  "%lu"
#endif
#else
#define VX_FMT_REF  "%p"
#endif
```

4.2.9. VX_FMT_SIZE

Use to aid in debugging values in OpenVX.

```
#if defined(_WIN32) || defined(UNDER_CE)
#if defined(_WIN64)
#define VX_FMT_SIZE "%I64u"
#else
#define VX_FMT_SIZE "%lu"
#endif
#else
#define VX_FMT_SIZE "%zu"
#endif
```

4.2.10. VX_KERNEL_BASE

Defines the manner in which to combine the Vendor and Library IDs to get the base value of the enumeration.

```
#define VX_KERNEL_BASE(vendor,lib) (((vendor) << 20) | (lib << 12))
```

4.2.11. VX_KERNEL_MASK

An individual kernel in a library has its own unique ID within $[0,2^{12} - 1]$ (inclusive).

```
#define VX_KERNEL_MASK                    (0x00000FFF)
```

4.2.12. VX_LIBRARY

A macro to extract the kernel library enumeration from a enumerated kernel value.

```
#define VX_LIBRARY(e) (((vx_uint32)(e) & VX_LIBRARY_MASK) >> 12)
```

4.2.13. VX_LIBRARY_MASK

A library is a set of vision kernels with its own ID supplied by a vendor. The vendor defines the library ID. The range is $[0,2^{8} - 1]$ inclusive.

```
#define VX_LIBRARY_MASK                   (0x000FF000)
```

4.2.14. VX_MAX_LOG_MESSAGE_LEN

Defines the length of a message buffer to copy from the log, including the trailing zero.

```
#define VX_MAX_LOG_MESSAGE_LEN            (1024)
```

4.2.15. VX_SCALE_UNITY

Use to indicate the 1:1 ratio in Q22.10 format.

```
#define VX_SCALE_UNITY                          (1024u)
```

4.2.16. VX_TYPE

A macro to extract the type from an enumerated attribute value.

```
#define VX_TYPE(e) (((vx_uint32)(e) & VX_TYPE_MASK) >> 8)
```

4.2.17. VX_TYPE_MASK

A type mask removes the scalar/object type from the attribute. It is 3 nibbles in size and is contained between the third and second byte.

```
#define VX_TYPE_MASK                            (0x000FFF00)
```

See also: vx_type_e

4.2.18. VX_VENDOR

A macro to extract the vendor ID from the enumerated value.

```
#define VX_VENDOR(e) (((vx_uint32)(e) & VX_VENDOR_MASK) >> 20)
```

4.2.19. VX_VENDOR_MASK

Vendor IDs are 2 nibbles in size and are located in the upper byte of the 4 bytes of an enumeration.

```
#define VX_VENDOR_MASK                          (0xFFF00000)
```

4.2.20. VX_VERSION

Defines the OpenVX Version Number.

```
#define VX_VERSION                              VX_VERSION_1_2
```

4.2.21. VX_VERSION_1_0

Defines the predefined version number for 1.0.

```
#define VX_VERSION_1_0                    (VX_VERSION_MAJOR(1) | VX_VERSION_MINOR(0))
```

4.2.22. VX_VERSION_1_1

Defines the predefined version number for 1.1.

```
#define VX_VERSION_1_1                    (VX_VERSION_MAJOR(1) | VX_VERSION_MINOR(1))
```

4.2.23. VX_VERSION_1_2

Defines the predefined version number for 1.2.

```
#define VX_VERSION_1_2                    (VX_VERSION_MAJOR(1) | VX_VERSION_MINOR(2))
```

4.2.24. VX_VERSION_MAJOR

Defines the major version number macro.

```
#define VX_VERSION_MAJOR(x) (((x) & 0xFF) << 8)
```

4.2.25. VX_VERSION_MINOR

Defines the minor version number macro.

```
#define VX_VERSION_MINOR(x) (((x) & 0xFF) << 0)
```

4.3. Typedefs

4.3.1. vx_bool

A formal boolean type with known fixed size.

```
typedef vx_enum    vx_bool;
```

See also: `vx_bool_e`

4.3.2. vx_char

An 8 bit ASCII character.

```
typedef char      vx_char;
```

4.3.3. vx_df_image

Used to hold a `VX_DF_IMAGE` code to describe the pixel format and color space.

```
typedef uint32_t  vx_df_image;
```

4.3.4. vx_enum

Sets the standard enumeration type size to be a fixed quantity.

```
typedef int32_t   vx_enum;
```

All enumerable fields must use this type as the container to enforce enumeration ranges and sizeof() operations.

4.3.5. vx_float32

A 32-bit float value.

```
typedef float     vx_float32;
```

4.3.6. vx_float64

A 64-bit float value (aka double).

```
typedef double    vx_float64;
```

4.3.7. vx_int16

A 16-bit signed value.

```
typedef int16_t   vx_int16;
```

4.3.8. vx_int32

A 32-bit signed value.

```
typedef int32_t   vx_int32;
```

4.3.9. vx_int64

A 64-bit signed value.

```
typedef int64_t    vx_int64;
```

4.3.10. vx_int8

An 8-bit signed value.

```
typedef int8_t     vx_int8;
```

4.3.11. vx_size

A wrapper of `size_t` to keep the naming convention uniform.

```
typedef size_t     vx_size;
```

4.3.12. vx_status

A formal status type with known fixed size.

```
typedef vx_enum    vx_status;
```

See also: `vx_status_e`

4.3.13. vx_uint16

A 16-bit unsigned value.

```
typedef uint16_t   vx_uint16;
```

4.3.14. vx_uint32

A 32-bit unsigned value.

```
typedef uint32_t   vx_uint32;
```

4.3.15. vx_uint64

A 64-bit unsigned value.

```
typedef uint64_t  vx_uint64;
```

4.3.16. vx_uint8

An 8-bit unsigned value.

```
typedef uint8_t   vx_uint8;
```

4.4. Enumerations

4.4.1. vx_bool_e

A Boolean value. This allows 0 to be FALSE, as it is in C, and any non-zero to be TRUE.

```
enum vx_bool_e {
    vx_false_e = 0,
    vx_true_e = 1,
};
```

```
vx_bool ret = vx_true_e;
if (ret) printf("true!\n");
ret = vx_false_e;
if (!ret) printf("false!\n");
```

This would print both strings.

See also: `vx_bool`

Enumerator

- `vx_false_e` - The “false” value.
- `vx_true_e` - The “true” value.

4.4.2. vx_channel_e

The channel enumerations for channel extractions.

```
enum vx_channel_e {
    VX_CHANNEL_0 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x0,
    VX_CHANNEL_1 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x1,
    VX_CHANNEL_2 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x2,
    VX_CHANNEL_3 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x3,
    VX_CHANNEL_R = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x10,
    VX_CHANNEL_G = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x11,
    VX_CHANNEL_B = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x12,
    VX_CHANNEL_A = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x13,
    VX_CHANNEL_Y = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x14,
    VX_CHANNEL_U = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x15,
    VX_CHANNEL_V = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CHANNEL) + 0x16,
};
```

See also: `vxChannelExtractNode`, `vxuChannelExtract`, `VX_KERNEL_CHANNEL_EXTRACT`

Enumerator

- `VX_CHANNEL_0` - Used by formats with unknown channel types.
- `VX_CHANNEL_1` - Used by formats with unknown channel types.
- `VX_CHANNEL_2` - Used by formats with unknown channel types.
- `VX_CHANNEL_3` - Used by formats with unknown channel types.
- `VX_CHANNEL_R` - Use to extract the RED channel, no matter the byte or packing order.
- `VX_CHANNEL_G` - Use to extract the GREEN channel, no matter the byte or packing order.
- `VX_CHANNEL_B` - Use to extract the BLUE channel, no matter the byte or packing order.
- `VX_CHANNEL_A` - Use to extract the ALPHA channel, no matter the byte or packing order.
- `VX_CHANNEL_Y` - Use to extract the LUMA channel, no matter the byte or packing order.
- `VX_CHANNEL_U` - Use to extract the Cb/U channel, no matter the byte or packing order.
- `VX_CHANNEL_V` - Use to extract the Cr/V/Value channel, no matter the byte or packing order.

4.4.3. vx_convert_policy_e

The Conversion Policy Enumeration.

```
enum vx_convert_policy_e {
    VX_CONVERT_POLICY_WRAP = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CONVERT_POLICY) +
0x0,
    VX_CONVERT_POLICY_SATURATE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_CONVERT_POLICY) +
0x1,
};
```

Enumerator

- `VX_CONVERT_POLICY_WRAP` - Results are the least significant bits of the output operand, as if stored in two's complement binary format in the size of its bit-depth.

- VX_CONVERT_POLICY_SATURATE - Results are saturated to the bit depth of the output operand.

4.4.4. vx_df_image_e

Based on the VX_DF_IMAGE definition.

```
enum vx_df_image_e {
    VX_DF_IMAGE_VIRT = VX_DF_IMAGE('V','I','R','T'),
    VX_DF_IMAGE_RGB = VX_DF_IMAGE('R','G','B','2'),
    VX_DF_IMAGE_RGBX = VX_DF_IMAGE('R','G','B','A'),
    VX_DF_IMAGE_NV12 = VX_DF_IMAGE('N','V','1','2'),
    VX_DF_IMAGE_NV21 = VX_DF_IMAGE('N','V','2','1'),
    VX_DF_IMAGE_UYVY = VX_DF_IMAGE('U','Y','V','Y'),
    VX_DF_IMAGE_YUYV = VX_DF_IMAGE('Y','U','Y','V'),
    VX_DF_IMAGE_IYUV = VX_DF_IMAGE('I','Y','U','V'),
    VX_DF_IMAGE_YUV4 = VX_DF_IMAGE('Y','U','V','4'),
    VX_DF_IMAGE_U8 = VX_DF_IMAGE('U','0','0','8'),
    VX_DF_IMAGE_U16 = VX_DF_IMAGE('U','0','1','6'),
    VX_DF_IMAGE_S16 = VX_DF_IMAGE('S','0','1','6'),
    VX_DF_IMAGE_U32 = VX_DF_IMAGE('U','0','3','2'),
    VX_DF_IMAGE_S32 = VX_DF_IMAGE('S','0','3','2'),
};
```

> *Note*
>
> Use vx_df_image to contain these values.

Enumerator

- VX_DF_IMAGE_VIRT - A virtual image of no defined type.
- VX_DF_IMAGE_RGB - A single plane of 24-bit pixel as 3 interleaved 8-bit units of R then G then B data. This uses the BT709 full range by default.
- VX_DF_IMAGE_RGBX - A single plane of 32-bit pixel as 4 interleaved 8-bit units of R then G then B data, then a *don't care* byte. This uses the BT709 full range by default.
- VX_DF_IMAGE_NV12 - A 2-plane YUV format of Luma (Y) and interleaved UV data at 4:2:0 sampling. This uses the BT709 full range by default.
- VX_DF_IMAGE_NV21 - A 2-plane YUV format of Luma (Y) and interleaved VU data at 4:2:0 sampling. This uses the BT709 full range by default.
- VX_DF_IMAGE_UYVY - A single plane of 32-bit macro pixel of U0, Y0, V0, Y1 bytes. This uses the BT709 full range by default.
- VX_DF_IMAGE_YUYV - A single plane of 32-bit macro pixel of Y0, U0, Y1, V0 bytes. This uses the BT709 full range by default.
- VX_DF_IMAGE_IYUV - A 3 plane of 8-bit 4:2:0 sampled Y, U, V planes. This uses the BT709 full range by default.

- VX_DF_IMAGE_YUV4 - A 3 plane of 8 bit 4:4:4 sampled Y, U, V planes. This uses the BT709 full range by default.
- VX_DF_IMAGE_U8 - A single plane of unsigned 8-bit data. The range of data is not specified, as it may be extracted from a YUV or generated.
- VX_DF_IMAGE_U16 - A single plane of unsigned 16-bit data. The range of data is not specified, as it may be extracted from a YUV or generated.
- VX_DF_IMAGE_S16 - A single plane of signed 16-bit data. The range of data is not specified, as it may be extracted from a YUV or generated.
- VX_DF_IMAGE_U32 - A single plane of unsigned 32-bit data. The range of data is not specified, as it may be extracted from a YUV or generated.
- VX_DF_IMAGE_S32 - A single plane of unsigned 32-bit data. The range of data is not specified, as it may be extracted from a YUV or generated.

4.4.5. vx_enum_e

The set of supported enumerations in OpenVX.

```
enum vx_enum_e {
    VX_ENUM_DIRECTION = 0x00,
    VX_ENUM_ACTION = 0x01,
    VX_ENUM_HINT = 0x02,
    VX_ENUM_DIRECTIVE = 0x03,
    VX_ENUM_INTERPOLATION = 0x04,
    VX_ENUM_OVERFLOW = 0x05,
    VX_ENUM_COLOR_SPACE = 0x06,
    VX_ENUM_COLOR_RANGE = 0x07,
    VX_ENUM_PARAMETER_STATE = 0x08,
    VX_ENUM_CHANNEL = 0x09,
    VX_ENUM_CONVERT_POLICY = 0x0A,
    VX_ENUM_THRESHOLD_TYPE = 0x0B,
    VX_ENUM_BORDER = 0x0C,
    VX_ENUM_COMPARISON = 0x0D,
    VX_ENUM_MEMORY_TYPE = 0x0E,
    VX_ENUM_TERM_CRITERIA = 0x0F,
    VX_ENUM_NORM_TYPE = 0x10,
    VX_ENUM_ACCESSOR = 0x11,
    VX_ENUM_ROUND_POLICY = 0x12,
    VX_ENUM_TARGET = 0x13,
    VX_ENUM_BORDER_POLICY = 0x14,
    VX_ENUM_GRAPH_STATE = 0x15,
    VX_ENUM_NONLINEAR = 0x16,
    VX_ENUM_PATTERN = 0x17,
    VX_ENUM_LBP_FORMAT = 0x18,
    VX_ENUM_COMP_METRIC = 0x19,
    VX_ENUM_SCALAR_OPERATION = 0x20,
};
```

These can be extracted from enumerated values using VX_ENUM_TYPE.

Enumerator

- VX_ENUM_DIRECTION - Parameter Direction.
- VX_ENUM_ACTION - Action Codes.
- VX_ENUM_HINT - Hint Values.
- VX_ENUM_DIRECTIVE - Directive Values.
- VX_ENUM_INTERPOLATION - Interpolation Types.
- VX_ENUM_OVERFLOW - Overflow Policies.
- VX_ENUM_COLOR_SPACE - Color Space.
- VX_ENUM_COLOR_RANGE - Color Space Range.
- VX_ENUM_PARAMETER_STATE - Parameter State.
- VX_ENUM_CHANNEL - Channel Name.
- VX_ENUM_CONVERT_POLICY - Convert Policy.
- VX_ENUM_THRESHOLD_TYPE - Threshold Type List.
- VX_ENUM_BORDER - Border Mode List.
- VX_ENUM_COMPARISON - Comparison Values.
- VX_ENUM_MEMORY_TYPE - The memory type enumeration.
- VX_ENUM_TERM_CRITERIA - A termination criteria.
- VX_ENUM_NORM_TYPE - A norm type.
- VX_ENUM_ACCESSOR - An accessor flag type.
- VX_ENUM_ROUND_POLICY - Rounding Policy.
- VX_ENUM_TARGET - Target.
- VX_ENUM_BORDER_POLICY - Unsupported Border Mode Policy List.
- VX_ENUM_GRAPH_STATE - Graph attribute states.
- VX_ENUM_NONLINEAR - Non-linear function list.
- VX_ENUM_PATTERN - Matrix pattern enumeration.
- VX_ENUM_LBP_FORMAT - Lbp format.
- VX_ENUM_COMP_METRIC - Compare metric.
- VX_ENUM_SCALAR_OPERATION - Scalar operation list.

4.4.6. vx_interpolation_type_e

The image reconstruction filters supported by image resampling operations.

```
enum vx_interpolation_type_e {
    VX_INTERPOLATION_NEAREST_NEIGHBOR = VX_ENUM_BASE(VX_ID_KHRONOS,
VX_ENUM_INTERPOLATION) + 0x0,
    VX_INTERPOLATION_BILINEAR = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_INTERPOLATION) +
0x1,
    VX_INTERPOLATION_AREA = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_INTERPOLATION) + 0x2,
};
```

The edge of a pixel is interpreted as being aligned to the edge of the image. The value for an output pixel is evaluated at the center of that pixel.

This means, for example, that an even enlargement of a factor of two in nearest-neighbor interpolation will replicate every source pixel into a 2x2 quad in the destination, and that an even shrink by a factor of two in bilinear interpolation will create each destination pixel by average a 2x2 quad of source pixels.

Samples that cross the boundary of the source image have values determined by the border mode - see `vx_border_e` and `VX_NODE_BORDER`.

See also: `vxuScaleImage`, `vxScaleImageNode`, `VX_KERNEL_SCALE_IMAGE`, `vxuWarpAffine`, `vxWarpAffineNode`, `VX_KERNEL_WARP_AFFINE`, `vxuWarpPerspective`, `vxWarpPerspectiveNode`, `VX_KERNEL_WARP_PERSPECTIVE`

Enumerator

- `VX_INTERPOLATION_NEAREST_NEIGHBOR` - Output values are defined to match the source pixel whose center is nearest to the sample position.
- `VX_INTERPOLATION_BILINEAR` - Output values are defined by bilinear interpolation between the pixels whose centers are closest to the sample position, weighted linearly by the distance of the sample from the pixel centers.
- `VX_INTERPOLATION_AREA` - Output values are determined by averaging the source pixels whose areas fall under the area of the destination pixel, projected onto the source image.

4.4.7. vx_non_linear_filter_e

An enumeration of non-linear filter functions.

```
enum vx_non_linear_filter_e {
    VX_NONLINEAR_FILTER_MEDIAN = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_NONLINEAR) + 0x0,
    VX_NONLINEAR_FILTER_MIN = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_NONLINEAR) + 0x1 ,
    VX_NONLINEAR_FILTER_MAX = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_NONLINEAR) + 0x2,
};
```

Enumerator

- `VX_NONLINEAR_FILTER_MEDIAN` - Nonlinear median filter.
- `VX_NONLINEAR_FILTER_MIN` - Nonlinear Erode.

* VX_NONLINEAR_FILTER_MAX - Nonlinear Dilate.

4.4.8. vx_pattern_e

An enumeration of matrix patterns. See vxCreateMatrixFromPattern and vxCreateMatrixFromPatternAndOrigin

```
enum vx_pattern_e {
    VX_PATTERN_BOX = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_PATTERN) + 0x0,
    VX_PATTERN_CROSS = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_PATTERN) + 0x1 ,
    VX_PATTERN_DISK = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_PATTERN) + 0x2,
    VX_PATTERN_OTHER = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_PATTERN) + 0x3,
};
```

Enumerator

* VX_PATTERN_BOX - Box pattern matrix.
* VX_PATTERN_CROSS - Cross pattern matrix.
* VX_PATTERN_DISK - A square matrix (rows = columns = size)
* VX_PATTERN_OTHER - Matrix with any pattern other than above.

4.4.9. vx_status_e

The enumeration of all status codes.

```
enum vx_status_e {
    VX_STATUS_MIN = -25,
    VX_ERROR_REFERENCE_NONZERO = -24,
    VX_ERROR_MULTIPLE_WRITERS = -23,
    VX_ERROR_GRAPH_ABANDONED = -22,
    VX_ERROR_GRAPH_SCHEDULED = -21,
    VX_ERROR_INVALID_SCOPE = -20,
    VX_ERROR_INVALID_NODE = -19,
    VX_ERROR_INVALID_GRAPH = -18,
    VX_ERROR_INVALID_TYPE = -17,
    VX_ERROR_INVALID_VALUE = -16,
    VX_ERROR_INVALID_DIMENSION = -15,
    VX_ERROR_INVALID_FORMAT = -14,
    VX_ERROR_INVALID_LINK = -13,
    VX_ERROR_INVALID_REFERENCE = -12,
    VX_ERROR_INVALID_MODULE = -11,
    VX_ERROR_INVALID_PARAMETERS = -10,
    VX_ERROR_OPTIMIZED_AWAY = -9,
    VX_ERROR_NO_MEMORY = -8,
    VX_ERROR_NO_RESOURCES = -7,
    VX_ERROR_NOT_COMPATIBLE = -6,
    VX_ERROR_NOT_ALLOCATED = -5,
    VX_ERROR_NOT_SUFFICIENT = -4,
    VX_ERROR_NOT_SUPPORTED = -3,
    VX_ERROR_NOT_IMPLEMENTED = -2,
    VX_FAILURE = -1,
    VX_SUCCESS =  0,
};
```

See also: `vx_status`.

Enumerator

- `VX_STATUS_MIN` - Indicates the lower bound of status codes in VX. Used for bounds checks only.
- `VX_ERROR_REFERENCE_NONZERO` - Indicates that an operation did not complete due to a reference count being non-zero.
- `VX_ERROR_MULTIPLE_WRITERS` - Indicates that the graph has more than one node outputting to the same data object. This is an invalid graph structure.
- `VX_ERROR_GRAPH_ABANDONED` - Indicates that the graph is stopped due to an error or a callback that abandoned execution.
- `VX_ERROR_GRAPH_SCHEDULED` - Indicates that the supplied graph already has been scheduled and may be currently executing.
- `VX_ERROR_INVALID_SCOPE` - Indicates that the supplied parameter is from another scope and cannot be used in the current scope.
- `VX_ERROR_INVALID_NODE` - Indicates that the supplied node could not be created.
- `VX_ERROR_INVALID_GRAPH` - Indicates that the supplied graph has invalid connections (cycles).

- VX_ERROR_INVALID_TYPE - Indicates that the supplied type parameter is incorrect.
- VX_ERROR_INVALID_VALUE - Indicates that the supplied parameter has an incorrect value.
- VX_ERROR_INVALID_DIMENSION - Indicates that the supplied parameter is too big or too small in dimension.
- VX_ERROR_INVALID_FORMAT - Indicates that the supplied parameter is in an invalid format.
- VX_ERROR_INVALID_LINK - Indicates that the link is not possible as specified. The parameters are incompatible.
- VX_ERROR_INVALID_REFERENCE - Indicates that the reference provided is not valid.
- VX_ERROR_INVALID_MODULE - This is returned from vxLoadKernels when the module does not contain the entry point.
- VX_ERROR_INVALID_PARAMETERS - Indicates that the supplied parameter information does not match the kernel contract.
- VX_ERROR_OPTIMIZED_AWAY - Indicates that the object refered to has been optimized out of existence.
- VX_ERROR_NO_MEMORY - Indicates that an internal or implicit allocation failed. Typically catastrophic. After detection, deconstruct the context.

  See also: vxVerifyGraph.

- VX_ERROR_NO_RESOURCES - Indicates that an internal or implicit resource can not be acquired (not memory). This is typically catastrophic. After detection, deconstruct the context.

  See also: vxVerifyGraph.

- VX_ERROR_NOT_COMPATIBLE - Indicates that the attempt to link two parameters together failed due to type incompatibilty.
- VX_ERROR_NOT_ALLOCATED - Indicates to the system that the parameter must be allocated by the system.
- VX_ERROR_NOT_SUFFICIENT - Indicates that the given graph has failed verification due to an insufficient number of required parameters, which cannot be automatically created. Typically this indicates required atomic parameters.

  See also: vxVerifyGraph.

- VX_ERROR_NOT_SUPPORTED - Indicates that the requested set of parameters produce a configuration that cannot be supported. Refer to the supplied documentation on the configured kernels.

  See also: vx_kernel_e. This is also returned if a function to set an attribute is called on a Read-only attribute.

- VX_ERROR_NOT_IMPLEMENTED - Indicates that the requested kernel is missing.

  See also: vx_kernel_e vxGetKernelByName.

- VX_FAILURE - Indicates a generic error code, used when no other describes the error.

- VX_SUCCESS - No error.

4.4.10. vx_target_e

The Target Enumeration.

```
enum vx_target_e {
    VX_TARGET_ANY = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_TARGET) + 0x0000,
    VX_TARGET_STRING = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_TARGET) + 0x0001,
    VX_TARGET_VENDOR_BEGIN = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_TARGET) + 0x1000,
};
```

Enumerator

- VX_TARGET_ANY - Any available target. An OpenVX implementation must support at least one target associated with this value.
- VX_TARGET_STRING - Target, explicitly specified by its (case-insensitive) name string.
- VX_TARGET_VENDOR_BEGIN - Start of Vendor specific target enumerates.

4.4.11. vx_type_e

The type enumeration lists all the known types in OpenVX.

```
enum vx_type_e {
    VX_TYPE_INVALID = 0x000,
    VX_TYPE_CHAR = 0x001,
    VX_TYPE_INT8 = 0x002,
    VX_TYPE_UINT8 = 0x003,
    VX_TYPE_INT16 = 0x004,
    VX_TYPE_UINT16 = 0x005,
    VX_TYPE_INT32 = 0x006,
    VX_TYPE_UINT32 = 0x007,
    VX_TYPE_INT64 = 0x008,
    VX_TYPE_UINT64 = 0x009,
    VX_TYPE_FLOAT32 = 0x00A,
    VX_TYPE_FLOAT64 = 0x00B,
    VX_TYPE_ENUM = 0x00C,
    VX_TYPE_SIZE = 0x00D,
    VX_TYPE_DF_IMAGE = 0x00E,
    VX_TYPE_FLOAT16 = 0x00F,
    VX_TYPE_BOOL = 0x010,
    VX_TYPE_RECTANGLE = 0x020,
    VX_TYPE_KEYPOINT = 0x021,
    VX_TYPE_COORDINATES2D = 0x022,
    VX_TYPE_COORDINATES3D = 0x023,
    VX_TYPE_COORDINATES2DF = 0x024,
    VX_TYPE_HOG_PARAMS = 0x028,
    VX_TYPE_HOUGH_LINES_PARAMS = 0x029,
```

```
    VX_TYPE_LINE_2D = 0x02A,
    VX_TYPE_TENSOR_MATRIX_MULTIPLY_PARAMS = 0x02B,
    VX_TYPE_USER_STRUCT_START = 0x100,
    VX_TYPE_VENDOR_STRUCT_START = 0x400,
    VX_TYPE_KHRONOS_OBJECT_START = 0x800,
    VX_TYPE_VENDOR_OBJECT_START = 0xC00,
    VX_TYPE_KHRONOS_STRUCT_MAX = VX_TYPE_USER_STRUCT_START - 1,
    VX_TYPE_USER_STRUCT_END = VX_TYPE_VENDOR_STRUCT_START - 1,
    VX_TYPE_VENDOR_STRUCT_END = VX_TYPE_KHRONOS_OBJECT_START - 1,
    VX_TYPE_KHRONOS_OBJECT_END = VX_TYPE_VENDOR_OBJECT_START - 1,
    VX_TYPE_VENDOR_OBJECT_END = 0xFFF,
    VX_TYPE_REFERENCE = 0x800,
    VX_TYPE_CONTEXT = 0x801,
    VX_TYPE_GRAPH = 0x802,
    VX_TYPE_NODE = 0x803,
    VX_TYPE_KERNEL = 0x804,
    VX_TYPE_PARAMETER = 0x805,
    VX_TYPE_DELAY = 0x806,
    VX_TYPE_LUT = 0x807,
    VX_TYPE_DISTRIBUTION = 0x808,
    VX_TYPE_PYRAMID = 0x809,
    VX_TYPE_THRESHOLD = 0x80A,
    VX_TYPE_MATRIX = 0x80B,
    VX_TYPE_CONVOLUTION = 0x80C,
    VX_TYPE_SCALAR = 0x80D,
    VX_TYPE_ARRAY = 0x80E,
    VX_TYPE_IMAGE = 0x80F,
    VX_TYPE_REMAP = 0x810,
    VX_TYPE_ERROR = 0x811,
    VX_TYPE_META_FORMAT = 0x812,
    VX_TYPE_OBJECT_ARRAY = 0x813,
    VX_TYPE_TENSOR = 0x815,
};
```

Enumerator

- VX_TYPE_INVALID - An invalid type value. When passed an error must be returned.
- VX_TYPE_CHAR - A vx_char.
- VX_TYPE_INT8 - A vx_int8.
- VX_TYPE_UINT8 - A vx_uint8.
- VX_TYPE_INT16 - A vx_int16.
- VX_TYPE_UINT16 - A vx_uint16.
- VX_TYPE_INT32 - A vx_int32.
- VX_TYPE_UINT32 - A vx_uint32.
- VX_TYPE_INT64 - A vx_int64.
- VX_TYPE_UINT64 - A vx_uint64.

- `VX_TYPE_FLOAT32` - A `vx_float32`.
- `VX_TYPE_FLOAT64` - A `vx_float64`.
- `VX_TYPE_ENUM` - A `vx_enum`. Equivalent in size to a `vx_int32`.
- `VX_TYPE_SIZE` - A `vx_size`.
- `VX_TYPE_DF_IMAGE` - A `vx_df_image`.
- `VX_TYPE_BOOL` - A `vx_bool`.
- `VX_TYPE_RECTANGLE` - A `vx_rectangle_t`.
- `VX_TYPE_KEYPOINT` - A `vx_keypoint_t`.
- `VX_TYPE_COORDINATES2D` - A `vx_coordinates2d_t`.
- `VX_TYPE_COORDINATES3D` - A `vx_coordinates3d_t`.
- `VX_TYPE_COORDINATES2DF` - A `vx_coordinates2df_t`.
- `VX_TYPE_HOG_PARAMS` - A `vx_hog_t`.
- `VX_TYPE_HOUGH_LINES_PARAMS` - A `vx_hough_lines_p_t`.
- `VX_TYPE_LINE_2D` - A `vx_line2d_t`.
- `VX_TYPE_TENSOR_MATRIX_MULTIPLY_PARAMS` - A `vx_tensor_matrix_multiply_params_t`.
- `VX_TYPE_USER_STRUCT_START` - A user-defined struct base index.
- `VX_TYPE_VENDOR_STRUCT_START` - A vendor-defined struct base index.
- `VX_TYPE_KHRONOS_OBJECT_START` - A Khronos defined object base index.
- `VX_TYPE_VENDOR_OBJECT_START` - A vendor defined object base index.
- `VX_TYPE_KHRONOS_STRUCT_MAX` - A value for comparison between Khronos defined structs and user structs.
- `VX_TYPE_USER_STRUCT_END` - A value for comparison between user structs and vendor structs.
- `VX_TYPE_VENDOR_STRUCT_END` - A value for comparison between vendor structs and Khronos defined objects.
- `VX_TYPE_KHRONOS_OBJECT_END` - A value for comparison between Khronos defined objects and vendor structs.
- `VX_TYPE_VENDOR_OBJECT_END` - A value used for bound checking of vendor objects.
- `VX_TYPE_REFERENCE` - A `vx_reference`.
- `VX_TYPE_CONTEXT` - A `vx_context`.
- `VX_TYPE_GRAPH` - A `vx_graph`.
- `VX_TYPE_NODE` - A `vx_node`.
- `VX_TYPE_KERNEL` - A `vx_kernel`.
- `VX_TYPE_PARAMETER` - A `vx_parameter`.
- `VX_TYPE_DELAY` - A `vx_delay`.
- `VX_TYPE_LUT` - A `vx_lut`.

- VX_TYPE_DISTRIBUTION - A vx_distribution.
- VX_TYPE_PYRAMID - A vx_pyramid.
- VX_TYPE_THRESHOLD - A vx_threshold.
- VX_TYPE_MATRIX - A vx_matrix.
- VX_TYPE_CONVOLUTION - A vx_convolution.
- VX_TYPE_SCALAR - A vx_scalar. when needed to be completely generic for kernel validation.
- VX_TYPE_ARRAY - A vx_array.
- VX_TYPE_IMAGE - A vx_image.
- VX_TYPE_REMAP - A vx_remap.
- VX_TYPE_ERROR - An error object which has no type.
- VX_TYPE_META_FORMAT - A vx_meta_format.
- VX_TYPE_OBJECT_ARRAY - A vx_object_array.
- VX_TYPE_TENSOR - A vx_tensor.

4.4.12. vx_vendor_id_e

The Vendor ID of the Implementation. As new vendors submit their implementations, this enumeration will grow.

```
enum vx_vendor_id_e {
    VX_ID_KHRONOS = 0x000,
    VX_ID_TI = 0x001,
    VX_ID_QUALCOMM = 0x002,
    VX_ID_NVIDIA = 0x003,
    VX_ID_ARM = 0x004,
    VX_ID_BDTI = 0x005,
    VX_ID_RENESAS = 0x006,
    VX_ID_VIVANTE = 0x007,
    VX_ID_XILINX = 0x008,
    VX_ID_AXIS = 0x009,
    VX_ID_MOVIDIUS = 0x00A,
    VX_ID_SAMSUNG = 0x00B,
    VX_ID_FREESCALE = 0x00C,
    VX_ID_AMD = 0x00D,
    VX_ID_BROADCOM = 0x00E,
    VX_ID_INTEL = 0x00F,
    VX_ID_MARVELL = 0x010,
    VX_ID_MEDIATEK = 0x011,
    VX_ID_ST = 0x012,
    VX_ID_CEVA = 0x013,
    VX_ID_ITSEEZ = 0x014,
    VX_ID_IMAGINATION = 0x015,
    VX_ID_NXP = 0x016,
    VX_ID_VIDEANTIS = 0x017,
    VX_ID_SYNOPSYS = 0x018,
    VX_ID_CADENCE = 0x019,
    VX_ID_HUAWEI = 0x01A,
    VX_ID_SOCIONEXT = 0x01B,
    VX_ID_USER = 0xFFE,
    VX_ID_MAX = 0xFFF,
    VX_ID_DEFAULT = VX_ID_MAX,
};
```

Enumerator

- `VX_ID_KHRONOS` - The Khronos Group.
- `VX_ID_TI` - Texas Instruments, Inc.
- `VX_ID_QUALCOMM` - Qualcomm, Inc.
- `VX_ID_NVIDIA` - NVIDIA Corporation.
- `VX_ID_ARM` - ARM Ltd.
- `VX_ID_BDTI` - Berkley Design Technology, Inc.
- `VX_ID_RENESAS` - Renasas Electronics.
- `VX_ID_VIVANTE` - Vivante Corporation.
- `VX_ID_XILINX` - Xilinx Inc.

- VX_ID_AXIS - Axis Communications.
- VX_ID_MOVIDIUS - Movidius Ltd.
- VX_ID_SAMSUNG - Samsung Electronics.
- VX_ID_FREESCALE - Freescale Semiconductor.
- VX_ID_AMD - Advanced Micro Devices.
- VX_ID_BROADCOM - Broadcom Corporation.
- VX_ID_INTEL - Intel Corporation.
- VX_ID_MARVELL - Marvell Technology Group Ltd.
- VX_ID_MEDIATEK - MediaTek, Inc.
- VX_ID_ST - STMicroelectronics.
- VX_ID_CEVA - CEVA DSP.
- VX_ID_ITSEEZ - Itseez, Inc.
- VX_ID_IMAGINATION - Imagination Technologies.
- VX_ID_NXP - NXP Semiconductors.
- VX_ID_VIDEANTIS - Videantis.
- VX_ID_SYNOPSYS - Synopsys.
- VX_ID_CADENCE - Cadence Design Systems.
- VX_ID_HUAWEI - Huawei.
- VX_ID_SOCIONEXT - Socionext.
- VX_ID_USER - For use by vxAllocateUserKernelId and vxAllocateUserKernelLibraryId.
- VX_ID_MAX
- VX_ID_DEFAULT - For use by all Kernel authors until they can obtain an assigned ID.

Chapter 5. Objects

Defines the basic objects within OpenVX.

All objects in OpenVX derive from a `vx_reference` and contain a reference to the `vx_context` from which they were made, except the `vx_context` itself.

Modules

- Object: Array
- Object: Context
- Object: Convolution
- Object: Distribution
- Object: Graph
- Object: Image
- Object: LUT
- Object: Matrix
- Object: Node
- Object: ObjectArray
- Object: Tensor
- Object: Pyramid
- Object: Reference
- Object: Remap
- Object: Scalar
- Object: Threshold

5.1. Object: Reference

Defines the Reference Object interface.

All objects in OpenVX are derived (in the object-oriented sense) from `vx_reference`. All objects shall be able to be cast back to this type safely.

Macros

- `VX_MAX_REFERENCE_NAME`

Typedefs

- `vx_reference`

Enumerations

- `vx_reference_attribute_e`

Functions

- vxGetStatus
- vxGetContext
- vxQueryReference
- vxReleaseReference
- vxRetainReference
- vxSetReferenceName

5.1.1. Macros

VX_MAX_REFERENCE_NAME

Defines the length of the reference name string, including the trailing zero.

```
#define VX_MAX_REFERENCE_NAME               (64)
```

See also: vxSetReferenceName

5.1.2. Typedefs

vx_reference

A generic opaque reference to any object within OpenVX.

```
typedef struct _vx_reference *vx_reference;
```

A user of OpenVX should not assume that this can be cast directly to anything; however, any object in OpenVX can be cast back to this for the purposes of querying attributes of the object or for passing the object as a parameter to functions that take a vx_reference type. If the API does not take that specific type but may take others, an error may be returned from the API.

5.1.3. Enumerations

vx_reference_attribute_e

The reference attributes list.

```
enum vx_reference_attribute_e {
    VX_REFERENCE_COUNT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_REFERENCE) + 0x0,
    VX_REFERENCE_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_REFERENCE) + 0x1,
    VX_REFERENCE_NAME = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_REFERENCE) + 0x2,
};
```

Enumerator

- VX_REFERENCE_COUNT - Returns the reference count of the object. Read-only. Use a vx_uint32 parameter.
- VX_REFERENCE_TYPE - Returns the vx_type_e of the reference. Read-only. Use a vx_enum parameter.
- VX_REFERENCE_NAME - Used to query the reference for its name. Read-write. Use a *vx_char parameter.

5.1.4. Functions

vxGetStatus

Provides a generic API to return status values from Object constructors if they fail.

```
vx_status vxGetStatus(
    vx_reference                                reference);
```

Note

Users do not need to strictly check every object creator as the errors should properly propagate and be detected during verification time or run-time.

```
vx_image img = vxCreateImage(context, 639, 480, VX_DF_IMAGE_UYVY);
vx_status status = vxGetStatus((vx_reference)img);
// status == VX_ERROR_INVALID_DIMENSIONS
vxReleaseImage(&img);
```

Precondition: Appropriate Object Creator function.

Postcondition: Appropriate Object Release function.

Parameters

- [in] *reference* - The reference to check for construction errors.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- * - Some error occurred, please check enumeration list and constructor.

vxGetContext

Retrieves the context from any reference from within a context.

```
vx_context vxGetContext(
    vx_reference                                reference);
```

Parameters

- [in] *reference* - The reference from which to extract the context.

Returns: The overall context that created the particular reference. Any possible errors preventing a successful completion of this function should be checked using vxGetStatus.

vxQueryReference

Queries any reference type for some basic information like count or type.

```
vx_status vxQueryReference(
    vx_reference                              ref,
    vx_enum                                   attribute,
    void*                                     ptr,
    vx_size                                   size);
```

Parameters

- [in] *ref* - The reference to query.
- [in] *attribute* - The value for which to query. Use vx_reference_attribute_e.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which ptr points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - ref is not a valid vx_reference reference.

vxReleaseReference

Releases a reference. The reference may potentially refer to multiple OpenVX objects of different types. This function can be used instead of calling a specific release function for each individual object type (e.g. vxRelease<object>). The object will not be destroyed until its total reference count is zero.

```
vx_status vxReleaseReference(
    vx_reference*                             ref_ptr);
```

> *Note*
>
> After returning from this function the reference is zeroed.

Parameters

- [in] *ref_ptr* - The pointer to the reference of the object to release.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - ref_ptr is not a valid vx_reference reference.

vxRetainReference

Increments the reference counter of an object This function is used to express the fact that the OpenVX object is referenced multiple times by an application. Each time this function is called for an object, the application will need to release the object one additional time before it can be destructed.

```
vx_status vxRetainReference(
    vx_reference                                ref);
```

Parameters

- [in] *ref* - The reference to retain.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - ref is not a valid vx_reference reference.

vxSetReferenceName

Name a reference

This function is used to associate a name to a referenced object. This name can be used by the OpenVX implementation in log messages and any other reporting mechanisms.

```
vx_status vxSetReferenceName(
    vx_reference                                ref,
    const vx_char*                              name);
```

The OpenVX implementation will not check if the name is unique in the reference scope (context or graph). Several references can then have the same name.

Parameters

- [in] *ref* - The reference to the object to be named.
- [in] *name* - Pointer to the '\0' terminated string that identifies the referenced object. The string is copied by the function so that it stays the property of the caller. NULL means that the reference is not named. The length of the string shall be lower than VX_MAX_REFERENCE_NAME bytes.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - ref is not a valid `vx_reference` reference.

5.2. Object: Context

Defines the Context Object Interface.

The OpenVX context is the object domain for all OpenVX objects. All data objects *live* in the context as well as all framework objects. The OpenVX context keeps reference counts on all objects and must do garbage collection during its deconstruction to free lost references. While multiple clients may connect to the OpenVX context, all data are private in that the references referring to data objects are given only to the creating party.

Macros

- `VX_MAX_IMPLEMENTATION_NAME`

Typedefs

- `vx_context`

Enumerations

- `vx_accessor_e`
- `vx_context_attribute_e`
- `vx_memory_type_e`
- `vx_round_policy_e`
- `vx_termination_criteria_e`

Functions

- `vxCreateContext`
- `vxQueryContext`
- `vxReleaseContext`
- `vxSetContextAttribute`
- `vxSetImmediateModeTarget`

5.2.1. Macros

VX_MAX_IMPLEMENTATION_NAME

Defines the length of the implementation name string, including the trailing zero.

```
#define VX_MAX_IMPLEMENTATION_NAME        (64)
```

5.2.2. Typedefs

vx_context

An opaque reference to the implementation context.

```
typedef struct _vx_context *vx_context;
```

See also: `vxCreateContext`

5.2.3. Enumerations

vx_accessor_e

The memory accessor hint flags. These enumeration values are used to indicate desired *system* behavior, not the **User** intent. For example: these can be interpretted as hints to the system about cache operations or marshalling operations.

```
enum vx_accessor_e {
    VX_READ_ONLY = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_ACCESSOR) + 0x1,
    VX_WRITE_ONLY = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_ACCESSOR) + 0x2,
    VX_READ_AND_WRITE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_ACCESSOR) + 0x3,
};
```

Enumerator

- `VX_READ_ONLY` - The memory shall be treated by the system as if it were read-only. If the User writes to this memory, the results are implementation defined.
- `VX_WRITE_ONLY` - The memory shall be treated by the system as if it were write-only. If the User reads from this memory, the results are implementation defined.
- `VX_READ_AND_WRITE` - The memory shall be treated by the system as if it were readable and writeable.

vx_context_attribute_e

A list of context attributes.

```
enum vx_context_attribute_e {
    VX_CONTEXT_VENDOR_ID = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) + 0x0,
    VX_CONTEXT_VERSION = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) + 0x1,
    VX_CONTEXT_UNIQUE_KERNELS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) +
0x2,
    VX_CONTEXT_MODULES = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) + 0x3,
    VX_CONTEXT_REFERENCES = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) + 0x4,
    VX_CONTEXT_IMPLEMENTATION = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) +
0x5,
    VX_CONTEXT_EXTENSIONS_SIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) +
0x6,
    VX_CONTEXT_EXTENSIONS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) + 0x7,
    VX_CONTEXT_CONVOLUTION_MAX_DIMENSION = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,
VX_TYPE_CONTEXT) + 0x8,
    VX_CONTEXT_OPTICAL_FLOW_MAX_WINDOW_DIMENSION = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,
VX_TYPE_CONTEXT) + 0x9,
    VX_CONTEXT_IMMEDIATE_BORDER = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) +
0xA,
    VX_CONTEXT_UNIQUE_KERNEL_TABLE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT)
+ 0xB,
    VX_CONTEXT_IMMEDIATE_BORDER_POLICY = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,
VX_TYPE_CONTEXT) + 0xC,
    VX_CONTEXT_NONLINEAR_MAX_DIMENSION = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,
VX_TYPE_CONTEXT) + 0xd,
    VX_CONTEXT_MAX_TENSOR_DIMS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONTEXT) +
0xE,
};
```

Enumerator

- `VX_CONTEXT_VENDOR_ID` - Queries the unique vendor ID. Read-only. Use a `vx_uint16`.
- `VX_CONTEXT_VERSION` - Queries the OpenVX Version Number. Read-only. Use a `vx_uint16`
- `VX_CONTEXT_UNIQUE_KERNELS` - Queries the context for the number of *unique* kernels. Read-only. Use a `vx_uint32` parameter.
- `VX_CONTEXT_MODULES` - Queries the context for the number of active modules. Read-only. Use a `vx_uint32` parameter.
- `VX_CONTEXT_REFERENCES` - Queries the context for the number of active references. Read-only. Use a `vx_uint32` parameter.
- `VX_CONTEXT_IMPLEMENTATION` - Queries the context for it's implementation name. Read-only. Use a `vx_char`[`VX_MAX_IMPLEMENTATION_NAME`] array.
- `VX_CONTEXT_EXTENSIONS_SIZE` - Queries the number of bytes in the extensions string. Read-only. Use a `vx_size` parameter.
- `VX_CONTEXT_EXTENSIONS` - Retrieves the extensions string. Read-only. This is a space-separated string of extension names. Each OpenVX official extension has a unique identifier, comprised of capital letters, numbers and the underscore character, prefixed with "KHR_", for example "KHR_NEW_FEATURE". Use a `vx_char` pointer allocated to the size returned from

VX_CONTEXT_EXTENSIONS_SIZE.

- VX_CONTEXT_CONVOLUTION_MAX_DIMENSION - The maximum width or height of a convolution matrix. Read-only. Use a vx_size parameter. Each vendor must support centered kernels of size w X h, where both w and h are odd numbers, $3 \le w \le n$ and $3 \le h \le n$, where n is the value of the VX_CONTEXT_CONVOLUTION_MAX_DIMENSION attribute. n is an odd number that should not be smaller than 9. w and h may or may not be equal to each other. All combinations of w and h meeting the conditions above must be supported. The behavior of vxCreateConvolution is undefined for values larger than the value returned by this attribute.

- VX_CONTEXT_OPTICAL_FLOW_MAX_WINDOW_DIMENSION - The maximum window dimension of the [OpticalFlowPyrLK] kernel. The value of this attribute shall be equal to or greater than '9'.

  See also: VX_KERNEL_OPTICAL_FLOW_PYR_LK. Read-only. Use a vx_size parameter.

- VX_CONTEXT_IMMEDIATE_BORDER - The border mode for immediate mode functions.

  Graph mode functions are unaffected by this attribute. Read-write. Use a pointer to a vx_border_t structure as parameter.

  > *Note*
  >
  > The assumed default value for immediate mode functions is VX_BORDER_UNDEFINED.

- VX_CONTEXT_UNIQUE_KERNEL_TABLE - Returns the table of all unique the kernels that exist in the context. Read-only. Use a vx_kernel_info_t array.

  Precondition: You must call vxQueryContext with VX_CONTEXT_UNIQUE_KERNELS to compute the necessary size of the array.

- VX_CONTEXT_IMMEDIATE_BORDER_POLICY - The unsupported border mode policy for immediate mode functions. Read-Write.

  Graph mode functions are unaffected by this attribute. Use a vx_enum as parameter. Will contain a vx_border_policy_e.

  > *Note*
  >
  > The assumed default value for immediate mode functions is VX_BORDER_POLICY_DEFAULT_TO_UNDEFINED. Users should refer to the documentation of their implementation to determine what border modes are supported by each kernel.

- VX_CONTEXT_NONLINEAR_MAX_DIMENSION - The dimension of the largest nonlinear filter supported. See vxNonLinearFilterNode.

  The implementation must support all dimensions (height or width, not necessarily the same) up to the value of this attribute. The lowest value that must be supported for this attribute is 9. Read-only. Use a vx_size parameter.

- VX_CONTEXT_MAX_TENSOR_DIMS - tensor Data maximal number of dimensions supported by the implementation.

vx_memory_type_e

An enumeration of memory import types.

```
enum vx_memory_type_e {
    VX_MEMORY_TYPE_NONE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_MEMORY_TYPE) + 0x0,
    VX_MEMORY_TYPE_HOST = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_MEMORY_TYPE) + 0x1,
};
```

Enumerator

- `VX_MEMORY_TYPE_NONE` - For memory allocated through OpenVX, this is the import type.
- `VX_MEMORY_TYPE_HOST` - The default memory type to import from the Host.

vx_round_policy_e

The Round Policy Enumeration.

```
enum vx_round_policy_e {
    VX_ROUND_POLICY_TO_ZERO = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_ROUND_POLICY) + 0x1,
    VX_ROUND_POLICY_TO_NEAREST_EVEN = VX_ENUM_BASE(VX_ID_KHRONOS,
VX_ENUM_ROUND_POLICY) + 0x2,
};
```

Enumerator

- `VX_ROUND_POLICY_TO_ZERO` - When scaling, this truncates the least significant values that are lost in operations.
- `VX_ROUND_POLICY_TO_NEAREST_EVEN` - When scaling, this rounds to nearest even output value.

vx_termination_criteria_e

The termination criteria list.

```
enum vx_termination_criteria_e {
    VX_TERM_CRITERIA_ITERATIONS = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_TERM_CRITERIA) +
0x0,
    VX_TERM_CRITERIA_EPSILON = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_TERM_CRITERIA) +
0x1,
    VX_TERM_CRITERIA_BOTH = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_TERM_CRITERIA) + 0x2,
};
```

See also: Optical Flow Pyramid (LK)

Enumerator

- VX_TERM_CRITERIA_ITERATIONS - Indicates a termination after a set number of iterations.
- VX_TERM_CRITERIA_EPSILON - Indicates a termination after matching against the value of eplison provided to the function.
- VX_TERM_CRITERIA_BOTH - Indicates that both an iterations and eplison method are employed. Whichever one matches first causes the termination.

5.2.4. Functions

vxCreateContext

Creates a vx_context.

```
vx_context vxCreateContext(void);
```

This creates a top-level object context for OpenVX.

> *Note*
>
> This is required to do anything else.

Returns: The reference to the implementation context vx_context. Any possible errors preventing a successful creation should be checked using vxGetStatus.

Postcondition: vxReleaseContext

vxQueryContext

Queries the context for some specific information.

```
vx_status vxQueryContext(
    vx_context                                  context,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *context* - The reference to the context.
- [in] *attribute* - The attribute to query. Use a vx_context_attribute_e.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.

* VX_ERROR_INVALID_REFERENCE - context is not a valid vx_context reference.
* VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.
* VX_ERROR_NOT_SUPPORTED - If the attribute is not supported on this implementation.

vxReleaseContext

Releases the OpenVX object context.

```
vx_status vxReleaseContext(
    vx_context*                                 context);
```

All reference counted objects are garbage-collected by the return of this call. No calls are possible using the parameter context after the context has been released until a new reference from vxCreateContext is returned. All outstanding references to OpenVX objects from this context are invalid after this call.

Parameters

* [in] *context* - The pointer to the reference to the context.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

* VX_SUCCESS - No errors; any other value indicates failure.
* VX_ERROR_INVALID_REFERENCE - context is not a valid vx_context reference.

Precondition: vxCreateContext

vxSetContextAttribute

Sets an attribute on the context.

```
vx_status vxSetContextAttribute(
    vx_context                                  context,
    vx_enum                                     attribute,
    const void*                                 ptr,
    vx_size                                     size);
```

Parameters

* [in] *context* - The handle to the overall context.
* [in] *attribute* - The attribute to set from vx_context_attribute_e.
* [in] *ptr* - The pointer to the data to which to set the attribute.
* [in] *size* - The size in bytes of the data to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - context is not a valid vx_context reference.
- VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.
- VX_ERROR_NOT_SUPPORTED - If the attribute is not settable.

vxSetImmediateModeTarget

Sets the default target of the immediate mode. Upon successful execution of this function any future execution of immediate mode function is attempted on the new default target of the context.

```
vx_status vxSetImmediateModeTarget(
    vx_context                                      context,
    vx_enum                                         target_enum,
    const char*                                     target_string);
```

Parameters

- [in] *context* - The reference to the implementation context.
- [in] *target_enum* - The default immediate mode target enum to be set to the vx_context object. Use a vx_target_e.
- [in] *target_string* - The target name ASCII string. This contains a valid value when target_enum is set to VX_TARGET_STRING, otherwise it is ignored.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Default target set; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - If the context is not a valid vx_context reference.
- VX_ERROR_NOT_SUPPORTED - If the specified target is not supported in this context.

5.3. Object: Graph

Defines the Graph Object interface.

A set of nodes connected in a directed (only goes one-way) acyclic (does not loop back) fashion. A Graph may have sets of Nodes that are unconnected to other sets of Nodes within the same Graph. See Graph Formalisms. Figure below shows the Graph state transition diagram. Also see vx_graph_state_e.

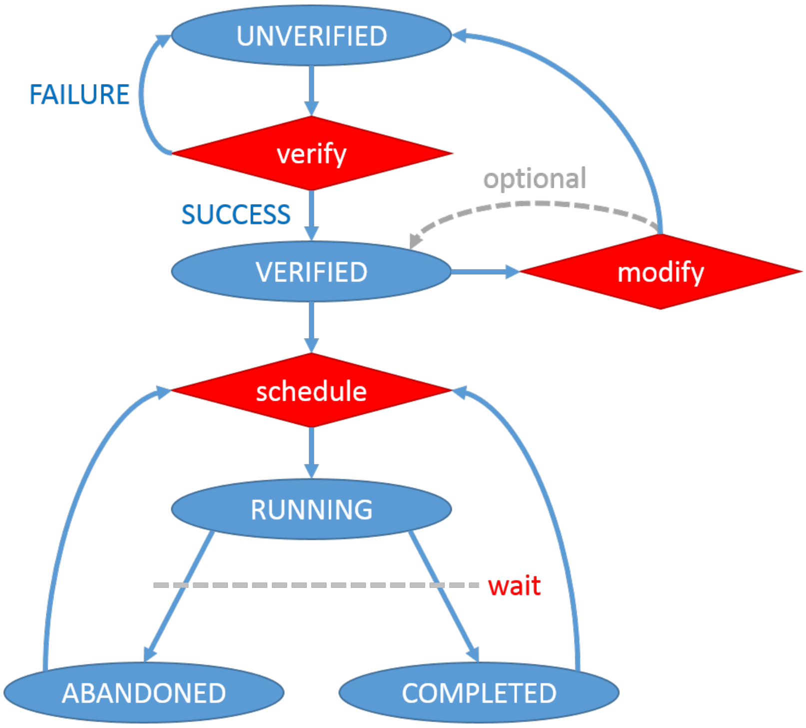


Figure 10. Graph State Transition

Typedefs

- `vx_graph`

Enumerations

- `vx_graph_attribute_e`
- `vx_graph_state_e`

Functions

- `vxCreateGraph`
- `vxIsGraphVerified`
- `vxProcessGraph`
- `vxQueryGraph`
- `vxRegisterAutoAging`
- `vxReleaseGraph`
- `vxScheduleGraph`
- `vxSetGraphAttribute`
- `vxVerifyGraph`
- `vxWaitGraph`

5.3.1. Typedefs

vx_graph

An opaque reference to a graph.

```
typedef struct _vx_graph *vx_graph;
```

See also: vxCreateGraph

5.3.2. Enumerations

vx_graph_attribute_e

The graph attributes list.

```
enum vx_graph_attribute_e {
    VX_GRAPH_NUMNODES = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_GRAPH) + 0x0,
    VX_GRAPH_PERFORMANCE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_GRAPH) + 0x2,
    VX_GRAPH_NUMPARAMETERS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_GRAPH) + 0x3,
    VX_GRAPH_STATE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_GRAPH) + 0x4,
};
```

Enumerator

- `VX_GRAPH_NUMNODES` - Returns the number of nodes in a graph. Read-only. Use a `vx_uint32` parameter.
- `VX_GRAPH_PERFORMANCE` - Returns the overall performance of the graph. Read-only. Use a `vx_perf_t` parameter. The accuracy of timing information is platform dependent.

  > *Note*
  >
  > Performance tracking must have been enabled. See `vx_directive_e`

- `VX_GRAPH_NUMPARAMETERS` - Returns the number of explicitly declared parameters on the graph. Read-only. Use a `vx_uint32` parameter.
- `VX_GRAPH_STATE` - Returns the state of the graph. See `vx_graph_state_e` enum.

vx_graph_state_e

The Graph State Enumeration.

```
enum vx_graph_state_e {
    VX_GRAPH_STATE_UNVERIFIED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_GRAPH_STATE) +
0x0,
    VX_GRAPH_STATE_VERIFIED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_GRAPH_STATE) + 0x1,
    VX_GRAPH_STATE_RUNNING = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_GRAPH_STATE) + 0x2,
    VX_GRAPH_STATE_ABANDONED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_GRAPH_STATE) + 0x3,
    VX_GRAPH_STATE_COMPLETED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_GRAPH_STATE) + 0x4,
};
```

Enumerator

* VX_GRAPH_STATE_UNVERIFIED - The graph should be verified before execution.
* VX_GRAPH_STATE_VERIFIED - The graph has been verified and has not been executed or scheduled for execution yet.
* VX_GRAPH_STATE_RUNNING - The graph either has been scheduled and not completed, or is being executed.
* VX_GRAPH_STATE_ABANDONED - The graph execution was abandoned.
* VX_GRAPH_STATE_COMPLETED - The graph execution is completed and the graph is not scheduled for execution.

5.3.3. Functions

vxCreateGraph

Creates an empty graph.

```
vx_graph vxCreateGraph(
    vx_context                                  context);
```

Parameters

* [in] *context* - The reference to the implementation context.

Returns: A graph reference vx_graph. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxIsGraphVerified

Returns a Boolean to indicate the state of graph verification.

```
vx_bool vxIsGraphVerified(
    vx_graph                                    graph);
```

Parameters

* [in] *graph* - The reference to the graph to check.

Returns: A vx_bool value.

Return Values

* vx_true_e - The graph is verified.
* vx_false_e - The graph is not verified. It must be verified before execution either through vxVerifyGraph or automatically through vxProcessGraph or vxScheduleGraph.

vxProcessGraph

This function causes the synchronous processing of a graph. If the graph has not been verified, then the implementation verifies the graph immediately. If verification fails this function returns a status identical to what `vxVerifyGraph` would return. After the graph verfies successfully then processing occurs. If the graph was previously verified via `vxVerifyGraph` or `vxProcessGraph` then the graph is processed. This function blocks until the graph is completed.

```
vx_status vxProcessGraph(
    vx_graph                                    graph);
```

Parameters

- `[in]` *graph* - The graph to execute.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Graph has been processed; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - graph is not a valid `vx_graph` reference.
- `VX_FAILURE` - A catastrophic error occurred during processing.

vxQueryGraph

Allows the user to query attributes of the Graph.

```
vx_status vxQueryGraph(
    vx_graph                                    graph,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- `[in]` *graph* - The reference to the created graph.
- `[in]` *attribute* - The `vx_graph_attribute_e` type needed.
- `[out]` *ptr* - The location at which to store the resulting value.
- `[in]` *size* - The size in bytes of the container to which *ptr* points.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - graph is not a valid `vx_graph` reference.

vxRegisterAutoAging

Register a delay for auto-aging.

```
vx_status vxRegisterAutoAging(
    vx_graph                                    graph,
    vx_delay                                    delay);
```

This function registers a delay object to be auto-aged by the graph. This delay object will be automatically aged after each successful completion of this graph. Aging of a delay object cannot be called during graph execution. A graph abandoned due to a node callback will trigger an auto-aging.

If a delay is registered for auto-aging multiple times in a same graph, the delay will be only aged a single time at each graph completion. If a delay is registered for auto-aging in multiple graphs, this delay will aged automatically after each successful completion of any of these graphs.

Parameters

- `[in]` *graph* - The graph to which the delay is registered for auto-aging.
- `[in]` *delay* - The delay to automatically age.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - graph is not a valid `vx_graph` reference, or delay is not a valid `vx_delay` reference.

vxReleaseGraph

Releases a reference to a graph. The object may not be garbage collected until its total reference count is zero. Once the reference count is zero, all node references in the graph are automatically released as well. Releasing the graph will only release the nodes if the nodes were not previously released by the application. Data referenced by those nodes may not be released as the user may still have references to the data.

```
vx_status vxReleaseGraph(
    vx_graph*                                   graph);
```

Parameters

- `[in]` *graph* - The pointer to the graph to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A `vx_status_e` enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - graph is not a valid vx_graph reference.

vxScheduleGraph

Schedules a graph for future execution. If the graph has not been verified, then the implementation verifies the graph immediately. If verification fails this function returns a status identical to what vxVerifyGraph would return. After the graph verfies successfully then processing occurs. If the graph was previously verified via vxVerifyGraph or vxProcessGraph then the graph is processed.

```
vx_status vxScheduleGraph(
    vx_graph                                    graph);
```

Parameters

- [in] *graph* - The graph to schedule.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - The graph has been scheduled; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - graph is not a valid vx_graph reference.
- VX_ERROR_NO_RESOURCES - The graph cannot be scheduled now.
- VX_ERROR_NOT_SUFFICIENT - The graph is not verified and has failed forced verification.

vxSetGraphAttribute

Allows the attributes of the Graph to be set to the provided value.

```
vx_status vxSetGraphAttribute(
    vx_graph                                    graph,
    vx_enum                                     attribute,
    const void*                                 ptr,
    vx_size                                     size);
```

Parameters

- [in] *graph* - The reference to the graph.
- [in] *attribute* - The vx_graph_attribute_e type needed.
- [in] *ptr* - The location from which to read the value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - graph is not a valid vx_graph reference.

vxVerifyGraph

Verifies the state of the graph before it is executed. This is useful to catch programmer errors and contract errors. If not verified, the graph verifies before being processed.

```
vx_status vxVerifyGraph(
    vx_graph                                    graph);
```

Precondition: Memory for data objects is not guarenteed to exist before this call.

Postcondition: After this call data objects exist unless the implementation optimized them out.

Parameters

- [in] *graph* - The reference to the graph to verify.

Returns: A status code for graphs with more than one error; it is undefined which error will be returned. Register a log callback using vxRegisterLogCallback to receive each specific error in the graph.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - graph is not a valid vx_graph reference.
- VX_ERROR_MULTIPLE_WRITERS - If the graph contains more than one writer to any data object.
- VX_ERROR_INVALID_NODE - If a node in the graph is invalid or failed be created.
- VX_ERROR_INVALID_GRAPH - If the graph contains cycles or some other invalid topology.
- VX_ERROR_INVALID_TYPE - If any parameter on a node is given the wrong type.
- VX_ERROR_INVALID_VALUE - If any value of any parameter is out of bounds of specification.
- VX_ERROR_INVALID_FORMAT - If the image format is not compatible.

See also: vxProcessGraph

vxWaitGraph

Waits for a specific graph to complete. If the graph has been scheduled multiple times since the last call to vxWaitGraph, then vxWaitGraph returns only when the last scheduled execution completes.

```
vx_status vxWaitGraph(
    vx_graph                                    graph);
```

Parameters

- [in] *graph* - The graph to wait on.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - The graph has successfully completed execution and its outputs are the valid results of the most recent execution; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - graph is not a valid vx_graph reference.
- VX_FAILURE - An error occurred or the graph was never scheduled. Output data of the graph is undefined.

Precondition: vxScheduleGraph

5.4. Object: Node

Defines the Node Object interface.

A node is an instance of a kernel that will be paired with a specific set of references (the parameters). Nodes are created from and associated with a single graph only. When a vx_parameter is extracted from a Node, an additional attribute can be accessed:

- *Reference* - The vx_reference assigned to this parameter index from the Node creation function (e.g., vxSobel3x3Node).

Typedefs

- vx_node

Enumerations

- vx_node_attribute_e

Functions

- vxQueryNode
- vxReleaseNode
- vxRemoveNode
- vxReplicateNode
- vxSetNodeAttribute
- vxSetNodeTarget

5.4.1. Typedefs

vx_node

An opaque reference to a kernel node.

```
typedef struct _vx_node *vx_node;
```

See also: vxCreateGenericNode

5.4.2. Enumerations

vx_node_attribute_e

The node attributes list.

```
enum vx_node_attribute_e {
    VX_NODE_STATUS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x0,
    VX_NODE_PERFORMANCE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x1,
    VX_NODE_BORDER = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x2,
    VX_NODE_LOCAL_DATA_SIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x3,
    VX_NODE_LOCAL_DATA_PTR = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x4,
    VX_NODE_PARAMETERS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x5,
    VX_NODE_IS_REPLICATED = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x6,
    VX_NODE_REPLICATE_FLAGS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x7,
    VX_NODE_VALID_RECT_RESET = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_NODE) + 0x8,
};
```

Enumerator

- `VX_NODE_STATUS` - Queries the status of node execution. Read-only. Use a `vx_status` parameter.
- `VX_NODE_PERFORMANCE` - Queries the performance of the node execution. The accuracy of timing information is platform dependent and also depends on the graph optimizations. Read-only.

  > *Note*
  >
  > Performance tracking must have been enabled. See `vx_directive_e`.

- `VX_NODE_BORDER` - Gets or sets the border mode of the node. Read-write. Use a `vx_border_t` structure with a default value of `VX_BORDER_UNDEFINED`.
- `VX_NODE_LOCAL_DATA_SIZE` - Indicates the size of the kernel local memory area. Read-only. Can be written only at user-node (de)initialization if `VX_KERNEL_LOCAL_DATA_SIZE` == 0. Use a `vx_size` parameter.
- `VX_NODE_LOCAL_DATA_PTR` - Indicates the pointer kernel local memory area. Read-Write. Can be written only at user-node (de)initialization if `VX_KERNEL_LOCAL_DATA_SIZE` == 0. Use a void * parameter.
- `VX_NODE_PARAMETERS` - Indicates the number of node parameters, including optional parameters

that are not passed. Read-only. Use a vx_uint32 parameter.

- VX_NODE_IS_REPLICATED - Indicates whether the node is replicated. Read-only. Use a vx_bool parameter.
- VX_NODE_REPLICATE_FLAGS - Indicates the replicated parameters. Read-only. Use a vx_bool* parameter.
- VX_NODE_VALID_RECT_RESET - Indicates the behavior with respect to the valid rectangle. Read-only. Use a vx_bool parameter.

5.4.3. Functions

vxQueryNode

Allows a user to query information out of a node.

```
vx_status vxQueryNode(
    vx_node                                     node,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *node* - The reference to the node to query.
- [in] *attribute* - Use vx_node_attribute_e value to query for information.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - node is not a valid vx_node reference.
- VX_ERROR_INVALID_PARAMETERS - The type or size is incorrect.

vxReleaseNode

Releases a reference to a Node object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseNode(
    vx_node*                                    node);
```

Parameters

- [in] *node* - The pointer to the reference of the node to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - *node* is not a valid vx_node reference.

vxRemoveNode

Removes a Node from its parent Graph and releases it.

```
vx_status vxRemoveNode(
    vx_node*                                    node);
```

Parameters

- [in] *node* - The pointer to the node to remove and release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - *node* is not a valid vx_node reference.

vxReplicateNode

Creates replicas of the same node first_node to process a set of objects stored in vx_pyramid or vx_object_array. first_node needs to have as parameter levels 0 of a vx_pyramid or the index 0 of a vx_object_array. Replica nodes are not accessible by the application through any means. An application request for removal of first_node from the graph will result in removal of all replicas. Any change of parameter or attribute of first_node will be propagated to the replicas. vxVerifyGraph shall enforce consistency of parameters and attributes in the replicas.

```
vx_status vxReplicateNode(
    vx_graph                                    graph,
    vx_node                                     first_node,
    vx_bool                                     replicate[],
    vx_uint32                                   number_of_parameters);
```

Parameters

- [in] *graph* - The reference to the graph.

- [in] *first_node* - The reference to the node in the graph that will be replicated.
- [in] *replicate* - an array of size equal to the number of node parameters, vx_true_e for the parameters that should be iterated over (should be a reference to a vx_pyramid or a vx_object_array), vx_false_e for the parameters that should be the same across replicated nodes and for optional parameters that are not used. Should be vx_true_e for all output and bidirectional parameters.
- [in] *number_of_parameters* - number of elements in the replicate array

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - *graph* is not a valid vx_graph reference, or first_node is not a valid vx_node reference.
- VX_ERROR_NOT_COMPATIBLE - At least one of replicated parameters is not of level 0 of a pyramid or at index 0 of an object array.
- VX_FAILURE - If the node does not belong to the graph, or the number of objects in the parent objects of inputs and output are not the same.

vxSetNodeAttribute

Allows a user to set attribute of a node before Graph Validation.

```
vx_status vxSetNodeAttribute(
    vx_node                                     node,
    vx_enum                                     attribute,
    const void*                                 ptr,
    vx_size                                     size);
```

Parameters

- [in] *node* - The reference to the node to set.
- [in] *attribute* - Use vx_node_attribute_e value to set the desired attribute.
- [in] *ptr* - The pointer to the desired value of the attribute.
- [in] *size* - The size in bytes of the objects to which *ptr* points.

> *Note*
>
> Some attributes are inherited from the vx_kernel, which was used to create the node. Some of these can be overridden using this API, notably VX_NODE_LOCAL_DATA_SIZE and VX_NODE_LOCAL_DATA_PTR.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - The attribute was set; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - node is not a valid vx_node reference.
- VX_ERROR_INVALID_PARAMETERS - size is not correct for the type needed.

vxSetNodeTarget

Sets the node target to the provided value. A success invalidates the graph that the node belongs to (vxVerifyGraph must be called before the next execution)

```
vx_status vxSetNodeTarget(
    vx_node                                     node,
    vx_enum                                     target_enum,
    const char*                                 target_string);
```

Parameters

- [in] *node* - The reference to the vx_node object.
- [in] *target_enum* - The target enum to be set to the vx_node object. Use a vx_target_e.
- [in] *target_string* - The target name ASCII string. This contains a valid value when *target_enum* is set to VX_TARGET_STRING, otherwise it is ignored.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Node target set; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - node is not a valid vx_node reference.
- VX_ERROR_NOT_SUPPORTED - If the node kernel is not supported by the specified target.

5.5. Object: Array

Defines the Array Object Interface.

Array is a strongly-typed container, which provides random access by index to its elements in constant time. It uses value semantics for its own elements and holds copies of data. This is an example for loop over an Array:

```
vx_size i, stride = sizeof(vx_size);
void *base = NULL;
vx_map_id map_id;
/* access entire array at once */
vxMapArrayRange(array, 0, num_items, &map_id, &stride, &base, VX_READ_AND_WRITE,
VX_MEMORY_TYPE_HOST, 0);
for (i = 0; i < num_items; i++)
{
    vxArrayItem(mystruct, base, i, stride).some_uint += i;
    vxArrayItem(mystruct, base, i, stride).some_double = 3.14f;
}
vxUnmapArrayRange(array, map_id);
```

Macros

- `vxArrayItem`
- `vxFormatArrayPointer`

Typedefs

- `vx_array`

Enumerations

- `vx_array_attribute_e`

Functions

- `vxAddArrayItems`
- `vxCopyArrayRange`
- `vxCreateArray`
- `vxCreateVirtualArray`
- `vxMapArrayRange`
- `vxQueryArray`
- `vxReleaseArray`
- `vxTruncateArray`
- `vxUnmapArrayRange`

5.5.1. Macros

vxArrayItem

Allows access to an array item as a typecast pointer deference.

```
#define vxArrayItem(type, ptr, index, stride) \
(*(type *)(&((uchar *)ptr)[index*stride]))
```

Parameters

- [in] *type* - The type of the item to access.
- [in] *ptr* - The base pointer for the array range.
- [in] *index* - The index of the element, not byte, to access.
- [in] *stride* - The 'number of bytes' between the beginning of two consecutive elements.

vxFormatArrayPointer

Accesses a specific indexed element in an array.

```
#define vxFormatArrayPointer(ptr, index, stride) \
    (&(((vx_uint8*)(ptr))[(index) * (stride)]))
```

Parameters

- [in] *ptr* - The base pointer for the array range.
- [in] *index* - The index of the element, not byte, to access.
- [in] *stride* - The 'number of bytes' between the beginning of two consecutive elements.

5.5.2. Typedefs

vx_array

The Array Object. Array is a strongly-typed container for other data structures.

```
typedef struct _vx_array *vx_array;
```

5.5.3. Enumerations

vx_array_attribute_e

The array object attributes.

```
enum vx_array_attribute_e {
    VX_ARRAY_ITEMTYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_ARRAY) + 0x0,
    VX_ARRAY_NUMITEMS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_ARRAY) + 0x1,
    VX_ARRAY_CAPACITY = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_ARRAY) + 0x2,
    VX_ARRAY_ITEMSIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_ARRAY) + 0x3,
};
```

Enumerator

- VX_ARRAY_ITEMTYPE - The type of the Array items. Read-only. Use a vx_enum parameter.
- VX_ARRAY_NUMITEMS - The number of items in the Array. Read-only. Use a vx_size parameter.
- VX_ARRAY_CAPACITY - The maximal number of items that the Array can hold. Read-only. Use a

vx_size parameter.

* VX_ARRAY_ITEMSIZE - Queries an array item size. Read-only. Use a vx_size parameter.

5.5.4. Functions

vxAddArrayItems

Adds items to the Array.

```
vx_status vxAddArrayItems(
    vx_array                                    arr,
    vx_size                                     count,
    const void*                                 ptr,
    vx_size                                     stride);
```

This function increases the container size.

By default, the function does not reallocate memory, so if the container is already full (number of elements is equal to capacity) or it doesn't have enough space, the function returns VX_FAILURE error code.

Parameters

* [in] *arr* - The reference to the Array.
* [in] *count* - The total number of elements to insert.
* [in] *ptr* - The location from which to read the input values.
* [in] *stride* - The number of bytes between the beginning of two consecutive elements.

Returns: A vx_status_e enumeration.

Return Values

* VX_SUCCESS - No errors; any other value indicates failure.
* VX_ERROR_INVALID_REFERENCE - arr is not a valid vx_array reference.
* VX_FAILURE - If the Array is full.
* VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.

vxCopyArrayRange

Allows the application to copy a range from/into an array object.

```
vx_status vxCopyArrayRange(
    vx_array                                    array,
    vx_size                                     range_start,
    vx_size                                     range_end,
    vx_size                                     user_stride,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- [in] *array* - The reference to the array object that is the source or the destination of the copy.
- [in] *range_start* - The index of the first item of the array object to copy.
- [in] *range_end* - The index of the item following the last item of the array object to copy. (*range_end* - *range_start*) items are copied from index *range_start* included. The range must be within the bounds of the array: 0 ≤ *range_start* < *range_end* ≤ number of items in the array.
- [in] *user_stride* - The number of bytes between the beginning of two consecutive items in the user memory pointed by user_ptr. The layout of the user memory must follow an item major order: *user_stride* ≥ element size in bytes.
- [in] *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the array object if the copy was requested in write mode. The accessible memory must be large enough to contain the specified range with the specified stride: accessible memory in bytes ≥ (*range_end* - *range_start*) * *user_stride*.
- [in] *usage* - This declares the effect of the copy with regard to the array object using the `vx_accessor_e` enumeration. Only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:
  - `VX_READ_ONLY` means that data are copied from the array object into the user memory.
  - `VX_WRITE_ONLY` means that data are copied into the array object from the user memory.
- [in] *user_mem_type* - A `vx_memory_type_e` enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_OPTIMIZED_AWAY` - This is a reference to a virtual array that cannot be accessed by the application.
- `VX_ERROR_INVALID_REFERENCE` - array is not a valid `vx_array` reference.
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

vxCreateArray

Creates a reference to an Array object.

```
vx_array vxCreateArray(
    vx_context                                  context,
    vx_enum                                     item_type,
    vx_size                                     capacity);
```

User must specify the Array capacity (i.e., the maximal number of items that the array can hold).

Parameters

- [in] *context* - The reference to the overall Context.
- [in] *item_type* - The type of data to hold. Must be greater than VX_TYPE_INVALID and less than or equal to VX_TYPE_VENDOR_STRUCT_END. Or must be a vx_enum returned from vxRegisterUserStruct.
- [in] *capacity* - The maximal number of items that the array can hold. This value must be greater than zero.

Returns: An array reference vx_array. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateVirtualArray

Creates an opaque reference to a virtual Array with no direct user access.

```
vx_array vxCreateVirtualArray(
    vx_graph                                    graph,
    vx_enum                                     item_type,
    vx_size                                     capacity);
```

Virtual Arrays are useful when item type or capacity are unknown ahead of time and the Array is used as internal graph edge. Virtual arrays are scoped within the parent graph only.

All of the following constructions are allowed.

```
vx_context context = vxCreateContext();
vx_graph graph = vxCreateGraph(context);
vx_array virt[] = {
vxCreateVirtualArray(graph, 0, 0), // totally unspecified
vxCreateVirtualArray(graph, VX_TYPE_KEYPOINT, 0), // unspecified capacity
vxCreateVirtualArray(graph, VX_TYPE_KEYPOINT, 1000), // no access
};
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *item_type* - The type of data to hold. Must be greater than VX_TYPE_INVALID and less than or equal to VX_TYPE_VENDOR_STRUCT_END. Or must be a vx_enum returned from vxRegisterUserStruct. This may to set to zero to indicate an unspecified item type.

- [in] *capacity* - The maximal number of items that the array can hold. This may be to set to zero to indicate an unspecified capacity.

See also: vxCreateArray for a type list.

Returns: A array reference vx_array. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxMapArrayRange

Allows the application to get direct access to a range of an array object.

```
vx_status vxMapArrayRange(
    vx_array                                    array,
    vx_size                                     range_start,
    vx_size                                     range_end,
    vx_map_id*                                  map_id,
    vx_size*                                    stride,
    void**                                      ptr,
    vx_enum                                     usage,
    vx_enum                                     mem_type,
    vx_uint32                                   flags);
```

Parameters

- [in] *array* - The reference to the array object that contains the range to map.
- [in] *range_start* - The index of the first item of the array object to map.
- [in] *range_end* - The index of the item following the last item of the array object to map. (*range_end* - *range_start*) items are mapped, starting from index *range_start* included. The range must be within the bounds of the array: must be 0 ≤ *range_start* < *range_end* ≤ number of items.
- [out] *map_id* - The address of a vx_map_id variable where the function returns a map identifier.
    - (*map_id) must eventually be provided as the map_id parameter of a call to vxUnmapArrayRange.
- [out] *stride* - The address of a vx_size variable where the function returns the memory layout of the mapped array range. The function sets (**stride*) to the number of bytes between the beginning of two consecutive items. The application must consult (**stride*) to access the array items starting from address (**ptr*). The layout of the mapped array follows an item major order: (**stride*) ≥ item size in bytes.
- [out] *ptr* - The address of a pointer that the function sets to the address where the requested data can be accessed. The returned (**ptr*) address is only valid between the call to the function and the corresponding call to vxUnmapArrayRange.
- [in] *usage* - This declares the access mode for the array range, using the vx_accessor_e enumeration.
    - VX_READ_ONLY: after the function call, the content of the memory location pointed by (**ptr*) contains the array range data. Writing into this memory location is forbidden and its

behavior is undefined.

  - VX_READ_AND_WRITE: after the function call, the content of the memory location pointed by (*ptr*) contains the array range data; writing into this memory is allowed only for the location of items and will result in a modification of the affected items in the array object once the range is unmapped. Writing into a gap between items (when (*stride) > item size in bytes) is forbidden and its behavior is undefined.
  - VX_WRITE_ONLY: after the function call, the memory location pointed by (*ptr*) contains undefined data; writing each item of the range is required prior to unmapping. Items not written by the application before unmap will become undefined after unmap, even if they were well defined before map. Like for VX_READ_AND_WRITE, writing into a gap between items is forbidden and its behavior is undefined.
- [in] *mem_type* - A vx_memory_type_e enumeration that specifies the type of the memory where the array range is requested to be mapped.
- [in] *flags* - An integer that allows passing options to the map operation. Use the vx_map_flag_e enumeration.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_OPTIMIZED_AWAY - This is a reference to a virtual array that cannot be accessed by the application.
- VX_ERROR_INVALID_REFERENCE - array is not a valid vx_array reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

Postcondition: vxUnmapArrayRange with same (*map_id) value.

vxQueryArray

Queries the Array for some specific information.

```
vx_status vxQueryArray(
    vx_array                                      arr,
    vx_enum                                       attribute,
    void*                                         ptr,
    vx_size                                       size);
```

Parameters

- [in] *arr* - The reference to the Array.
- [in] *attribute* - The attribute to query. Use a vx_array_attribute_e.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - arr is not a valid `vx_array` reference.
- `VX_ERROR_NOT_SUPPORTED` - If the *attribute* is not a value supported on this implementation.
- `VX_ERROR_INVALID_PARAMETERS` - If any of the other parameters are incorrect.

vxReleaseArray

Releases a reference of an Array object. The object may not be garbage collected until its total reference count is zero. After returning from this function the reference is zeroed.

```
vx_status vxReleaseArray(
    vx_array*                                   arr);
```

Parameters

- `[in]` *arr* - The pointer to the Array to release.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - arr is not a valid `vx_array` reference.

vxTruncateArray

Truncates an Array (remove items from the end).

```
vx_status vxTruncateArray(
    vx_array                                    arr,
    vx_size                                     new_num_items);
```

Parameters

- `[inout]` *arr* - The reference to the Array.
- `[in]` *new_num_items* - The new number of items for the Array.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - arr is not a valid `vx_array` reference.

- VX_ERROR_INVALID_PARAMETERS - The *new_size* is greater than the current size.

vxUnmapArrayRange

Unmap and commit potential changes to an array object range that was previously mapped. Unmapping an array range invalidates the memory location from which the range could be accessed by the application. Accessing this memory location after the unmap function completes has an undefined behavior.

```
vx_status vxUnmapArrayRange(
    vx_array                                    array,
    vx_map_id                                   map_id);
```

Parameters

- [in] *array* - The reference to the array object to unmap.
- [out] *map_id* - The unique map identifier that was returned when calling vxMapArrayRange.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - array is not a valid vx_array reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

Precondition: vxMapArrayRange returning the same map_id value

5.6. Object: Convolution

Defines the Image Convolution Object interface.

Typedefs

- vx_convolution

Enumerations

- vx_convolution_attribute_e

Functions

- vxCopyConvolutionCoefficients
- vxCreateConvolution
- vxCreateVirtualConvolution
- vxQueryConvolution
- vxReleaseConvolution
- vxSetConvolutionAttribute

5.6.1. Typedefs

vx_convolution

The Convolution Object. A user-defined convolution kernel of MxM elements.

```
typedef struct _vx_convolution *vx_convolution;
```

5.6.2. Enumerations

vx_convolution_attribute_e

The convolution attributes.

```
enum vx_convolution_attribute_e {
    VX_CONVOLUTION_ROWS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONVOLUTION) + 0x0,
    VX_CONVOLUTION_COLUMNS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONVOLUTION) +
0x1,
    VX_CONVOLUTION_SCALE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONVOLUTION) +
0x2,
    VX_CONVOLUTION_SIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_CONVOLUTION) + 0x3,
};
```

Enumerator

- `VX_CONVOLUTION_ROWS` - The number of rows of the convolution matrix. Read-only. Use a `vx_size` parameter.
- `VX_CONVOLUTION_COLUMNS` - The number of columns of the convolution matrix. Read-only. Use a `vx_size` parameter.
- `VX_CONVOLUTION_SCALE` - The scale of the convolution matrix. Read-write. Use a `vx_uint32` parameter.

  > *Note*
  >
  > For 1.0, only powers of 2 are supported up to 2^{31}.

- `VX_CONVOLUTION_SIZE` - The total size of the convolution matrix in bytes. Read-only. Use a `vx_size` parameter.

5.6.3. Functions

vxCopyConvolutionCoefficients

Allows the application to copy coefficients from/into a convolution object.

```
vx_status vxCopyConvolutionCoefficients(
    vx_convolution                              conv,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- `[in]` *conv* - The reference to the convolution object that is the source or the destination of the copy.
- `[in]` *user_ptr* - The address of the memory location where to store the requested coefficient data if the copy was requested in read mode, or from where to get the coefficient data to store into the convolution object if the copy was requested in write mode. In the user memory, the convolution coefficient data is structured as a row-major 2D array with elements of the type corresponding to `VX_TYPE_CONVOLUTION`, with a number of rows corresponding to `VX_CONVOLUTION_ROWS` and a number of columns corresponding to `VX_CONVOLUTION_COLUMNS`. The accessible memory must be large enough to contain this 2D array: accessible memory in bytes >= sizeof(data_element) * rows * columns.
- `[in]` *usage* - This declares the effect of the copy with regard to the convolution object using the `vx_accessor_e` enumeration. Only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:
    - `VX_READ_ONLY` means that data are copied from the convolution object into the user memory.
    - `VX_WRITE_ONLY` means that data are copied into the convolution object from the user memory.
- `[in]` *user_mem_type* - A `vx_memory_type_e` enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - conv is not a valid `vx_convolution` reference.
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

vxCreateConvolution

Creates a reference to a convolution matrix object.

```
vx_convolution vxCreateConvolution(
    vx_context                                  context,
    vx_size                                     columns,
    vx_size                                     rows);
```

Parameters

- `[in]` *context* - The reference to the overall context.

- [in] *columns* - The columns dimension of the convolution. Must be odd and greater than or equal to 3 and less than the value returned from VX_CONTEXT_CONVOLUTION_MAX_DIMENSION.
- [in] *rows* - The rows dimension of the convolution. Must be odd and greater than or equal to 3 and less than the value returned from VX_CONTEXT_CONVOLUTION_MAX_DIMENSION.

Returns: A convolution reference vx_convolution. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateVirtualConvolution

Creates an opaque reference to a convolution matrix object without direct user access.

```
vx_convolution vxCreateVirtualConvolution(
    vx_graph                                    graph,
    vx_size                                     columns,
    vx_size                                     rows);
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *columns* - The columns dimension of the convolution. Must be odd and greater than or equal to 3 and less than the value returned from VX_CONTEXT_CONVOLUTION_MAX_DIMENSION.
- [in] *rows* - The rows dimension of the convolution. Must be odd and greater than or equal to 3 and less than the value returned from VX_CONTEXT_CONVOLUTION_MAX_DIMENSION.

See also: vxCreateConvolution

Returns: A convolution reference vx_convolution. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxQueryConvolution

Queries an attribute on the convolution matrix object.

```
vx_status vxQueryConvolution(
    vx_convolution                              conv,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *conv* - The convolution matrix object to set.
- [in] *attribute* - The attribute to query. Use a vx_convolution_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - conv is not a valid vx_convolution reference.

vxReleaseConvolution

Releases the reference to a convolution matrix. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseConvolution(
    vx_convolution*                             conv);
```

Parameters

- [in] *conv* - The pointer to the convolution matrix to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - conv is not a valid vx_convolution reference.

vxSetConvolutionAttribute

Sets attributes on the convolution object.

```
vx_status vxSetConvolutionAttribute(
    vx_convolution                              conv,
    vx_enum                                     attribute,
    const void*                                 ptr,
    vx_size                                     size);
```

Parameters

- [in] *conv* - The coordinates object to set.
- [in] *attribute* - The attribute to modify. Use a vx_convolution_attribute_e enumeration.
- [in] *ptr* - The pointer to the value to which to set the attribute.
- [in] *size* - The size in bytes of the data pointed to by *ptr*.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - conv is not a valid vx_convolution reference.

5.7. Object: Distribution

Defines the Distribution Object Interface.

Typedefs

- vx_distribution

Enumerations

- vx_distribution_attribute_e

Functions

- vxCopyDistribution
- vxCreateDistribution
- vxCreateVirtualDistribution
- vxMapDistribution
- vxQueryDistribution
- vxReleaseDistribution
- vxUnmapDistribution

5.7.1. Typedefs

vx_distribution

The Distribution object. This has a user-defined number of bins over a user-defined range (within a uint32_t range).

```
typedef struct _vx_distribution *vx_distribution;
```

5.7.2. Enumerations

vx_distribution_attribute_e

The distribution attribute list.

```
enum vx_distribution_attribute_e {
    VX_DISTRIBUTION_DIMENSIONS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,
VX_TYPE_DISTRIBUTION) + 0x0,
    VX_DISTRIBUTION_OFFSET = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_DISTRIBUTION) +
0x1,
    VX_DISTRIBUTION_RANGE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_DISTRIBUTION) +
0x2,
    VX_DISTRIBUTION_BINS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_DISTRIBUTION) +
0x3,
    VX_DISTRIBUTION_WINDOW = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_DISTRIBUTION) +
0x4,
    VX_DISTRIBUTION_SIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_DISTRIBUTION) +
0x5,
};
```

Enumerator

- `VX_DISTRIBUTION_DIMENSIONS` - Indicates the number of dimensions in the distribution. Read-only. Use a `vx_size` parameter.
- `VX_DISTRIBUTION_OFFSET` - Indicates the start of the values to use (inclusive). Read-only. Use a `vx_int32` parameter.
- `VX_DISTRIBUTION_RANGE` - Indicates the total number of the consecutive values of the distribution interval.
- `VX_DISTRIBUTION_BINS` - Indicates the number of bins. Read-only. Use a `vx_size` parameter.
- `VX_DISTRIBUTION_WINDOW` - Indicates the width of a bin. Equal to the range divided by the number of bins. If the range is not a multiple of the number of bins, it is not valid. Read-only. Use a `vx_uint32` parameter.
- `VX_DISTRIBUTION_SIZE` - Indicates the total size of the distribution in bytes. Read-only. Use a `vx_size` parameter.

5.7.3. Functions

vxCopyDistribution

Allows the application to copy from/into a distribution object.

```
vx_status vxCopyDistribution(
    vx_distribution                             distribution,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- `[in]` *distribution* - The reference to the distribution object that is the source or the destination of the copy.

- [in] *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the distribution object if the copy was requested in write mode. In the user memory, the distribution is represented as a `vx_uint32` array with a number of elements equal to the value returned via `VX_DISTRIBUTION_BINS`. The accessible memory must be large enough to contain this vx_uint32 array: accessible memory in bytes ≥ sizeof(vx_uint32) * num_bins.
- [in] *usage* - This declares the effect of the copy with regard to the distribution object using the `vx_accessor_e` enumeration. Only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:
  - `VX_READ_ONLY` means that data are copied from the distribution object into the user memory.
  - `VX_WRITE_ONLY` means that data are copied into the distribution object from the user memory.
- [in] *user_mem_type* - A `vx_memory_type_e` enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - distribution is not a valid `vx_distribution` reference.
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

vxCreateDistribution

Creates a reference to a 1D Distribution of a consecutive interval [offset,offset+range-1] defined by a start *offset* and valid *range*, divided equally into *numBins* parts.

```
vx_distribution vxCreateDistribution(
    vx_context                                  context,
    vx_size                                     numBins,
    vx_int32                                    offset,
    vx_uint32                                   range);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *numBins* - The number of bins in the distribution.
- [in] *offset* - The start offset into the range value that marks the begining of the 1D Distribution.
- [in] *range* - The total number of the consecutive values of the distribution interval.

Returns: A distribution reference `vx_distribution`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateVirtualDistribution

Creates an opaque reference to a 1D Distribution object without direct user access.

```
vx_distribution vxCreateVirtualDistribution(
    vx_graph                                    graph,
    vx_size                                     numBins,
    vx_int32                                    offset,
    vx_uint32                                   range);
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *numBins* - The number of bins in the distribution.
- [in] *offset* - The start offset into the range value that marks the begining of the 1D Distribution.
- [in] *range* - The total number of the consecutive values of the distribution interval.

See also: vxCreateDistribution

Returns: A distribution reference vx_distribution. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxMapDistribution

Allows the application to get direct access to distribution object.

```
vx_status vxMapDistribution(
    vx_distribution                             distribution,
    vx_map_id*                                  map_id,
    void**                                      ptr,
    vx_enum                                     usage,
    vx_enum                                     mem_type,
    vx_bitfield                                 flags);
```

Parameters

- [in] *distribution* - The reference to the distribution object to map.
- [out] *map_id* - The address of a vx_map_id variable where the function returns a map identifier.
  - (**map_id*) must eventually be provided as the *map_id* parameter of a call to vxUnmapDistribution.
- [out] *ptr* - The address of a pointer that the function sets to the address where the requested data can be accessed. In the mapped memory area, data are structured as a vx_uint32 array with a number of elements equal to the value returned via VX_DISTRIBUTION_BINS. Each element of this array corresponds to a bin of the distribution, with a range-major ordering. Accessing the memory out of the bound of this array is forbidden and has an undefined behavior. The returned (**ptr*) address is only valid between the call to the function and the corresponding call to vxUnmapDistribution.
- [in] *usage* - This declares the access mode for the distribution, using the vx_accessor_e enumeration.

    ◦ VX_READ_ONLY: after the function call, the content of the memory location pointed by (*ptr) contains the distribution data. Writing into this memory location is forbidden and its behavior is undefined.
    ◦ VX_READ_AND_WRITE: after the function call, the content of the memory location pointed by (*ptr) contains the distribution data; writing into this memory is allowed only for the location of bins and will result in a modification of the affected bins in the distribution object once the distribution is unmapped.
    ◦ VX_WRITE_ONLY: after the function call, the memory location pointed by (*ptr) contains undefined data; writing each bin of distribution is required prior to unmapping. Bins not written by the application before unmap will become undefined after unmap, even if they were well defined before map.
- [in] *mem_type* - A vx_memory_type_e enumeration that specifies the type of the memory where the distribution is requested to be mapped.
- [in] *flags* - An integer that allows passing options to the map operation. Use 0 for this option.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - distribution is not a valid vx_distribution reference. reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

Postcondition: vxUnmapDistribution with same (*map_id) value.

vxQueryDistribution

Queries a Distribution object.

```
vx_status vxQueryDistribution(
    vx_distribution                             distribution,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *distribution* - The reference to the distribution to query.
- [in] *attribute* - The attribute to query. Use a vx_distribution_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

* `VX_SUCCESS` - No errors; any other value indicates failure.
* `VX_ERROR_INVALID_REFERENCE` - distribution is not a valid `vx_distribution` reference.

vxReleaseDistribution

Releases a reference to a distribution object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseDistribution(
    vx_distribution*                            distribution);
```

Parameters

* `[in]` *distribution* - The reference to the distribution to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A `vx_status_e` enumeration.

Return Values

* `VX_SUCCESS` - No errors; any other value indicates failure.
* `VX_ERROR_INVALID_REFERENCE` - distribution is not a valid `vx_distribution` reference.

vxUnmapDistribution

Unmap and commit potential changes to distribution object that was previously mapped. Unmapping a distribution invalidates the memory location from which the distribution data could be accessed by the application. Accessing this memory location after the unmap function completes has an undefined behavior.

```
vx_status vxUnmapDistribution(
    vx_distribution                             distribution,
    vx_map_id                                   map_id);
```

Parameters

* `[in]` *distribution* - The reference to the distribution object to unmap.
* `[out]` *map_id* - The unique map identifier that was returned when calling `vxMapDistribution`.

Returns: A `vx_status_e` enumeration.

Return Values

* `VX_SUCCESS` - No errors; any other value indicates failure.
* `VX_ERROR_INVALID_REFERENCE` - distribution is not a valid `vx_distribution` reference.
* `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

Precondition: vxMapDistribution returning the same map_id value

5.8. Object: Image

Defines the Image Object interface.

Data Structures

- vx_imagepatch_addressing_t
- vx_pixel_value_t

Macros

- VX_IMAGEPATCH_ADDR_INIT

Typedefs

- vx_image
- vx_map_id

Enumerations

- vx_channel_range_e
- vx_color_space_e
- vx_image_attribute_e
- vx_map_flag_e

Functions

- vxCopyImagePatch
- vxCreateImage
- vxCreateImageFromChannel
- vxCreateImageFromHandle
- vxCreateImageFromROI
- vxCreateUniformImage
- vxCreateVirtualImage
- vxFormatImagePatchAddress1d
- vxFormatImagePatchAddress2d
- vxGetValidRegionImage
- vxMapImagePatch
- vxQueryImage
- vxReleaseImage
- vxSetImageAttribute
- vxSetImagePixelValues
- vxSetImageValidRectangle
- vxSwapImageHandle
- vxUnmapImagePatch

5.8.1. Data Structures

vxUnmapImagePatch

The addressing image patch structure is used by the Host only to address pixels in an image patch. The fields of the structure are defined as:

```
typedef struct _vx_imagepatch_addressing_t {
    vx_uint32    dim_x;
    vx_uint32    dim_y;
    vx_int32     stride_x;
    vx_int32     stride_y;
    vx_uint32    scale_x;
    vx_uint32    scale_y;
    vx_uint32    step_x;
    vx_uint32    step_y;
} vx_imagepatch_addressing_t;
```

- dim_x, dim_y - The dimensions of the image in logical pixel units in the x & y direction.
- stride_x, stride_y - The physical byte distance from a logical pixel to the next logically adjacent pixel in the positive x or y direction.
- scale_x, scale_y - The relationship of scaling from the primary plane (typically the zero indexed plane) to this plane. An integer down-scaling factor of f shall be set to a value equal to scale = unity / f and an integer up-scaling factor of f shall be set to a value of scale = unity × f. unity is defined as `VX_SCALE_UNITY`.
- step_x, step_y - The step is the number of logical pixel units to skip to arrive at the next physically unique pixel. For example, on a plane that is half-scaled in a dimension, the step in that dimension is 2 to indicate that every other pixel in that dimension is an alias. This is useful in situations where iteration over unique pixels is required, such as in serializing or de-serializing the image patch information.

See also: `vxMapImagePatch`

vxUnmapImagePatch

Union that describes the value of a pixel for any image format. Use the field corresponding to the image format.

```
typedef union _vx_pixel_value_t {
    vx_uint8     RGB[3];
    vx_uint8     RGBX[4];
    vx_uint8     YUV[3];
    vx_uint8     U8;
    vx_uint16    U16;
    vx_int16     S16;
    vx_uint32    U32;
    vx_int32     S32;
    vx_uint8     reserved[16];
} vx_pixel_value_t;
```

- RGB - `VX_DF_IMAGE_RGB` format in the R,G,B order
- RGBX - `VX_DF_IMAGE_RGBX` format in the R,G,B,X order
- YUV - All YUV formats in the Y,U,V order
- U8 - `VX_DF_IMAGE_U8`
- U16 - `VX_DF_IMAGE_U16`
- S16 - `VX_DF_IMAGE_S16`
- U32 - `VX_DF_IMAGE_U32`
- S32 - `VX_DF_IMAGE_S32`
- reserved - unused

5.8.2. Macros

VX_IMAGEPATCH_ADDR_INIT

Use to initialize a `vx_imagepatch_addressing_t` structure on the stack.

```
#define VX_IMAGEPATCH_ADDR_INIT           {0u, 0u, 0, 0, 0u, 0u, 0u, 0u}
```

5.8.3. Typedefs

vx_image

An opaque reference to an image.

```
typedef struct _vx_image *vx_image;
```

See also: `vxCreateImage`

vx_map_id

Holds the address of a variable where the map/unmap functions return a map identifier.

```
typedef uintptr_t vx_map_id;
```

5.8.4. Enumerations

vx_channel_range_e

The image channel range list used by the VX_IMAGE_RANGE attribute of a vx_image.

```
enum vx_channel_range_e {
    VX_CHANNEL_RANGE_FULL = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_COLOR_RANGE) + 0x0,
    VX_CHANNEL_RANGE_RESTRICTED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_COLOR_RANGE) +
0x1,
};
```

Enumerator

- VX_CHANNEL_RANGE_FULL - Full range of the unit of the channel.
- VX_CHANNEL_RANGE_RESTRICTED - Restricted range of the unit of the channel based on the space given.

vx_color_space_e

The image color space list used by the VX_IMAGE_SPACE attribute of a vx_image.

```
enum vx_color_space_e {
    VX_COLOR_SPACE_NONE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_COLOR_SPACE) + 0x0,
    VX_COLOR_SPACE_BT601_525 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_COLOR_SPACE) + 0x1,
    VX_COLOR_SPACE_BT601_625 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_COLOR_SPACE) + 0x2,
    VX_COLOR_SPACE_BT709 = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_COLOR_SPACE) + 0x3,
    VX_COLOR_SPACE_DEFAULT = VX_COLOR_SPACE_BT709,
};
```

Enumerator

- VX_COLOR_SPACE_NONE - Use to indicate that no color space is used.
- VX_COLOR_SPACE_BT601_525 - Use to indicate that the BT.601 coefficients and SMPTE C primaries are used for conversions.
- VX_COLOR_SPACE_BT601_625 - Use to indicate that the BT.601 coefficients and BTU primaries are used for conversions.
- VX_COLOR_SPACE_BT709 - Use to indicate that the BT.709 coefficients are used for conversions.
- VX_COLOR_SPACE_DEFAULT - All images in VX are by default BT.709.

vx_image_attribute_e

The image attributes list.

```
enum vx_image_attribute_e {
    VX_IMAGE_WIDTH = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x0,
    VX_IMAGE_HEIGHT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x1,
    VX_IMAGE_FORMAT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x2,
    VX_IMAGE_PLANES = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x3,
    VX_IMAGE_SPACE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x4,
    VX_IMAGE_RANGE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x5,
    VX_IMAGE_MEMORY_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x7,
    VX_IMAGE_IS_UNIFORM = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x8,
    VX_IMAGE_UNIFORM_VALUE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_IMAGE) + 0x9,
};
```

Enumerator

- `VX_IMAGE_WIDTH` - Queries an image for its width. Read-only. Use a `vx_uint32` parameter.
- `VX_IMAGE_HEIGHT` - Queries an image for its height. Read-only. Use a `vx_uint32` parameter.
- `VX_IMAGE_FORMAT` - Queries an image for its format. Read-only. Use a `vx_df_image` parameter.
- `VX_IMAGE_PLANES` - Queries an image for its number of planes. Read-only. Use a `vx_size` parameter.
- `VX_IMAGE_SPACE` - Queries an image for its color space (see `vx_color_space_e`). Read-write. Use a `vx_enum` parameter.
- `VX_IMAGE_RANGE` - Queries an image for its channel range (see `vx_channel_range_e`). Read-only. Use a `vx_enum` parameter.
- `VX_IMAGE_MEMORY_TYPE` - Queries memory type if created using vxCreateImageFromHandle. If `vx_image` was not created using vxCreateImageFromHandle, `VX_MEMORY_TYPE_NONE` is returned. Use a `vx_memory_type_e` parameter.
- `VX_IMAGE_IS_UNIFORM` - Queries if an image is uniform. Read-only. Use a `vx_bool` parameter.
- `VX_IMAGE_UNIFORM_VALUE` - Queries the image uniform value if any. Read-only. Use a `vx_pixel_value_t` parameter.

vx_map_flag_e

The Map/Unmap operation enumeration.

```
enum vx_map_flag_e {
    VX_NOGAP_X = 1,
};
```

Enumerator

- `VX_NOGAP_X` - No Gap.

5.8.5. Functions

vxCopyImagePatch

Allows the application to copy a rectangular patch from/into an image object plane.

```
vx_status vxCopyImagePatch(
    vx_image                                    image,
    const vx_rectangle_t*                       image_rect,
    vx_uint32                                   image_plane_index,
    const vx_imagepatch_addressing_t*           user_addr,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- `[in]` *image* - The reference to the image object that is the source or the destination of the copy.
- `[in]` *image_rect* - The coordinates of the image patch. The patch must be within the bounds of the image. (*start_x*, *start_y*) gives the coordinates of the topleft pixel inside the patch, while (*end_x*, *end_y*) gives the coordinates of the bottomright element out of the patch. Must be 0 ≤ start < end ≤ number of pixels in the image dimension.
- `[in]` *image_plane_index* - The plane index of the image object that is the source or the destination of the patch copy.
- `[in]` *user_addr* - The address of a structure describing the layout of the user memory location pointed by user_ptr. In the structure, only *dim_x*, *dim_y*, *stride_x* and *stride_y* fields must be provided, other fields are ignored by the function. The layout of the user memory must follow a row major order: *stride_x* ≥ pixel size in bytes, and *stride_y* ≥ *stride_x* * *dim_x*.
- `[in]` *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the image object if the copy was requested in write mode. The accessible memory must be large enough to contain the specified patch with the specified layout: accessible memory in bytes ≥ (*end_y* - *start_y*) * *stride_y*.
- `[in]` *usage* - This declares the effect of the copy with regard to the image object using the `vx_accessor_e` enumeration. For uniform images, only `VX_READ_ONLY` is supported. For other images, only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:
  - `VX_READ_ONLY` means that data is copied from the image object into the application memory
  - `VX_WRITE_ONLY` means that data is copied into the image object from the application memory
- `[in]` *user_mem_type* - A `vx_memory_type_e` enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A `vx_status_e` enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_OPTIMIZED_AWAY - This is a reference to a virtual image that cannot be accessed by the application.
- VX_ERROR_INVALID_REFERENCE - image is not a valid vx_image reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

> *Note*
>
> The application may ask for data outside the bounds of the valid region, but such data has an undefined value.

vxCreateImage

Creates an opaque reference to an image buffer.

```
vx_image vxCreateImage(
    vx_context                                  context,
    vx_uint32                                   width,
    vx_uint32                                   height,
    vx_df_image                                 color);
```

Not guaranteed to exist until the vx_graph containing it has been verified.

Parameters

- [in] *context* - The reference to the implementation context.
- [in] *width* - The image width in pixels. The image in the formats of VX_DF_IMAGE_NV12, VX_DF_IMAGE_NV21, VX_DF_IMAGE_IYUV, VX_DF_IMAGE_UYVY, VX_DF_IMAGE_YUYV must have even width.
- [in] *height* - The image height in pixels. The image in the formats of VX_DF_IMAGE_NV12, VX_DF_IMAGE_NV21, VX_DF_IMAGE_IYUV must have even height.
- [in] *color* - The VX_DF_IMAGE (vx_df_image_e) code that represents the format of the image and the color space.

Returns: An image reference vx_image. Any possible errors preventing a successful creation should be checked using vxGetStatus.

See also: vxMapImagePatch to obtain direct memory access to the image data.

vxCreateImageFromChannel

Create a sub-image from a single plane channel of another image.

```
vx_image vxCreateImageFromChannel(
    vx_image                                    img,
    vx_enum                                     channel);
```

The sub-image refers to the data in the original image. Updates to this image update the parent image and reversely.

The function supports only channels that occupy an entire plane of a multi-planar images, as listed below. Other cases are not supported. `VX_CHANNEL_Y` from YUV4, IYUV, NV12, NV21 `VX_CHANNEL_U` from YUV4, IYUV `VX_CHANNEL_V` from YUV4, IYUV

Parameters

- `[in]` *img* - The reference to the parent image.
- `[in]` *channel* - The `vx_channel_e` channel to use.

Returns: An image reference `vx_image` to the sub-image. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateImageFromHandle

Creates a reference to an image object that was externally allocated.

```
vx_image vxCreateImageFromHandle(
    vx_context                                  context,
    vx_df_image                                 color,
    const vx_imagepatch_addressing_t            addrs[],
    void* const                                 ptrs[],
    vx_enum                                     memory_type);
```

Parameters

- `[in]` *context* - The reference to the implementation context.
- `[in]` *color* - See the `vx_df_image_e` codes. This mandates the number of planes needed to be valid in the *addrs* and *ptrs* arrays based on the format given.
- `[in]` *addrs[]* - The array of image patch addressing structures that define the dimension and stride of the array of pointers. See note below.
- `[in]` *ptrs[]* - The array of platform-defined references to each plane. See note below.
- `[in]` *memory_type* - `vx_memory_type_e`. When giving `VX_MEMORY_TYPE_HOST` the *ptrs* array is assumed to be HOST accessible pointers to memory.

Returns: An image reference `vx_image`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

Note

The user must call vxMapImagePatch prior to accessing the pixels of an image, even if the image was created via `vxCreateImageFromHandle`. Reads or writes to memory referenced by ptrs[ ] after calling `vxCreateImageFromHandle` without first calling `vxMapImagePatch` will result in undefined behavior. The property of addr[] and ptrs[] arrays is kept by the caller (It means that the implementation will make an internal copy of the provided information. *addr* and *ptrs* can then simply be application's local variables). Only *dim_x*, *dim_y*, *stride_x* and *stride_y* fields of the `vx_imagepatch_addressing_t` need to be provided by the application. Other fields (*step_x*, *step_y*, *scale_x* & *scale_y*) are ignored by this function. The layout of the imported memory must follow a row-major order. In other words, *stride_x* should be sufficiently large so that there is no overlap between data elements corresponding to different pixels, and

In order to release the image back to the application we should use `vxSwapImageHandle`.

Import type of the created image is available via the image attribute `vx_image_attribute_e` parameter.

vxCreateImageFromROI

Creates an image from another image given a rectangle. This second reference refers to the data in the original image. Updates to this image updates the parent image. The rectangle must be defined within the pixel space of the parent image.

```
vx_image vxCreateImageFromROI(
    vx_image                                    img,
    const vx_rectangle_t*                       rect);
```

Parameters

- `[in]` *img* - The reference to the parent image.
- `[in]` *rect* - The region of interest rectangle. Must contain points within the parent image pixel space.

Returns: An image reference `vx_image` to the sub-image. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateUniformImage

Creates a reference to an image object that has a singular, uniform value in all pixels. The uniform image created is read-only.

```
vx_image vxCreateUniformImage(
    vx_context                                  context,
    vx_uint32                                   width,
    vx_uint32                                   height,
    vx_df_image                                 color,
    const vx_pixel_value_t*                     value);
```

Parameters

- `[in]` *context* - The reference to the implementation context.
- `[in]` *width* - The image width in pixels. The image in the formats of `VX_DF_IMAGE_NV12`, `VX_DF_IMAGE_NV21`, `VX_DF_IMAGE_IYUV`, `VX_DF_IMAGE_UYVY`, `VX_DF_IMAGE_YUYV` must have even width.
- `[in]` *height* - The image height in pixels. The image in the formats of `VX_DF_IMAGE_NV12`, `VX_DF_IMAGE_NV21`, `VX_DF_IMAGE_IYUV` must have even height.
- `[in]` *color* - The `VX_DF_IMAGE` (`vx_df_image_e`) code that represents the format of the image and the color space.
- `[in]` *value* - The pointer to the pixel value to which to set all pixels. See `vx_pixel_value_t`.

Returns: An image reference `vx_image`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`. ``

See also: `vxMapImagePatch` to obtain direct memory access to the image data.

> *Note*
>
> `vxMapImagePatch` and `vxUnmapImagePatch` may be called with a uniform image reference.

vxCreateVirtualImage

Creates an opaque reference to an image buffer with no direct user access. This function allows setting the image width, height, or format.

```
vx_image vxCreateVirtualImage(
    vx_graph                                    graph,
    vx_uint32                                   width,
    vx_uint32                                   height,
    vx_df_image                                 color);
```

Virtual data objects allow users to connect various nodes within a graph via data references without access to that data, but they also permit the implementation to take maximum advantage of possible optimizations. Use this API to create a data reference to link two or more nodes together when the intermediate data are not required to be accessed by outside entities. This API in particular allows the user to define the image format of the data without requiring the exact dimensions. Virtual objects are scoped within the graph they are declared a part of, and can't be shared outside of this scope. All of the following constructions of virtual images are valid.

```
vx_context context = vxCreateContext();
vx_graph graph = vxCreateGraph(context);
vx_image virt[] = {
vxCreateVirtualImage(graph, 0, 0, VX_DF_IMAGE_U8), // no specified dimension
vxCreateVirtualImage(graph, 320, 240, VX_DF_IMAGE_VIRT), // no specified format
vxCreateVirtualImage(graph, 640, 480, VX_DF_IMAGE_U8), // no user access
};
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *width* - The width of the image in pixels. A value of zero informs the interface that the value is unspecified. The image in the formats of VX_DF_IMAGE_NV12, VX_DF_IMAGE_NV21, VX_DF_IMAGE_IYUV, VX_DF_IMAGE_UYVY, VX_DF_IMAGE_YUYV must have even width.
- [in] *height* - The height of the image in pixels. A value of zero informs the interface that the value is unspecified. The image in the formats of VX_DF_IMAGE_NV12, VX_DF_IMAGE_NV21, VX_DF_IMAGE_IYUV must have even height.
- [in] *color* - The VX_DF_IMAGE (vx_df_image_e) code that represents the format of the image and the color space. A value of VX_DF_IMAGE_VIRT informs the interface that the format is unspecified.

Returns: An image reference vx_image. Any possible errors preventing a successful creation should be checked using vxGetStatus.

Note

Passing this reference to vxMapImagePatch will return an error.

vxFormatImagePatchAddress1d

Accesses a specific indexed pixel in an image patch.

```
void* vxFormatImagePatchAddress1d(
    void*                                 ptr,
    vx_uint32                             index,
    const vx_imagepatch_addressing_t*     addr);
```

Parameters

- [in] *ptr* - The base pointer of the patch as returned from vxMapImagePatch.
- [in] *index* - The 0 based index of the pixel count in the patch. Indexes increase horizontally by 1 then wrap around to the next row.
- [in] *addr* - The pointer to the addressing mode information returned from vxMapImagePatch.

Returns: void * Returns the pointer to the specified pixel.

Precondition: vxMapImagePatch

vxFormatImagePatchAddress2d

Accesses a specific pixel at a 2d coordinate in an image patch.

```
void* vxFormatImagePatchAddress2d(
    void*                                       ptr,
    vx_uint32                                   x,
    vx_uint32                                   y,
    const vx_imagepatch_addressing_t*           addr);
```

Parameters

- [in] *ptr* - The base pointer of the patch as returned from vxMapImagePatch.
- [in] *x* - The x dimension within the patch.
- [in] *y* - The y dimension within the patch.
- [in] *addr* - The pointer to the addressing mode information returned from vxMapImagePatch.

Returns: void * Returns the pointer to the specified pixel.

Precondition: vxMapImagePatch

vxGetValidRegionImage

Retrieves the valid region of the image as a rectangle.

```
vx_status vxGetValidRegionImage(
    vx_image                                    image,
    vx_rectangle_t*                             rect);
```

Parameters

- [in] *image* - The image from which to retrieve the valid region.
- [out] *rect* - The destination rectangle.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - image is not a valid vx_image reference.
- VX_ERROR_INVALID_PARAMETERS - Invalid rect.

> *Note*
>
> This rectangle can be passed directly to vxMapImagePatch to get the full valid region of the image.

vxMapImagePatch

Allows the application to get direct access to a rectangular patch of an image object plane.

```
vx_status vxMapImagePatch(
    vx_image                                    image,
    const vx_rectangle_t*                       rect,
    vx_uint32                                   plane_index,
    vx_map_id*                                  map_id,
    vx_imagepatch_addressing_t*                 addr,
    void**                                      ptr,
    vx_enum                                     usage,
    vx_enum                                     mem_type,
    vx_uint32                                   flags);
```

Parameters

- `[in]` *image* - The reference to the image object that contains the patch to map.
- `[in]` *rect* - The coordinates of image patch. The patch must be within the bounds of the image. (*start_x*, *start_y*) gives the coordinate of the topleft element inside the patch, while (*end_x*, *end_y*) give the coordinate of the bottomright element out of the patch. Must be 0 ≤ start < end.
- `[in]` *plane_index* - The plane index of the image object to be accessed.
- `[out]` *map_id* - The address of a `vx_map_id` variable where the function returns a map identifier.
  - (*map_id) must eventually be provided as the *map_id* parameter of a call to `vxUnmapImagePatch`.
- `[out]` *addr* - The address of a structure describing the memory layout of the image patch to access. The function fills the structure pointed by addr with the layout information that the application must consult to access the pixel data at address (**ptr*). The layout of the mapped memory follows a row-major order: $stride\_x > 0$, $stride\_y > 0$ and $stride\_y \geq stride\_x * dim\_x$. If the image object being accessed was created via `vxCreateImageFromHandle`, then the returned memory layout will be the identical to that of the addressing structure provided when `vxCreateImageFromHandle` was called.
- `[out]` *ptr* - The address of a pointer that the function sets to the address where the requested data can be accessed. This returned (**ptr*) address is only valid between the call to this function and the corresponding call to `vxUnmapImagePatch`. If image was created via `vxCreateImageFromHandle` then the returned address (**ptr*) will be the address of the patch in the original pixel buffer provided when image was created.
- `[in]` *usage* - This declares the access mode for the image patch, using the `vx_accessor_e` enumeration. For uniform images, only `VX_READ_ONLY` is supported.
  - `VX_READ_ONLY`: after the function call, the content of the memory location pointed by (**ptr*) contains the image patch data. Writing into this memory location is forbidden and its behavior is undefined.
  - `VX_READ_AND_WRITE`: after the function call, the content of the memory location pointed by (**ptr*) contains the image patch data; writing into this memory is allowed only for the location of pixels only and will result in a modification of the written pixels in the image

object once the patch is unmapped. Writing into a gap between pixels (when *addr->stride_x* > pixel size in bytes or *addr->stride_y* > *addr->stride_x* * *addr->dim_x*) is forbidden and its behavior is undefined.

   - `VX_WRITE_ONLY`: after the function call, the memory location pointed by (**ptr*) contains undefined data; writing each pixel of the patch is required prior to unmapping. Pixels not written by the application before unmap will become undefined after unmap, even if they were well defined before map. Like for `VX_READ_AND_WRITE`, writing into a gap between pixels is forbidden and its behavior is undefined.

- `[in]` *mem_type* - A `vx_memory_type_e` enumeration that specifies the type of the memory where the image patch is requested to be mapped.
- `[in]` *flags* - An integer that allows passing options to the map operation. Use the `vx_map_flag_e` enumeration.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_OPTIMIZED_AWAY` - This is a reference to a virtual image that cannot be accessed by the application.
- `VX_ERROR_INVALID_REFERENCE` - image is not a valid `vx_image` reference. reference.
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

> *Note*
>
> The user may ask for data outside the bounds of the valid region, but such data has an undefined value.

Postcondition: `vxUnmapImagePatch` with same (*map_id) value.

vxQueryImage

Retrieves various attributes of an image.

```
vx_status vxQueryImage(
    vx_image                                    image,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- `[in]` *image* - The reference to the image to query.
- `[in]` *attribute* - The attribute to query. Use a `vx_image_attribute_e`.
- `[out]` *ptr* - The location at which to store the resulting value.
- `[in]` *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - image is not a valid vx_image reference.
- VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.
- VX_ERROR_NOT_SUPPORTED - If the attribute is not supported on this implementation.

vxReleaseImage

Releases a reference to an image object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseImage(
    vx_image*                                    image);
```

An implementation may defer the actual object destruction after its total reference count is zero (potentially until context destruction). Thus, releasing an image created from handle (see vxCreateImageFromHandle) and all others objects that may reference it (nodes, ROI, or channel for instance) are not sufficient to get back the ownership of the memory referenced by the current image handle. The only way for this is to call vxSwapImageHandle) before releasing the image.

Parameters

- [in] *image* - The pointer to the image to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - image is not a valid vx_image reference.

vxSetImageAttribute

Allows setting attributes on the image.

```
vx_status vxSetImageAttribute(
    vx_image                                     image,
    vx_enum                                      attribute,
    const void*                                  ptr,
    vx_size                                      size);
```

Parameters

- [in] *image* - The reference to the image on which to set the attribute.
- [in] *attribute* - The attribute to set. Use a vx_image_attribute_e enumeration.
- [in] *ptr* - The pointer to the location from which to read the value.
- [in] *size* - The size in bytes of the object pointed to by *ptr*.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - image is not a valid vx_image reference.
- VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.

vxSetImagePixelValues

Initialize an image with the given pixel value.

```
vx_status vxSetImagePixelValues(
    vx_image                                    image,
    const vx_pixel_value_t*                     pixel_value);
```

Parameters

- [in] *image* - The reference to the image to initialize.
- [in] *pixel_value* - The pointer to the constant pixel value to initialize all image pixels. See vx_pixel_value_t.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors.
- VX_ERROR_INVALID_REFERENCE - If the image is a uniform image, a virtual image, or not a vx_image.
- VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.

> *Note*
>
> All pixels of the entire image are initialized to the indicated pixel value, independently from the valid region. The valid region of the image is unaffected by this function. The image remains mutable after the call to this function, so its pixels and mutable attributes may be changed by subsequent functions.

vxSetImageValidRectangle

Sets the valid rectangle for an image according to a supplied rectangle.

```
vx_status vxSetImageValidRectangle(
    vx_image                                    image,
    const vx_rectangle_t*                       rect);
```

> *Note*
>
> Setting or changing the valid region from within a user node by means other than the call-back, for example by calling `vxSetImageValidRectangle`, might result in an incorrect valid region calculation by the framework.

Parameters

- `[in]` *image* - The reference to the image.
- `[in]` *rect* - The value to be set to the image valid rectangle. A `NULL` indicates that the valid region is the entire image.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - image is not a valid `vx_image` reference.
- `VX_ERROR_INVALID_PARAMETERS` - The rect does not define a proper valid rectangle.

vxSwapImageHandle

Swaps the image handle of an image previously created from handle.

```
vx_status vxSwapImageHandle(
    vx_image                                    image,
    void* const                                 new_ptrs[],
    void*                                       prev_ptrs[],
    vx_size                                     num_planes);
```

This function sets the new image handle (i.e. pointer to all image planes) and returns the previous one.

Once this function call has completed, the application gets back the ownership of the memory referenced by the previous handle. This memory contains up-to-date pixel data, and the application can safely reuse or release it.

The memory referenced by the new handle must have been allocated consistently with the image properties since the import type, memory layout and dimensions are unchanged (see addrs, color, and memory_type in `vxCreateImageFromHandle`).

All images created from ROI or channel with this image as parent or ancestor will automatically use the memory referenced by the new handle.

The behavior of `vxSwapImageHandle` when called from a user node is undefined.

Parameters

- `[in]` *image* - The reference to an image created from handle
- `[in]` *new_ptrs[]* - pointer to a caller owned array that contains the new image handle (image plane pointers)
  - *new_ptrs* is non-`NULL`. *new_ptrs*[i] must be non-`NULL` for each i such as 0 < i < nbPlanes, otherwise, this is an error. The address of the storage memory for image plane i is set to *new_ptrs*[i]
  - *new_ptrs* is `NULL`: the previous image storage memory is reclaimed by the caller, while no new handle is provided.
- `[out]` *prev_ptrs[]* - pointer to a caller owned array in which the application returns the previous image handle
  - *prev_ptrs* is non-`NULL`. *prev_ptrs* must have at least as many elements as the number of image planes. For each i such as 0 < i < nbPlanes, *prev_ptrs*[i] is set to the address of the previous storage memory for plane i.
  - *prev_ptrs* is `NULL`: the previous handle is not returned.
- `[in]` *num_planes* - Number of planes in the image. This must be set equal to the number of planes of the input image. The number of elements in *new_ptrs* and *prev_ptrs* arrays must be equal to or greater than *num_planes*. If either array has more than *num_planes* elements, the extra elements are ignored. If either array is smaller than *num_planes*, the results are undefined.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors.
- `VX_ERROR_INVALID_REFERENCE` - image is not a valid `vx_image` reference. reference.
- `VX_ERROR_INVALID_PARAMETERS` - The image was not created from handle or the content of new_ptrs is not valid.
- `VX_FAILURE` - The image was already being accessed.

vxUnmapImagePatch

Unmap and commit potential changes to a image object patch that were previously mapped. Unmapping an image patch invalidates the memory location from which the patch could be accessed by the application. Accessing this memory location after the unmap function completes has an undefined behavior.

```
vx_status vxUnmapImagePatch(
    vx_image                                    image,
    vx_map_id                                   map_id);
```

Parameters

- [in] *image* - The reference to the image object to unmap.
- [out] *map_id* - The unique map identifier that was returned by vxMapImagePatch.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - image is not a valid vx_image reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

Precondition: vxMapImagePatch with same map_id value

5.9. Object: LUT

Defines the Look-Up Table Interface.

A lookup table is an array that simplifies run-time computation by replacing computation with a simpler array indexing operation.

Typedefs

- vx_lut

Enumerations

- vx_lut_attribute_e

Functions

- vxCopyLUT
- vxCreateLUT
- vxCreateVirtualLUT
- vxMapLUT
- vxQueryLUT
- vxReleaseLUT
- vxUnmapLUT

5.9.1. Typedefs

vx_lut

The Look-Up Table (LUT) Object.

```
typedef struct _vx_lut *vx_lut;
```

5.9.2. Enumerations

vx_lut_attribute_e

The Look-Up Table (LUT) attribute list.

```
enum vx_lut_attribute_e {
    VX_LUT_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,VX_TYPE_LUT) + 0x0,
    VX_LUT_COUNT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,VX_TYPE_LUT) + 0x1,
    VX_LUT_SIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,VX_TYPE_LUT) + 0x2,
    VX_LUT_OFFSET = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS,VX_TYPE_LUT) + 0x3,
};
```

Enumerator

- `VX_LUT_TYPE` - Indicates the value type of the LUT. Read-only. Use a `vx_enum`.
- `VX_LUT_COUNT` - Indicates the number of elements in the LUT. Read-only. Use a `vx_size`.
- `VX_LUT_SIZE` - Indicates the total size of the LUT in bytes. Read-only. Uses a `vx_size`.
- `VX_LUT_OFFSET` - Indicates the index of the input value = 0. Read-only. Uses a `vx_uint32`.

5.9.3. Functions

vxCopyLUT

Allows the application to copy from/into a LUT object.

```
vx_status vxCopyLUT(
    vx_lut                                      lut,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- `[in]` *lut* - The reference to the LUT object that is the source or the destination of the copy.
- `[in]` *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the LUT object if the copy was requested in write mode. In the user memory, the LUT is represented as a array with elements of the type corresponding to `VX_LUT_TYPE`, and with a number of elements equal to the value returned via `VX_LUT_COUNT`. The accessible memory must be large enough to contain this array: accessible memory in bytes ≥ sizeof(data_element) * count.
- `[in]` *usage* - This declares the effect of the copy with regard to the LUT object using the `vx_accessor_e` enumeration. Only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:
  - `VX_READ_ONLY` means that data are copied from the LUT object into the user memory.
  - `VX_WRITE_ONLY` means that data are copied into the LUT object from the user memory.

- [in] *user_mem_type* - A vx_memory_type_e enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - lut is not a valid vx_lut reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

vxCreateLUT

Creates LUT object of a given type. The value of VX_LUT_OFFSET is equal to 0 for data_type = VX_TYPE_UINT8, and (vx_uint32)(count/2) for VX_TYPE_INT16.

```
vx_lut vxCreateLUT(
    vx_context                                  context,
    vx_enum                                     data_type,
    vx_size                                     count);
```

Parameters

- [in] *context* - The reference to the context.
- [in] *data_type* - The type of data stored in the LUT.
- [in] *count* - The number of entries desired.

> *Note*
>
> *data_type* can only be VX_TYPE_UINT8 or VX_TYPE_INT16. If *data_type* is VX_TYPE_UINT8, *count* should not be greater than 256. If *data_type* is VX_TYPE_INT16, *count* should not be greater than 65536.

Returns: An LUT reference vx_lut. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateVirtualLUT

Creates an opaque reference to a LUT object with no direct user access.

```
vx_lut vxCreateVirtualLUT(
    vx_graph                                    graph,
    vx_enum                                     data_type,
    vx_size                                     count);
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *data_type* - The type of data stored in the LUT.
- [in] *count* - The number of entries desired.

See also: vxCreateLUT

> *Note*
>
> *data_type* can only be VX_TYPE_UINT8 or VX_TYPE_INT16. If *data_type* is VX_TYPE_UINT8, *count* should not be greater than 256. If *data_type* is VX_TYPE_INT16, *count* should not be greater than 65536.

Returns: An LUT reference vx_lut. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxMapLUT

Allows the application to get direct access to LUT object.

```
vx_status vxMapLUT(
    vx_lut                                      lut,
    vx_map_id*                                  map_id,
    void**                                      ptr,
    vx_enum                                     usage,
    vx_enum                                     mem_type,
    vx_bitfield                                 flags);
```

Parameters

- [in] *lut* - The reference to the LUT object to map.
- [out] *map_id* - The address of a vx_map_id variable where the function returns a map identifier.
  - (*map_id) must eventually be provided as the map_id parameter of a call to vxUnmapLUT.
- [out] *ptr* - The address of a pointer that the function sets to the address where the requested data can be accessed. In the mapped memory area, the LUT data are structured as an array with elements of the type corresponding to VX_LUT_TYPE, with a number of elements equal to the value returned via VX_LUT_COUNT. Accessing the memory out of the bound of this array is forbidden and has an undefined behavior. The returned (**ptr*) address is only valid between the call to the function and the corresponding call to vxUnmapLUT.
- [in] *usage* - This declares the access mode for the LUT, using the vx_accessor_e enumeration.
  - VX_READ_ONLY: after the function call, the content of the memory location pointed by (**ptr*) contains the LUT data. Writing into this memory location is forbidden and its behavior is undefined.
  - VX_READ_AND_WRITE: after the function call, the content of the memory location pointed by (**ptr*) contains the LUT data; writing into this memory is allowed only for the location of entries and will result in a modification of the affected entries in the LUT object once the LUT is unmapped.

    ◦ VX_WRITE_ONLY: after the function call, the memory location pointed by(*ptr*) contains undefined data; writing each entry of LUT is required prior to unmapping. Entries not written by the application before unmap will become undefined after unmap, even if they were well defined before map.

- [in] *mem_type* - A vx_memory_type_e enumeration that specifies the type of the memory where the LUT is requested to be mapped.
- [in] *flags* - An integer that allows passing options to the map operation. Use 0 for this option.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - lut is not a valid vx_lut reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

Postcondition: vxUnmapLUT with same (*map_id) value.

vxQueryLUT

Queries attributes from a LUT.

```
vx_status vxQueryLUT(
    vx_lut                                      lut,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *lut* - The LUT to query.
- [in] *attribute* - The attribute to query. Use a vx_lut_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - lut is not a valid vx_lut reference.

vxReleaseLUT

Releases a reference to a LUT object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseLUT(
    vx_lut*                                     lut);
```

Parameters

- [in] *lut* - The pointer to the LUT to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - lut is not a valid vx_lut reference.

vxUnmapLUT

Unmap and commit potential changes to LUT object that was previously mapped. Unmapping a LUT invalidates the memory location from which the LUT data could be accessed by the application. Accessing this memory location after the unmap function completes has an undefined behavior.

```
vx_status vxUnmapLUT(
    vx_lut                                      lut,
    vx_map_id                                   map_id);
```

Parameters

- [in] *lut* - The reference to the LUT object to unmap.
- [out] *map_id* - The unique map identifier that was returned when calling vxMapLUT.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - lut is not a valid vx_lut reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

Precondition: vxMapLUT returning the same map_id value

5.10. Object: Matrix

Defines the Matrix Object Interface.

Typedefs

- vx_matrix

Enumerations

- vx_matrix_attribute_e

Functions

- vxCopyMatrix
- vxCreateMatrix
- vxCreateMatrixFromPattern
- vxCreateMatrixFromPatternAndOrigin
- vxCreateVirtualMatrix
- vxQueryMatrix
- vxReleaseMatrix

5.10.1. Typedefs

vx_matrix

The Matrix Object. An MxN matrix of some unit type.

```
typedef struct _vx_matrix *vx_matrix;
```

5.10.2. Enumerations

vx_matrix_attribute_e

The matrix attributes.

```
enum vx_matrix_attribute_e {
    VX_MATRIX_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_MATRIX) + 0x0,
    VX_MATRIX_ROWS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_MATRIX) + 0x1,
    VX_MATRIX_COLUMNS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_MATRIX) + 0x2,
    VX_MATRIX_SIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_MATRIX) + 0x3,
    VX_MATRIX_ORIGIN = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_MATRIX) + 0x4,
    VX_MATRIX_PATTERN = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_MATRIX) + 0x5,
};
```

Enumerator

- VX_MATRIX_TYPE - The value type of the matrix. Read-only. Use a vx_enum parameter.
- VX_MATRIX_ROWS - The M dimension of the matrix. Read-only. Use a vx_size parameter.
- VX_MATRIX_COLUMNS - The N dimension of the matrix. Read-only. Use a vx_size parameter.
- VX_MATRIX_SIZE - The total size of the matrix in bytes. Read-only. Use a vx_size parameter.
- VX_MATRIX_ORIGIN - The origin of the matrix with a default value of [floor(

VX_MATRIX_COLUMNS/2),floor(VX_MATRIX_ROWS/2)] Read-only. Use a vx_coordinates2d_t parameter.

- VX_MATRIX_PATTERN - The pattern of the matrix. See vx_pattern_e. Read-only. Use a vx_enum parameter. If the matrix was created via vxCreateMatrixFromPattern or vxCreateMatrixFromPatternAndOrigin, the attribute corresponds to the given pattern. Otherwise the attribute is VX_PATTERN_OTHER.

5.10.3. Functions

vxCopyMatrix

Allows the application to copy from/into a matrix object.

```
vx_status vxCopyMatrix(
    vx_matrix                                   matrix,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- [in] *matrix* - The reference to the matrix object that is the source or the destination of the copy.
- [in] *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the matrix object if the copy was requested in write mode. In the user memory, the matrix is structured as a row-major 2D array with elements of the type corresponding to VX_MATRIX_TYPE, with a number of rows corresponding to VX_MATRIX_ROWS and a number of columns corresponding to VX_MATRIX_COLUMNS. The accessible memory must be large enough to contain this 2D array: accessible memory in bytes ≥ sizeof(data_element) * rows * columns.
- [in] *usage* - This declares the effect of the copy with regard to the matrix object using the vx_accessor_e enumeration. Only VX_READ_ONLY and VX_WRITE_ONLY are supported:
  - VX_READ_ONLY means that data are copied from the matrix object into the user memory.
  - VX_WRITE_ONLY means that data are copied into the matrix object from the user memory.
- [in] *user_mem_type* - A vx_memory_type_e enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - matrix is not a valid vx_matrix reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

vxCreateMatrix

Creates a reference to a matrix object.

```
vx_matrix vxCreateMatrix(
    vx_context                                    c,
    vx_enum                                       data_type,
    vx_size                                       columns,
    vx_size                                       rows);
```

Parameters

- [in] *c* - The reference to the overall context.
- [in] *data_type* - The unit format of the matrix. VX_TYPE_UINT8 or VX_TYPE_INT32 or VX_TYPE_FLOAT32.
- [in] *columns* - The first dimensionality.
- [in] *rows* - The second dimensionality.

Returns: An matrix reference vx_matrix. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateMatrixFromPattern

Creates a reference to a matrix object from a boolean pattern.

```
vx_matrix vxCreateMatrixFromPattern(
    vx_context                                    context,
    vx_enum                                       pattern,
    vx_size                                       columns,
    vx_size                                       rows);
```

See also: vxCreateMatrixFromPatternAndOrigin for a description of the matrix patterns.

Parameters

- [in] *context* - The reference to the overall context.
- [in] *pattern* - The pattern of the matrix. See VX_MATRIX_PATTERN.
- [in] *columns* - The first dimensionality.
- [in] *rows* - The second dimensionality.

Returns: A matrix reference vx_matrix of type VX_TYPE_UINT8. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateMatrixFromPatternAndOrigin

Creates a reference to a matrix object from a boolean pattern, with a user-specified origin.

```
vx_matrix vxCreateMatrixFromPatternAndOrigin(
    vx_context                                   context,
    vx_enum                                      pattern,
    vx_size                                      columns,
    vx_size                                      rows,
    vx_size                                      origin_col,
    vx_size                                      origin_row);
```

The matrix created by this function is of type `VX_TYPE_UINT8`, with the value 0 representing False, and the value 255 representing True. It supports the patterns as described below:

- `VX_PATTERN_BOX` is a matrix with dimensions equal to the given number of rows and columns, and all cells equal to 255. Dimensions of 3x3 and 5x5 must be supported.
- `VX_PATTERN_CROSS` is a matrix with dimensions equal to the given number of rows and columns, which both must be odd numbers. All cells in the center row and center column are equal to 255, and the rest are equal to zero. Dimensions of 3x3 and 5x5 must be supported.
- `VX_PATTERN_DISK` is a matrix with dimensions equal to the given number of rows ® and columns ©, where R and C are odd and cell (c, r) is 255 if:

  $(r-R/2 + 0.5)^2 / (R/2)^2 + (c-C/2 + 0.5)^2 / (C/2)^2$ is less than or equal to 1, and 0 otherwise.

A matrix created from pattern is read-only. The behavior when attempting to modify such a matrix is undefined.

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *pattern* - The pattern of the matrix. See `VX_MATRIX_PATTERN`.
- `[in]` *columns* - The first dimensionality.
- `[in]` *rows* - The second dimensionality.
- `[in]` *origin_col* - The origin (first dimensionality).
- `[in]` *origin_row* - The origin (second dimensionality).

Returns: A matrix reference `vx_matrix` of type `VX_TYPE_UINT8`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateVirtualMatrix

Creates an opaque reference to a matrix object without direct user access.

```
vx_matrix vxCreateVirtualMatrix(
    vx_graph                                     graph,
    vx_enum                                      data_type,
    vx_size                                      columns,
    vx_size                                      rows);
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *data_type* - The unit format of the matrix. VX_TYPE_UINT8 or VX_TYPE_INT32 or VX_TYPE_FLOAT32.
- [in] *columns* - The first dimensionality.
- [in] *rows* - The second dimensionality.

See also: vxCreateMatrix

Returns: An matrix reference vx_matrix. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxQueryMatrix

Queries an attribute on the matrix object.

```
vx_status vxQueryMatrix(
    vx_matrix                                    mat,
    vx_enum                                      attribute,
    void*                                        ptr,
    vx_size                                      size);
```

Parameters

- [in] *mat* - The matrix object to set.
- [in] *attribute* - The attribute to query. Use a vx_matrix_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - mat is not a valid vx_matrix reference.

vxReleaseMatrix

Releases a reference to a matrix object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseMatrix(
    vx_matrix*                                   mat);
```

Parameters

- [in] *mat* - The matrix reference to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - mat is not a valid vx_matrix reference.

5.11. Object: Pyramid

Defines the Image Pyramid Object Interface.

A Pyramid object in OpenVX represents a collection of related images. Typically, these images are created by either downscaling or upscaling a *base image*, contained in level zero of the pyramid. Successive levels of the pyramid increase or decrease in size by a factor given by the VX_PYRAMID_SCALE attribute. For instance, in a pyramid with 3 levels and VX_SCALE_PYRAMID_HALF, the level one image is one-half the width and one-half the height of the level zero image, and the level two image is one-quarter the width and one quarter the height of the level zero image. When downscaling or upscaling results in a non-integral number of pixels at any level, fractional pixels always get rounded up to the nearest integer. (E.g., a 3-level image pyramid beginning with level zero having a width of 9 and a scaling of VX_SCALE_PYRAMID_HALF results in the level one image with a width of 5 = **ceil**(9 × 0.5) and a level two image with a width of 3 = **ceil**(5 × 0.5). Position (r_N,c_N) at level N corresponds to position (r_{N-1} / **scale**, c_{N-1} / **scale**) at level N-1.

Macros

- VX_SCALE_PYRAMID_HALF
- VX_SCALE_PYRAMID_ORB

Typedefs

- vx_pyramid

Enumerations

- vx_pyramid_attribute_e

Functions

- vxCreatePyramid
- vxCreateVirtualPyramid
- vxGetPyramidLevel
- vxQueryPyramid
- vxReleasePyramid

5.11.1. Macros

VX_SCALE_PYRAMID_HALF

Use to indicate a half-scale pyramid.

```
#define VX_SCALE_PYRAMID_HALF            (0.5f)
```

VX_SCALE_PYRAMID_ORB

Use to indicate a ORB scaled pyramid whose scaling factor is $\frac{1}{\sqrt[4]{2}}$.

```
#define VX_SCALE_PYRAMID_ORB             ((vx_float32)0.8408964f)
```

5.11.2. Typedefs

vx_pyramid

The Image Pyramid object. A set of scaled images.

```
typedef struct _vx_pyramid *vx_pyramid;
```

5.11.3. Enumerations

vx_pyramid_attribute_e

The pyramid object attributes.

```
enum vx_pyramid_attribute_e {
    VX_PYRAMID_LEVELS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PYRAMID) + 0x0,
    VX_PYRAMID_SCALE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PYRAMID) + 0x1,
    VX_PYRAMID_WIDTH = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PYRAMID) + 0x2,
    VX_PYRAMID_HEIGHT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PYRAMID) + 0x3,
    VX_PYRAMID_FORMAT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PYRAMID) + 0x4,
};
```

Enumerator

- `VX_PYRAMID_LEVELS` - The number of levels of the pyramid. Read-only. Use a `vx_size` parameter.
- `VX_PYRAMID_SCALE` - The scale factor between each level of the pyramid. Read-only. Use a `vx_float32` parameter.
- `VX_PYRAMID_WIDTH` - The width of the 0th image in pixels. Read-only. Use a `vx_uint32` parameter.
- `VX_PYRAMID_HEIGHT` - The height of the 0th image in pixels. Read-only. Use a `vx_uint32` parameter.
- `VX_PYRAMID_FORMAT` - The `vx_df_image_e` format of the image. Read-only. Use a `vx_df_image`

parameter.

5.11.4. Functions

vxCreatePyramid

Creates a reference to a pyramid object of the supplied number of levels.

```
vx_pyramid vxCreatePyramid(
    vx_context                                  context,
    vx_size                                     levels,
    vx_float32                                  scale,
    vx_uint32                                   width,
    vx_uint32                                   height,
    vx_df_image                                 format);
```

Parameters

- `[in]` *context* - The reference to the overall context.
- `[in]` *levels* - The number of levels desired. This is required to be a non-zero value.
- `[in]` *scale* - Used to indicate the scale between pyramid levels. This is required to be a non-zero positive value. `VX_SCALE_PYRAMID_HALF` and `VX_SCALE_PYRAMID_ORB` must be supported.
- `[in]` *width* - The width of the 0th level image in pixels.
- `[in]` *height* - The height of the 0th level image in pixels.
- `[in]` *format* - The format of all images in the pyramid. NV12, NV21, IYUV, UYVY and YUYV formats are not supported.

Returns: A pyramid reference `vx_pyramid` containing the sub-images. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateVirtualPyramid

Creates a reference to a virtual pyramid object of the supplied number of levels.

```
vx_pyramid vxCreateVirtualPyramid(
    vx_graph                                    graph,
    vx_size                                     levels,
    vx_float32                                  scale,
    vx_uint32                                   width,
    vx_uint32                                   height,
    vx_df_image                                 format);
```

Virtual Pyramids can be used to connect Nodes together when the contents of the pyramids will not be accessed by the user of the API. All of the following constructions are valid:

```
vx_context context = vxCreateContext();
vx_graph graph = vxCreateGraph(context);
vx_pyramid virt[] = {
vxCreateVirtualPyramid(graph, 4, VX_SCALE_PYRAMID_HALF, 0, 0, VX_DF_IMAGE_VIRT), // no
dimension and format specified for level 0
vxCreateVirtualPyramid(graph, 4, VX_SCALE_PYRAMID_HALF, 640, 480, VX_DF_IMAGE_VIRT),
// no format specified.
vxCreateVirtualPyramid(graph, 4, VX_SCALE_PYRAMID_HALF, 640, 480, VX_DF_IMAGE_U8), //
no access
};
```

Parameters

- `[in]` *graph* - The reference to the parent graph.
- `[in]` *levels* - The number of levels desired. This is required to be a non-zero value.
- `[in]` *scale* - Used to indicate the scale between pyramid levels. This is required to be a non-zero positive value. `VX_SCALE_PYRAMID_HALF` and `VX_SCALE_PYRAMID_ORB` must be supported.
- `[in]` *width* - The width of the 0th level image in pixels. This may be set to zero to indicate to the interface that the value is unspecified.
- `[in]` *height* - The height of the 0th level image in pixels. This may be set to zero to indicate to the interface that the value is unspecified.
- `[in]` *format* - The format of all images in the pyramid. This may be set to `VX_DF_IMAGE_VIRT` to indicate that the format is unspecified.

Returns: A pyramid reference `vx_pyramid`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

> *Note*
>
> Images extracted with `vxGetPyramidLevel` behave as Virtual Images and cause `vxMapImagePatch` to return errors.

vxGetPyramidLevel

Retrieves a level of the pyramid as a `vx_image`, which can be used elsewhere in OpenVX. A call to vxReleaseImage is necessary to release an image for each call of vxGetPyramidLevel.

```
vx_image vxGetPyramidLevel(
    vx_pyramid                                  pyr,
    vx_uint32                                   index);
```

Parameters

- `[in]` *pyr* - The pyramid object.
- `[in]` *index* - The index of the level, such that index is less than levels.

Returns: A vx_image reference. Any possible errors preventing a successful function completion should be checked using vxGetStatus.

vxQueryPyramid

Queries an attribute from an image pyramid.

```
vx_status vxQueryPyramid(
    vx_pyramid                                  pyr,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *pyr* - The pyramid to query.
- [in] *attribute* - The attribute for which to query. Use a vx_pyramid_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - pyr is not a valid vx_pyramid reference.

vxReleasePyramid

Releases a reference to a pyramid object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleasePyramid(
    vx_pyramid*                                 pyr);
```

Parameters

- [in] *pyr* - The pointer to the pyramid to release.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - pyr is not a valid vx_pyramid reference.

Postcondition: After returning from this function the reference is zeroed.

5.12. Object: Remap

Defines the Remap Object Interface.

Typedefs

- vx_remap

Enumerations

- vx_remap_attribute_e

Functions

- vxCopyRemapPatch
- vxCreateRemap
- vxCreateVirtualRemap
- vxMapRemapPatch
- vxQueryRemap
- vxReleaseRemap
- vxUnmapRemapPatch

5.12.1. Typedefs

vx_remap

The remap table Object. A remap table contains per-pixel mapping of output pixels to input pixels.

```
typedef struct _vx_remap *vx_remap;
```

5.12.2. Enumerations

vx_remap_attribute_e

The remap object attributes.

```
enum vx_remap_attribute_e {
    VX_REMAP_SOURCE_WIDTH = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_REMAP) + 0x0,
    VX_REMAP_SOURCE_HEIGHT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_REMAP) + 0x1,
    VX_REMAP_DESTINATION_WIDTH = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_REMAP) +
0x2,
    VX_REMAP_DESTINATION_HEIGHT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_REMAP) +
0x3,
};
```

Enumerator

- VX_REMAP_SOURCE_WIDTH - The source width. Read-only. Use a vx_uint32 parameter.

- VX_REMAP_SOURCE_HEIGHT - The source height. Read-only. Use a vx_uint32 parameter.
- VX_REMAP_DESTINATION_WIDTH - The destination width. Read-only. Use a vx_uint32 parameter.
- VX_REMAP_DESTINATION_HEIGHT - The destination height. Read-only. Use a vx_uint32 parameter.

5.12.3. Functions

vxCopyRemapPatch

Allows the application to copy a rectangular patch from/into a remap object.

```
vx_status vxCopyRemapPatch(
    vx_remap                                remap,
    const vx_rectangle_t*                   rect,
    vx_size*                                user_stride_y,
    void*                                   user_ptr,
    vx_enum                                 user_coordinate_type,
    vx_enum                                 usage,
    vx_enum                                 user_mem_type);
```

The patch is specified within the destination dimensions and its data provide the corresponding coordinate within the source dimensions. The patch in user memory is a 2D array of elements of the type associated with the *user_coordinate_type* parameter (i.e., vx_coordinates2df_t for VX_TYPE_COORDINATES2DF). The memory layout of this array follows a row-major order where rows are compact (without any gap between elements), and where the potential padding after each line is determined by the *user_stride_y* parameter.

Parameters

- [in] *remap* - The reference to the remap object that is the source or the destination of the patch copy.
- [in] *rect* - The coordinates of remap patch. The patch must be specified within the bounds of the remap destination dimensions (VX_REMAP_DESTINATION_WIDTH x VX_REMAP_DESTINATION_HEIGHT). (*start_x*, *start_y*) gives the coordinate of the topleft element inside the patch, while (*end_x*, *end_y*) gives the coordinate of the bottomright element out of the patch.
- [in] *user_stride_y* - The difference between the address of the first element of two successive lines of the remap patch in user memory (pointed by *user_ptr*). The layout of the user memory must follow a row major order and user_stride_y must follow the following rule : *user_stride_y* ≥ sizeof(<ELEMENT_TYPE>) * (*rect->end_x* - *rect->start_x*).
- [in] *user_ptr* - The address of the user memory location where to store the requested remap data if the copy was requested in read mode, or from where to get the remap data to store into the remap object if the copy was requested in write mode. *user_ptr* is the address of the the top-left element of the remap patch. The accessible user memory must be large enough to contain the specified patch with the specified layout: accessible memory in bytes ≥ (*rect->end_y* - *rect->start_y*) * *user_stride_y*.
- [in] *user_coordinate_type* - This declares the type of the source coordinate remap data in the user memory. It must be VX_TYPE_COORDINATES2DF.

- [in] *usage* - This declares the effect of the copy with regard to the remap object using the vx_accessor_e enumeration. Only VX_READ_ONLY and VX_WRITE_ONLY are supported:
    - VX_READ_ONLY means that data is copied from the remap object into the user memory pointer by *user_ptr*. The potential padding after each line in user memory will stay unchanged.
    - VX_WRITE_ONLY means that data is copied into the remap object from the user memory.
- [in] *user_mem_type* - A vx_memory_type_e enumeration that specifies the type of the memory pointer by *user_ptr*.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - remap is not a valid vx_remap reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

vxCreateRemap

Creates a remap table object.

```
vx_remap vxCreateRemap(
    vx_context                                  context,
    vx_uint32                                   src_width,
    vx_uint32                                   src_height,
    vx_uint32                                   dst_width,
    vx_uint32                                   dst_height);
```

Parameters

- [in] *context* - The reference to the overall context.
- [in] *src_width* - Width of the source image in pixel.
- [in] *src_height* - Height of the source image in pixels.
- [in] *dst_width* - Width of the destination image in pixels.
- [in] *dst_height* - Height of the destination image in pixels.

Returns: A remap reference vx_remap. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateVirtualRemap

Creates an opaque reference to a remap table object without direct user access.

```
vx_remap vxCreateVirtualRemap(
    vx_graph                                    graph,
    vx_uint32                                   src_width,
    vx_uint32                                   src_height,
    vx_uint32                                   dst_width,
    vx_uint32                                   dst_height);
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *src_width* - Width of the source image in pixel.
- [in] *src_height* - Height of the source image in pixels.
- [in] *dst_width* - Width of the destination image in pixels.
- [in] *dst_height* - Height of the destination image in pixels.

See also: `vxCreateRemap`

Returns: A remap reference `vx_remap`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxMapRemapPatch

Allows the application to get direct access to a rectangular patch of a remap object.

```
vx_status vxMapRemapPatch(
    vx_remap                                    remap,
    const vx_rectangle_t*                       rect,
    vx_map_id*                                  map_id,
    vx_size*                                    stride_y,
    void**                                      ptr,
    vx_enum                                     coordinate_type,
    vx_enum                                     usage,
    vx_enum                                     mem_type);
```

The patch is specified within the destination dimensions and its data provide the corresponding coordinate within the source dimensions. The patch is mapped as a 2D array of elements of the type associated with the *coordinate_type* parameter (i.e., `vx_coordinates2df_t` for `VX_TYPE_COORDINATES2DF`). The memory layout of the mapped 2D array follows a row-major order where rows are compact (without any gap between elements), and where the potential padding after each lines is determined by (**stride_y*).

Parameters

- [in] *remap* - The reference to the remap object that contains the patch to map.
- [in] *rect* - The coordinates of remap patch. The patch must be specified within the bounds of the remap destination dimensions (`VX_REMAP_DESTINATION_WIDTH` x `VX_REMAP_DESTINATION_HEIGHT`).

(*start_x*, *start_y*) gives the coordinate of the topleft element inside the patch, while (*end_x*, *end_y*) gives the coordinate of the bottomright element out of the patch.

- `[out]` *map_id* - The address of a `vx_map_id` variable where the function returns a map identifier.
  - (*map_id) must eventually be provided as the map_id parameter of a call to `vxUnmapRemapPatch`.
- `[out]` *stride_y* - The address of a vx_size variable where the function returns the difference between the address of the first element of two successive lines in the mapped remap patch. The stride value follows the following rule : (**stride_y*) ≥ sizeof(<ELEMENT_TYPE>) * (*rect->end_x* - *rect->start_x*)
- `[out]` *ptr* - The address of a pointer where the function returns where (**ptr*) is the address of the the top-left element of the remap patch. The returned (**ptr*) address is only valid between the call to this function and the corresponding call to `vxUnmapRemapPatch`.
- `[in]` *coordinate_type* - This declares the type of the source coordinate data that the application wants to access in the remap patch. It must be `VX_TYPE_COORDINATES2DF`.
- `[in]` *usage* - This declares the access mode for the remap patch, using the `vx_accessor_e` enumeration.
  - `VX_READ_ONLY`: after the function call, the content of the memory location pointed by (**ptr*) contains the remap patch data. Writing into this memory location is forbidden and its behavior is undefined.
  - `VX_READ_AND_WRITE`: after the function call, the content of the memory location pointed by (**ptr*) contains the remap patch data; writing into this memory is allowed for the location of elements only and will result in a modification of the written elements in the remap object once the patch is unmapped. Writing into a gap between element lines (when (*stride_y) > sizeof(<ELEMENT_TYPE>) * (*rect->end_x* - *rect->start_x*)) is forbidden and its behavior is undefined.
  - `VX_WRITE_ONLY`: after the function call, the memory location pointed by (**ptr*) contains undefined data; writing each element of the patch is required prior to unmapping. Elements not written by the application before unmap will become undefined after unmap, even if they were well defined before map. Like for `VX_READ_AND_WRITE`, writing into a gap between element lines is forbidden and its behavior is undefined.
- `[in]` *mem_type* - A `vx_memory_type_e` enumeration that specifies the type of the memory where the remap patch is requested to be mapped.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - remap is not a valid `vx_remap` reference.
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

Postcondition: `vxUnmapRemapPatch` with same (*map_id) value.

vxQueryRemap

Queries attributes from a Remap table.

```
vx_status vxQueryRemap(
    vx_remap                                    table,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *table* - The remap to query.
- [in] *attribute* - The attribute to query. Use a vx_remap_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - table is not a valid vx_remap reference.

vxReleaseRemap

Releases a reference to a remap table object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseRemap(
    vx_remap*                                   table);
```

Parameters

- [in] *table* - The pointer to the remap table to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - table is not a valid vx_remap reference.

vxUnmapRemapPatch

Unmap and commit potential changes to a remap object patch that was previously mapped.

```
vx_status vxUnmapRemapPatch(
    vx_remap                                    remap,
    vx_map_id                                   map_id);
```

Unmapping a remap patch invalidates the memory location from which the patch could be accessed by the application. Accessing this memory location after the unmap function completes has an undefined behavior.

Parameters

- `[in]` *remap* - The reference to the remap object to unmap.
- `[out]` *map_id* - The unique map identifier that was returned by `vxMapRemapPatch`.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - remap is not a valid `vx_remap` reference.
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

Precondition: `vxMapRemapPatch` with same map_id value

5.13. Object: Scalar

Defines the Scalar Object interface.

Typedefs

- `vx_scalar`

Enumerations

- `vx_scalar_attribute_e`
- `vx_scalar_operation_e`

Functions

- `vxCopyScalar`
- `vxCopyScalarWithSize`
- `vxCreateScalar`
- `vxCreateScalarWithSize`
- `vxCreateVirtualScalar`
- `vxQueryScalar`

* vxReleaseScalar

5.13.1. Typedefs

vx_scalar

An opaque reference to a scalar.

```
typedef struct _vx_scalar *vx_scalar;
```

A scalar can be up to 64 bits wide.

See also: vxCreateScalar

5.13.2. Enumerations

vx_scalar_attribute_e

The scalar attributes list.

```
enum vx_scalar_attribute_e {
    VX_SCALAR_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_SCALAR) + 0x0,
};
```

Enumerator

* VX_SCALAR_TYPE - Queries the type of atomic that is contained in the scalar. Read-only. Use a vx_enum parameter.

vx_scalar_operation_e

A type of operation in which both operands are scalars.

```
enum vx_scalar_operation_e {
    VX_SCALAR_OP_AND = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x0,
    VX_SCALAR_OP_OR = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x1,
    VX_SCALAR_OP_XOR = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x2,
    VX_SCALAR_OP_NAND = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x3,
    VX_SCALAR_OP_EQUAL = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x4,
    VX_SCALAR_OP_NOTEQUAL = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) +
0x5,
    VX_SCALAR_OP_LESS = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x6,
    VX_SCALAR_OP_LESSEQ = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x7,
    VX_SCALAR_OP_GREATER = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) +
0x8,
    VX_SCALAR_OP_GREATEREQ = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) +
0x9,
    VX_SCALAR_OP_ADD = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0xA,
    VX_SCALAR_OP_SUBTRACT = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) +
0xB,
    VX_SCALAR_OP_MULTIPLY = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) +
0xC,
    VX_SCALAR_OP_DIVIDE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0xD,
    VX_SCALAR_OP_MODULUS = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) +
0xE,
    VX_SCALAR_OP_MIN = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0xF,
    VX_SCALAR_OP_MAX = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_SCALAR_OPERATION) + 0x10,
};
```

See also: Object: Scalar

Enumerator

- `VX_SCALAR_OP_AND` - logical and.
- `VX_SCALAR_OP_OR` - logical or.
- `VX_SCALAR_OP_XOR` - logical exclusive or.
- `VX_SCALAR_OP_NAND` - logical nand.
- `VX_SCALAR_OP_EQUAL` - comparison (equal).
- `VX_SCALAR_OP_NOTEQUAL` - comparison (not equal).
- `VX_SCALAR_OP_LESS` - comparison (less than).
- `VX_SCALAR_OP_LESSEQ` - comparison (less than or equal to).
- `VX_SCALAR_OP_GREATER` - comparison (greater than).
- `VX_SCALAR_OP_GREATEREQ` - comparison (greater than or equal to).
- `VX_SCALAR_OP_ADD` - arithmetic addition.
- `VX_SCALAR_OP_SUBTRACT` - arithmetic subtraction.
- `VX_SCALAR_OP_MULTIPLY` - arithmetic multiplication.
- `VX_SCALAR_OP_DIVIDE` - arithmetic division.

- VX_SCALAR_OP_MODULUS - arithmetic (modulo operator).
- VX_SCALAR_OP_MIN - minimum of two scalars.
- VX_SCALAR_OP_MAX - maximum of two scalars.

5.13.3. Functions

vxCopyScalar

Allows the application to copy from/into a scalar object.

```
vx_status vxCopyScalar(
    vx_scalar                                   scalar,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- [in] *scalar* - The reference to the scalar object that is the source or the destination of the copy.
- [in] *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the scalar object if the copy was requested in write mode. In the user memory, the scalar is a variable of the type corresponding to VX_SCALAR_TYPE. The accessible memory must be large enough to contain this variable.
- [in] *usage* - This declares the effect of the copy with regard to the scalar object using the vx_accessor_e enumeration. Only VX_READ_ONLY and VX_WRITE_ONLY are supported:
  - VX_READ_ONLY means that data are copied from the scalar object into the user memory.
  - VX_WRITE_ONLY means that data are copied into the scalar object from the user memory.
- [in] *user_mem_type* - A vx_memory_type_e enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - scalar is not a valid vx_scalar reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

vxCopyScalarWithSize

Allows the application to copy from/into a scalar object with size.

```
vx_status vxCopyScalarWithSize(
    vx_scalar                                   scalar,
    vx_size                                     size,
    void*                                       user_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- [in] *scalar* - The reference to the scalar object that is the source or the destination of the copy.
- [in] *size* - The size in bytes of the container to which *user_ptr* points.
- [in] *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the scalar object if the copy was requested in write mode. In the user memory, the scalar is a variable of the type corresponding to VX_SCALAR_TYPE. The accessible memory must be large enough to contain this variable.
- [in] *usage* - This declares the effect of the copy with regard to the scalar object using the vx_accessor_e enumeration. Only VX_READ_ONLY and VX_WRITE_ONLY are supported:
    - VX_READ_ONLY means that data are copied from the scalar object into the user memory.
    - VX_WRITE_ONLY means that data are copied into the scalar object from the user memory.
- [in] *user_mem_type* - A vx_memory_type_e enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A vx_status_e enumeration.

Return Values

- VX_ERROR_INVALID_REFERENCE - The scalar reference is not actually a scalar reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

vxCreateScalar

Creates a reference to a scalar object. Also see Node Parameters.

```
vx_scalar vxCreateScalar(
    vx_context                                  context,
    vx_enum                                     data_type,
    const void*                                 ptr);
```

Parameters

- [in] *context* - The reference to the system context.
- [in] *data_type* - The type of data to hold. Must be greater than VX_TYPE_INVALID and less than or equal to VX_TYPE_VENDOR_STRUCT_END. Or must be a vx_enum returned from vxRegisterUserStruct.

- [in] *ptr* - The pointer to the initial value of the scalar.

Returns: A scalar reference `vx_scalar`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateScalarWithSize

Creates a reference to a scalar object. Also see Node Parameters.

```
vx_scalar vxCreateScalarWithSize(
    vx_context                                  context,
    vx_enum                                     data_type,
    const void*                                 ptr,
    vx_size                                     size);
```

Parameters

- [in] *context* - The reference to the system context.
- [in] *data_type* - The type of data to hold. Must be greater than `VX_TYPE_INVALID` and less than or equal to `VX_TYPE_VENDOR_STRUCT_END`. Or must be a `vx_enum` returned from `vxRegisterUserStruct`.
- [in] *ptr* - The pointer to the initial value of the scalar.
- [in] *size* - Size of data at ptr in bytes.

Returns: A scalar reference `vx_scalar`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateVirtualScalar

Creates an opaque reference to a scalar object with no direct user access.

```
vx_scalar vxCreateVirtualScalar(
    vx_graph                                    graph,
    vx_enum                                     data_type);
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *data_type* - The type of data to hold. Must be greater than `VX_TYPE_INVALID` and less than or equal to `VX_TYPE_VENDOR_STRUCT_END`. Or must be a `vx_enum` returned from `vxRegisterUserStruct`.

See also: `vxCreateScalar`

Returns: A scalar reference `vx_scalar`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxQueryScalar

Queries attributes from a scalar.

```
vx_status vxQueryScalar(
    vx_scalar                                    scalar,
    vx_enum                                      attribute,
    void*                                        ptr,
    vx_size                                      size);
```

Parameters

- `[in]` *scalar* - The scalar object.
- `[in]` *attribute* - The enumeration to query. Use a `vx_scalar_attribute_e` enumeration.
- `[out]` *ptr* - The location at which to store the resulting value.
- `[in]` *size* - The size of the container to which *ptr* points.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - scalar is not a valid `vx_scalar` reference.

vxReleaseScalar

Releases a reference to a scalar object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseScalar(
    vx_scalar*                                   scalar);
```

Parameters

- `[in]` *scalar* - The pointer to the scalar to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - scalar is not a valid `vx_scalar` reference.

5.14. Object: Threshold

Defines the Threshold Object Interface.

Typedefs

- vx_threshold

Enumerations

- vx_threshold_attribute_e
- vx_threshold_type_e

Functions

- vxCopyThresholdOutput
- vxCopyThresholdRange
- vxCopyThresholdValue
- vxCreateThresholdForImage
- vxCreateVirtualThresholdForImage
- vxQueryThreshold
- vxReleaseThreshold
- vxSetThresholdAttribute

5.14.1. Typedefs

vx_threshold

The Threshold Object. A thresholding object contains the types and limit values of the thresholding required.

```
typedef struct _vx_threshold *vx_threshold;
```

5.14.2. Enumerations

vx_threshold_attribute_e

The threshold attributes.

```
enum vx_threshold_attribute_e {
    VX_THRESHOLD_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_THRESHOLD) + 0x0,
    VX_THRESHOLD_INPUT_FORMAT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_THRESHOLD) +
0x7,
    VX_THRESHOLD_OUTPUT_FORMAT = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_THRESHOLD) +
0x8,
};
```

Enumerator

- VX_THRESHOLD_TYPE - The value type of the threshold. Read-only. Use a vx_enum parameter. Will contain a vx_threshold_type_e.
- VX_THRESHOLD_INPUT_FORMAT - The input image format the threshold was created for. Read-only. Use a vx_enum parameter. Will contain a vx_df_image_e.
- VX_THRESHOLD_OUTPUT_FORMAT - The output image format the threshold was created for. Read-only. Use a vx_enum parameter. Will contain a vx_df_image_e.

vx_threshold_type_e

The Threshold types.

```
enum vx_threshold_type_e {
    VX_THRESHOLD_TYPE_BINARY = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_THRESHOLD_TYPE) +
0x0,
    VX_THRESHOLD_TYPE_RANGE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_THRESHOLD_TYPE) +
0x1,
};
```

Enumerator

- VX_THRESHOLD_TYPE_BINARY - A threshold with only 1 value.
- VX_THRESHOLD_TYPE_RANGE - A threshold with 2 values (upper/lower). Use with Canny Edge Detection.

5.14.3. Functions

vxCopyThresholdOutput

Allows the application to copy the true and false output values from/into a threshold object.

```
vx_status vxCopyThresholdOutput(
    vx_threshold                                thresh,
    vx_pixel_value_t*                           true_value_ptr,
    vx_pixel_value_t*                           false_value_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- [in] *thresh* - The reference to the threshold object that is the source or the destination of the copy.
- [inout] *true_value_ptr* - The address of the memory location where to store the true output value if the copy was requested in read mode, or from where to get the true output value to store into the threshold object if the copy was requested in write mode.

- [inout] *false_value_ptr* - The address of the memory location where to store the false output value if the copy was requested in read mode, or from where to get the false output value to store into the threshold object if the copy was requested in write mode.
- [in] *usage* - This declares the effect of the copy with regard to the threshold object using the `vx_accessor_e` enumeration. Only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:
  - `VX_READ_ONLY` means that true and false output values are copied from the threshold object into the user memory. After the copy, only the field of (**true_value_ptr*) and (**false_value_ptr*) unions that corresponds to the output image format of the threshold object is meaningful.
  - `VX_WRITE_ONLY` means the field of the (**true_value_ptr*) and (**false_value_ptr*) unions corresponding to the output format of the threshold object is copied into the threshold object.
- [in] *user_mem_type* - A `vx_memory_type_e` enumeration that specifies the type of the memory referenced by *true_value_ptr* and *false_value_ptr*.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_ERROR_INVALID_REFERENCE` - The threshold reference is not actually a threshold reference.
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

vxCopyThresholdRange

Allows the application to copy thresholding values from/into a threshold object with type `VX_THRESHOLD_TYPE_RANGE`.

```
vx_status vxCopyThresholdRange(
    vx_threshold                                       thresh,
    vx_pixel_value_t*                                  lower_value_ptr,
    vx_pixel_value_t*                                  upper_value_ptr,
    vx_enum                                            usage,
    vx_enum                                            user_mem_type);
```

Parameters

- [in] *thresh* - The reference to the threshold object that is the source or the destination of the copy.
- [inout] *lower_value_ptr* - The address of the memory location where to store the lower thresholding value if the copy was requested in read mode, or from where to get the lower thresholding value to store into the threshold object if the copy was requested in write mode.
- [inout] *upper_value_ptr* - The address of the memory location where to store the upper thresholding value if the copy was requested in read mode, or from where to get the upper thresholding value to store into the threshold object if the copy was requested in write mode.
- [in] *usage* - This declares the effect of the copy with regard to the threshold object using the

`vx_accessor_e` enumeration. Only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:

  - `VX_READ_ONLY` means that thresholding values are copied from the threshold object into the user memory. After the copy, only the field of (**lower_value_ptr*) and (*upper_value_ptr) unions that corresponds to the input image format of the threshold object is meaningful.
  - `VX_WRITE_ONLY` means the field of the (**lower_value_ptr*) and (**upper_value_ptr*) unions corresponding to the input format of the threshold object is copied into the threshold object.

- `[in]` *user_mem_type* - A `vx_memory_type_e` enumeration that specifies the type of the memory referenced by *lower_value_ptr* and *upper_value_ptr*.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_ERROR_INVALID_REFERENCE` - The threshold reference is not actually a threshold reference.
- `VX_ERROR_NOT_COMPATIBLE` - The threshold object doesn't have type `VX_THRESHOLD_TYPE_RANGE`
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

vxCopyThresholdValue

Allows the application to copy the thresholding value from/into a threshold object with type `VX_THRESHOLD_TYPE_BINARY`.

```
vx_status vxCopyThresholdValue(
    vx_threshold                                thresh,
    vx_pixel_value_t*                           value_ptr,
    vx_enum                                     usage,
    vx_enum                                     user_mem_type);
```

Parameters

- `[in]` *thresh* - The reference to the threshold object that is the source or the destination of the copy.
- `[inout]` *value_ptr* - The address of the memory location where to store the thresholding value if the copy was requested in read mode, or from where to get the thresholding value to store into the threshold object if the copy was requested in write mode.
- `[in]` *usage* - This declares the effect of the copy with regard to the threshold object using the `vx_accessor_e` enumeration. Only `VX_READ_ONLY` and `VX_WRITE_ONLY` are supported:
  - `VX_READ_ONLY` means that the thresholding value is copied from the threshold object into the user memory. After the copy, only the field of the (**value_ptr*) union that corresponds to the input image format of the threshold object is meaningful.
  - `VX_WRITE_ONLY` means the field of the (**value_ptr*) union corresponding to the input format of the threshold object is copied into the threshold object.
- `[in]` *user_mem_type* - A `vx_memory_type_e` enumeration that specifies the type of the memory referenced by *value_ptr*.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_ERROR_INVALID_REFERENCE` - The threshold reference is not actually a threshold reference.
- `VX_ERROR_NOT_COMPATIBLE` - The threshold object doesn't have type `VX_THRESHOLD_TYPE_BINARY`
- `VX_ERROR_INVALID_PARAMETERS` - An other parameter is incorrect.

vxCreateThresholdForImage

Creates a threshold object and returns a reference to it.

```
vx_threshold vxCreateThresholdForImage(
    vx_context                                  context,
    vx_enum                                     thresh_type,
    vx_df_image                                 input_format,
    vx_df_image                                 output_format);
```

The threshold object defines the parameters of a thresholding operation to an input image, that generates an output image that can have a different format. The thresholding 'false' or 'true' output values are specified per pixel channels of the output format and can be modified with `vxCopyThresholdOutput`. The default 'false' output value of pixels channels should be 0, and the default 'true' value should be non-zero. For standard image formats, default output pixel values are defined as following:

- `VX_DF_IMAGE_RGB` : false={0, 0, 0}, true={255,255,255}
- `VX_DF_IMAGE_RGBX` : false={0, 0, 0, 0}, true={255,255,255,255}
- `VX_DF_IMAGE_NV12` : false={0, 0, 0}, true={255,255,255}
- `VX_DF_IMAGE_NV21` : false={0, 0, 0}, true={255,255,255}
- `VX_DF_IMAGE_UYVY` : false={0, 0, 0}, true={255,255,255}
- `VX_DF_IMAGE_YUYV` : false={0, 0, 0}, true={255,255,255}
- `VX_DF_IMAGE_IYUV` : false={0, 0, 0}, true={255,255,255}
- `VX_DF_IMAGE_YUV4` : false={0, 0, 0}, true={255,255,255}
- `VX_DF_IMAGE_U8` : false=0, true=0xFF
- `VX_DF_IMAGE_S16` : false=0, true=-1
- `VX_DF_IMAGE_U16` : false=0, true=0xFFFF
- `VX_DF_IMAGE_S32` : false=0, true=-1
- `VX_DF_IMAGE_U32` : false=0, true=0xFFFFFFFF

Parameters

- `[in]` *context* - The reference to the context in which the object is created.
- `[in]` *thresh_type* - The type of thresholding operation.

- [in] *input_format* - The format of images that will be used as input of the thresholding operation.
- [in] *output_format* - The format of images that will be generated by the thresholding operation.

Returns: A threshold reference vx_threshold. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateVirtualThresholdForImage

Creates an opaque reference to a threshold object without direct user access.

```
vx_threshold vxCreateVirtualThresholdForImage(
    vx_graph                                    graph,
    vx_enum                                     thresh_type,
    vx_df_image                                 input_format,
    vx_df_image                                 output_format);
```

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *thresh_type* - The type of thresholding operation.
- [in] *input_format* - The format of images that will be used as input of the thresholding operation.
- [in] *output_format* - The format of images that will be generated by the thresholding operation.

See also: vxCreateThresholdForImage

Returns: A threshold reference vx_threshold. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxQueryThreshold

Queries an attribute on the threshold object.

```
vx_status vxQueryThreshold(
    vx_threshold                                thresh,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *thresh* - The threshold object to set.
- [in] *attribute* - The attribute to query. Use a vx_threshold_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - thresh is not a valid vx_threshold reference.

vxReleaseThreshold

Releases a reference to a threshold object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseThreshold(
    vx_threshold*                               thresh);
```

Parameters

- [in] *thresh* - The pointer to the threshold to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - thresh is not a valid vx_threshold reference.

vxSetThresholdAttribute

Sets attributes on the threshold object.

```
vx_status vxSetThresholdAttribute(
    vx_threshold                                thresh,
    vx_enum                                     attribute,
    const void*                                 ptr,
    vx_size                                     size);
```

Parameters

- [in] *thresh* - The threshold object to set.
- [in] *attribute* - The attribute to modify. Use a vx_threshold_attribute_e enumeration.
- [in] *ptr* - The pointer to the value to which to set the attribute.
- [in] *size* - The size of the data pointed to by *ptr*.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - thresh is not a valid vx_threshold reference.

5.15. Object: ObjectArray

An opaque array object that could be an array of any data-object (not data-type) of OpenVX except Delay and ObjectArray objects.

ObjectArray is a strongly-typed container of OpenVX data-objects. ObjectArray refers to the collection of similar data-objects as a single entity that can be created or assigned as inputs/outputs and as a single entity. In addition, a single object from the collection can be accessed individually by getting its reference. The single object remains as part of the ObjectArray through its entire life cycle.

Typedefs

- vx_object_array

Enumerations

- vx_object_array_attribute_e

Functions

- vxCreateObjectArray
- vxCreateVirtualObjectArray
- vxGetObjectArrayItem
- vxQueryObjectArray
- vxReleaseObjectArray

5.15.1. Typedefs

vx_object_array

The ObjectArray Object. ObjectArray is a strongly-typed container of OpenVX data-objects.

```
typedef struct _vx_object_array *vx_object_array;
```

5.15.2. Enumerations

vx_object_array_attribute_e

The ObjectArray object attributes.

```
enum vx_object_array_attribute_e {
    VX_OBJECT_ARRAY_ITEMTYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_OBJECT_ARRAY)
+ 0x0,
    VX_OBJECT_ARRAY_NUMITEMS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_OBJECT_ARRAY)
+ 0x1,
};
```

Enumerator

- `VX_OBJECT_ARRAY_ITEMTYPE` - The type of the ObjectArray items. Read-only. Use a `vx_enum` parameter.
- `VX_OBJECT_ARRAY_NUMITEMS` - The number of items in the ObjectArray. Read-only. Use a `vx_size` parameter.

5.15.3. Functions

vxCreateObjectArray

Creates a reference to an ObjectArray of count objects.

```
vx_object_array vxCreateObjectArray(
    vx_context                                  context,
    vx_reference                                exemplar,
    vx_size                                     count);
```

It uses the metadata of the exemplar to determine the object attributes, ignoring the object data. It does not alter the exemplar or keep or release the reference to the exemplar. For the definition of supported attributes see `vxSetMetaFormatAttribute`. In case the exemplar is a virtual object it must be of immutable metadata, thus it is not allowed to be dimensionless or formatless.

Parameters

- `[in]` *context* - The reference to the overall Context.
- `[in]` *exemplar* - The exemplar object that defines the metadata of the created objects in the ObjectArray.
- `[in]` *count* - Number of Objects to create in the ObjectArray. This value must be greater than zero.

Returns: An ObjectArray reference `vx_object_array`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`. Data objects are not initialized by this function.

vxCreateVirtualObjectArray

Creates an opaque reference to a virtual ObjectArray with no direct user access.

```
vx_object_array vxCreateVirtualObjectArray(
    vx_graph                                    graph,
    vx_reference                                exemplar,
    vx_size                                     count);
```

This function creates an ObjectArray of count objects with similar behavior as `vxCreateObjectArray`. The only difference is that the objects that are created are virtual in the given graph.

Parameters

- `[in]` *graph* - Reference to the graph where to create the virtual ObjectArray.
- `[in]` *exemplar* - The exemplar object that defines the type of object in the ObjectArray. Only exemplar type of `vx_image`, `vx_array` and `vx_pyramid` are allowed.
- `[in]` *count* - Number of Objects to create in the ObjectArray.

Returns: A ObjectArray reference `vx_object_array`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxGetObjectArrayItem

Retrieves the reference to the OpenVX Object in location index of the ObjectArray.

```
vx_reference vxGetObjectArrayItem(
    vx_object_array                             arr,
    vx_uint32                                   index);
```

This is a vx_reference, which can be used elsewhere in OpenVX. A call to vxRelease<Object> or `vxReleaseReference` is necessary to release the Object for each call to this function.

Parameters

- `[in]` *arr* - The ObjectArray.
- `[in]` *index* - The index of the object in the ObjectArray.

Returns: A reference to an OpenVX data object. Any possible errors preventing a successful completion of the function should be checked using `vxGetStatus`.

vxQueryObjectArray

Queries an atribute from the ObjectArray.

```
vx_status vxQueryObjectArray(
    vx_object_array                             arr,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *arr* - The reference to the ObjectArray.
- [in] *attribute* - The attribute to query. Use a vx_object_array_attribute_e.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - arr is not a valid vx_object_array reference.
- VX_ERROR_NOT_SUPPORTED - If the *attribute* is not a value supported on this implementation.
- VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.

vxReleaseObjectArray

Releases a reference of an ObjectArray object.

```
vx_status vxReleaseObjectArray(
    vx_object_array*                            arr);
```

The object may not be garbage collected until its total reference and its contained objects count is zero. After returning from this function the reference is zeroed/cleared.

Parameters

- [in] *arr* - The pointer to the ObjectArray to release.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - arr is not a valid vx_object_array reference.

5.16. Object: Tensor

Defines The Tensor Object Interface.

The vx_tensor object represents an opaque multidimensional array. The object is said to be opaque because the programmer has no visibility into the internal implementation of the object, and can only manipulate them via the defined API. Implementations can apply many optimizations that are transparent to the user. OpenVX implementations must support vx_tensor objects of at least 4 dimensions, although a vendor can choose to support more dimensions in his implementation. The maximum number of dimensions supported by a given implementation can be queried via the context attribute VX_CONTEXT_MAX_TENSOR_DIMS. Implementations must support tensors from one dimension (i.e., vectors) through VX_CONTEXT_MAX_TENSOR_DIMS, inclusive. The individual elements of the tensor object may be any numerical data type. For each kernel in the specification, it is specified which data types a compliant implementations must support. Integer elements can represent fractional values by assigning a non-zero radix point. As an example: VX_TYPE_INT16 element with radix point of 8, corresponds to Q7.8 signed fixed-point in “Q” notation. A vendor may choose to support whatever values for the radix point in his implementation. Since functions using tensors, need to understand the context of each dimension. We describe a layout of the dimensions in each function. That layout is not mandated. It is done specifically to explain the functions and not to mandate layout. Different implementation may have different layout. Therefore the layout description is logical and not physical. It refers to the order of dimensions given in vxCreateTensor and vxCreateVirtualTensor.

Typedefs

- vx_tensor

Enumerations

- vx_tensor_attribute_e

Functions

- vxCopyTensorPatch
- vxCreateImageObjectArrayFromTensor
- vxCreateTensor
- vxCreateTensorFromView
- vxCreateVirtualTensor
- vxQueryTensor
- vxReleaseTensor

5.16.1. Typedefs

vx_tensor

The multidimensional data object (Tensor).

```
typedef struct _vx_tensor_t *vx_tensor;
```

See also: vxCreateTensor

5.16.2. Enumerations

vx_tensor_attribute_e

Tensor Data attributes.

```
enum vx_tensor_attribute_e {
    VX_TENSOR_NUMBER_OF_DIMS = VX_ATTRIBUTE_BASE( VX_ID_KHRONOS, VX_TYPE_TENSOR ) +
0x0,
    VX_TENSOR_DIMS = VX_ATTRIBUTE_BASE( VX_ID_KHRONOS, VX_TYPE_TENSOR ) + 0x1,
    VX_TENSOR_DATA_TYPE = VX_ATTRIBUTE_BASE( VX_ID_KHRONOS, VX_TYPE_TENSOR ) + 0x2,
    VX_TENSOR_FIXED_POINT_POSITION = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_TENSOR)
+ 0x3,
};
```

Enumerator

- `VX_TENSOR_NUMBER_OF_DIMS` - Number of dimensions.
- `VX_TENSOR_DIMS` - Dimension sizes.
- `VX_TENSOR_DATA_TYPE` - Tensor Data element data type. `vx_type_e`
- `VX_TENSOR_FIXED_POINT_POSITION` - fixed point position when the input element type is integer.

5.16.3. Functions

vxCopyTensorPatch

Allows the application to copy a view patch from/into an tensor object .

```
vx_status vxCopyTensorPatch(
    vx_tensor                                    tensor,
    vx_size                                      number_of_dims,
    const vx_size*                               view_start,
    const vx_size*                               view_end,
    const vx_size*                               user_stride,
    void*                                        user_ptr,
    vx_enum                                      usage,
    vx_enum                                      user_memory_type);
```

Parameters

- `[in]` *tensor* - The reference to the tensor object that is the source or the destination of the copy.
- `[in]` *number_of_dims* - Number of patch dimension. Error return if 0 or greater than number of tensor dimensions. If smaller than number of tensor dimensions, the lower dimensions are assumed.
- `[in]` *view_start* - Array of patch start points in each dimension
- `[in]` *view_end* - Array of patch end points in each dimension
- `[in]` *user_stride* - Array of user memory strides in each dimension
- `[in]` *user_ptr* - The address of the memory location where to store the requested data if the copy was requested in read mode, or from where to get the data to store into the tensor object if the copy was requested in write mode. The accessible memory must be large enough to contain the

specified patch with the specified layout: accessible memory in bytes ≥ (end[last_dimension] - start[last_dimension]) * stride[last_dimension].

The layout of the user memory must follow a row major order.

- [in] *usage* - This declares the effect of the copy with regard to the tensor object using the vx_accessor_e enumeration. Only VX_READ_ONLY and VX_WRITE_ONLY are supported:
  - VX_READ_ONLY means that data is copied from the tensor object into the application memory
  - VX_WRITE_ONLY means that data is copied into the tensor object from the application memory
- [in] *user_memory_type* - A vx_memory_type_e enumeration that specifies the memory type of the memory referenced by the user_addr.

Returns: A vx_status_e enumeration.

Return Values

- VX_ERROR_OPTIMIZED_AWAY - This is a reference to a virtual tensor that cannot be accessed by the application.
- VX_ERROR_INVALID_REFERENCE - The tensor reference is not actually an tensor reference.
- VX_ERROR_INVALID_PARAMETERS - An other parameter is incorrect.

vxCreateImageObjectArrayFromTensor

Creates an array of images into the multi-dimension data, this can be adjacent 2D images or not depending on the stride value. The stride value is representing bytes in the third dimension. The OpenVX image object that points to a three dimension data and access it as an array of images. This has to be portion of the third lowest dimension, and the stride correspond to that third dimension. The returned Object array is an array of images. Where the image data is pointing to a specific memory in the input tensor.

```
vx_object_array vxCreateImageObjectArrayFromTensor(
    vx_tensor                                   tensor,
    const vx_rectangle_t*                       rect,
    vx_size                                     array_size,
    vx_size                                     jump,
    vx_df_image                                 image_format);
```

Parameters

- [in] *tensor* - The tensor data from which to extract the images. Has to be a 3d tensor.
- [in] *rect* - Image coordinates within tensor data.
- [in] *array_size* - Number of images to extract.
- [in] *jump* - Delta between two images in the array.
- [in] *image_format* - The requested image format. Should match the tensor data's data type.

Returns: An array of images pointing to the tensor data's data.

vxCreateTensor

Creates an opaque reference to a tensor data buffer.

```
vx_tensor vxCreateTensor(
    vx_context                                  context,
    vx_size                                     number_of_dims,
    const vx_size*                              dims,
    vx_enum                                     data_type,
    vx_int8                                     fixed_point_position);
```

Not guaranteed to exist until the `vx_graph` containing it has been verified. Since functions using tensors, need to understand the context of each dimension. We describe a layout of the dimensions in each function using tensors. That layout is not mandatory. It is done specifically to explain the functions and not to mandate layout. Different implementation may have different layout. Therefore the layout description is logical and not physical. It refers to the order of dimensions given in this function.

Parameters

- `[in]` *context* - The reference to the implementation context.
- `[in]` *number_of_dims* - The number of dimensions.
- `[in]` *dims* - Dimensions sizes in elements.
- `[in]` *data_type* - The `vx_type_e` that represents the data type of the tensor data elements.
- `[in]` *fixed_point_position* - Specifies the fixed point position when the input element type is integer. if 0, calculations are performed in integer math.

Returns: A tensor data reference. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

vxCreateTensorFromView

Creates a tensor data from another tensor data given a view. This second reference refers to the data in the original tensor data. Updates to this tensor data updates the parent tensor data. The view must be defined within the dimensions of the parent tensor data.

```
vx_tensor vxCreateTensorFromView(
    vx_tensor                                   tensor,
    vx_size                                     number_of_dims,
    const vx_size*                              view_start,
    const vx_size*                              view_end);
```

Parameters

- `[in]` *tensor* - The reference to the parent tensor data.
- `[in]` *number_of_dims* - Number of dimensions in the view. Error return if 0 or greater than

number of tensor dimensions. If smaller than number of tensor dimensions, the lower dimensions are assumed.

- [in] *view_start* - View start coordinates
- [in] *view_end* - View end coordinates

Returns: The reference to the sub-tensor. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxCreateVirtualTensor

Creates an opaque reference to a tensor data buffer with no direct user access. This function allows setting the tensor data dimensions or data format.

```
vx_tensor vxCreateVirtualTensor(
    vx_graph                                     graph,
    vx_size                                      number_of_dims,
    const vx_size*                               dims,
    vx_enum                                      data_type,
    vx_int8                                      fixed_point_position);
```

Virtual data objects allow users to connect various nodes within a graph via data references without access to that data, but they also permit the implementation to take maximum advantage of possible optimizations. Use this API to create a data reference to link two or more nodes together when the intermediate data are not required to be accessed by outside entities. This API in particular allows the user to define the tensor data format of the data without requiring the exact dimensions. Virtual objects are scoped within the graph they are declared a part of, and can't be shared outside of this scope. Since functions using tensors, need to understand the context of each dimension. We describe a layout of the dimensions in each function. That layout is not mandated. It is done specifically to explain the functions and not to mandate layout. Different implementation may have different layout. Therfore the layout description is logical and not physical. It refers to the order of dimensions given in vxCreateTensor and vxCreateVirtualTensor.

Parameters

- [in] *graph* - The reference to the parent graph.
- [in] *number_of_dims* - The number of dimensions.
- [in] *dims* - Dimensions sizes in elements.
- [in] *data_type* - The vx_type_e that represents the data type of the tensor data elements.
- [in] *fixed_point_position* - Specifies the fixed point position when the input element type is integer. If 0, calculations are performed in integer math.

Returns: A tensor data reference.Any possible errors preventing a successful creation should be checked using vxGetStatus.

> *Note*
>
> Passing this reference to vxCopyTensorPatch will return an error.

vxQueryTensor

Retrieves various attributes of a tensor data.

```
vx_status vxQueryTensor(
    vx_tensor                                   tensor,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *tensor* - The reference to the tensor data to query.
- [in] *attribute* - The attribute to query. Use a vx_tensor_attribute_e.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors.
- VX_ERROR_INVALID_REFERENCE - If data is not a vx_tensor.
- VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.

vxReleaseTensor

Releases a reference to a tensor data object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseTensor(
    vx_tensor*                                  tensor);
```

Parameters

- [in] *tensor* - The pointer to the tensor data to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; all other values indicate failure
- * - An error occurred. See vx_status_e.

Chapter 6. Advanced Objects

Defines the Advanced Objects of OpenVX.

Modules

- Object: Array (Advanced)
- Object: Node (Advanced)
- Object: Delay
- Object: Kernel
- Object: Parameter

6.1. Object: Array (Advanced)

Defines the advanced features of the Array Interface.

Functions

- `vxRegisterUserStruct`

6.1.1. Functions

vxRegisterUserStruct

Registers user-defined structures to the context.

```
vx_enum vxRegisterUserStruct(
    vx_context                                  context,
    vx_size                                     size);
```

Parameters * `[in]` *context* - The reference to the implementation context. * `[in]` *size* - The size of user struct in bytes.

Returns: A `vx_enum` value that is a type given to the User to refer to their custom structure when declaring a `vx_array` of that structure.

Return Values

- `VX_TYPE_INVALID` - If the namespace of types has been exhausted.

> *Note*
>
> This call should only be used once within the lifetime of a context for a specific structure.

6.2. Object: Node (Advanced)

Defines the advanced features of the Node Interface.

Modules

- Node: Border Modes

Functions

- `vxCreateGenericNode`

6.2.1. Functions

vxCreateGenericNode

Creates a reference to a node object for a given kernel.

```
vx_node vxCreateGenericNode(
    vx_graph                                    graph,
    vx_kernel                                   kernel);
```

This node has no references assigned as parameters after completion. The client is then required to set these parameters manually by `vxSetParameterByIndex`. When clients supply their own node creation functions (for use with User Kernels), this is the API to use along with the parameter setting API.

Parameters

- `[in]` *graph* - The reference to the graph in which this node exists.
- `[in]` *kernel* - The kernel reference to associate with this new node.

Returns: A node reference `vx_node`. Any possible errors preventing a successful creation should be checked using `vxGetStatus`.

> *Note*
>
> A call to this API sets all parameters to `NULL`.

Postcondition: Call `vxSetParameterByIndex` for as many parameters as needed to be set.

6.3. Node: Border Modes

Defines the border mode behaviors.

Border Mode behavior is set as an attribute of the node, not as a direct parameter to the kernel. This allows clients to *set-and-forget* the modes of any particular node that supports border modes. All nodes shall support `VX_BORDER_UNDEFINED`.

Data Structures

- vx_border_t

Enumerations

- vx_border_e
- vx_border_policy_e

6.3.1. Data Structures

vx_border_policy_e

Use with the enumeration VX_NODE_BORDER to set the border mode behavior of a node that supports borders.

```
typedef struct _vx_border_t {
    vx_enum             mode;
    vx_pixel_value_t    constant_value;
} vx_border_t;
```

- mode - See vx_border_e.
- constant_value - For the mode VX_BORDER_CONSTANT, this union contains the value of out-of-bound pixels.

If the indicated border mode is not supported, an error VX_ERROR_NOT_SUPPORTED will be reported either at the time the VX_NODE_BORDER is set or at the time of graph verification.

6.3.2. Enumerations

vx_border_e

The border mode list.

```
enum vx_border_e {
    VX_BORDER_UNDEFINED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_BORDER) + 0x0,
    VX_BORDER_CONSTANT = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_BORDER) + 0x1,
    VX_BORDER_REPLICATE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_BORDER) + 0x2,
};
```

Enumerator

- VX_BORDER_UNDEFINED - No defined border mode behavior is given.
- VX_BORDER_CONSTANT - For nodes that support this behavior, a constant value is *filled-in* when accessing out-of-bounds pixels.
- VX_BORDER_REPLICATE - For nodes that support this behavior, a replication of the nearest edge pixels value is given for out-of-bounds pixels.

vx_border_policy_e

The unsupported border mode policy list.

```
enum vx_border_policy_e {
    VX_BORDER_POLICY_DEFAULT_TO_UNDEFINED = VX_ENUM_BASE(VX_ID_KHRONOS,
VX_ENUM_BORDER_POLICY) + 0x0,
    VX_BORDER_POLICY_RETURN_ERROR = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_BORDER_POLICY)
+ 0x1,
};
```

Enumerator

- `VX_BORDER_POLICY_DEFAULT_TO_UNDEFINED` - Use `VX_BORDER_UNDEFINED` instead of unsupported border modes.
- `VX_BORDER_POLICY_RETURN_ERROR` - Return `VX_ERROR_NOT_SUPPORTED` for unsupported border modes.

6.4. Object: Delay

Defines the Delay Object interface.

A Delay is an opaque object that contains a manually-controlled, temporally-delayed list of objects. A Delay cannot be an output of a kernel. Also, aging of a Delay (see `vxAgeDelay`) cannot be performed during graph execution. Supported delay object types include:

- `VX_TYPE_ARRAY`,
- `VX_TYPE_IMAGE`,
- `VX_TYPE_PYRAMID`,
- `VX_TYPE_MATRIX`,
- `VX_TYPE_CONVOLUTION`,
- `VX_TYPE_DISTRIBUTION`,
- `VX_TYPE_REMAP`,
- `VX_TYPE_LUT`,
- `VX_TYPE_THRESHOLD`,
- `VX_TYPE_SCALAR`.

Typedefs

- `vx_delay`

Enumerations

- `vx_delay_attribute_e`

Functions

* vxAgeDelay
* vxCreateDelay
* vxGetReferenceFromDelay
* vxQueryDelay
* vxReleaseDelay

6.4.1. Typedefs

vx_delay

The delay object. This is like a ring buffer of objects that is maintained by the OpenVX implementation.

```
typedef struct _vx_delay *vx_delay;
```

See also: vxCreateDelay

6.4.2. Enumerations

vx_delay_attribute_e

The delay attribute list.

```
enum vx_delay_attribute_e {
    VX_DELAY_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_DELAY) + 0x0,
    VX_DELAY_SLOTS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_DELAY) + 0x1,
};
```

Enumerator

* `VX_DELAY_TYPE` - The type of objects in the delay. Read-only. Use a `vx_enum` parameter.
* `VX_DELAY_SLOTS` - The number of items in the delay. Read-only. Use a `vx_size` parameter.

6.4.3. Functions

vxAgeDelay

Shifts the internal delay ring by one.

```
vx_status vxAgeDelay(
    vx_delay                                    delay);
```

This function performs a shift of the internal delay ring by one. This means that, the data originally at index 0 move to index -1 and so forth until index -count + 1. The data originally at index -count + 1 move to index 0. Here count is the number of slots in delay ring. When a delay is aged, any graph making use of this delay (delay object itself or data objects in delay slots) gets its data automatically updated accordingly.

Parameters

- `[in]` *delay* -

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Delay was aged; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - delay is not a valid `vx_delay` reference.

vxCreateDelay

Creates a Delay object.

```
vx_delay vxCreateDelay(
    vx_context                                  context,
    vx_reference                                exemplar,
    vx_size                                     num_slots);
```

This function creates a delay object with *num_slots* slots. Each slot contains a clone of the exemplar. The clones only inherit the metadata of the exemplar. The data content of the exemplar is ignored and the clones have their data undefined at delay creation time. The function does not alter the exemplar. Also, it doesn't retain or release the reference to the exemplar.

> *Note*
>
> For the definition of metadata attributes see `vxSetMetaFormatAttribute`.

Parameters

- `[in]` *context* - The reference to the context.
- `[in]` *exemplar* - The exemplar object. Supported exemplar object types are:
- `VX_TYPE_ARRAY`
- `VX_TYPE_CONVOLUTION`
- `VX_TYPE_DISTRIBUTION`
- `VX_TYPE_IMAGE`
- `VX_TYPE_LUT`
- `VX_TYPE_MATRIX`
- `VX_TYPE_OBJECT_ARRAY`
- `VX_TYPE_PYRAMID`
- `VX_TYPE_REMAP`
- `VX_TYPE_SCALAR`
- `VX_TYPE_THRESHOLD`
- `VX_TYPE_TENSOR`

- [in] *num_slots* - The number of objects in the delay. This value must be greater than zero.

Returns: A delay reference vx_delay. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxGetReferenceFromDelay

Retrieves a reference to a delay slot object.

```
vx_reference vxGetReferenceFromDelay(
    vx_delay                                    delay,
    vx_int32                                    index);
```

Parameters

- [in] *delay* - The reference to the delay object.
- [in] *index* - The index of the delay slot from which to extract the object reference.

Returns: vx_reference. Any possible errors preventing a successful completion of the function should be checked using vxGetStatus.

> *Note*
>
> The delay index is in the range [-count + 1, 0]. 0 is always the *current* object.

> *Note*
>
> A reference retrieved with this function must not be given to its associated release API (e.g. vxReleaseImage) unless vxRetainReference is used.

vxQueryDelay

Queries a vx_delay object attribute.

```
vx_status vxQueryDelay(
    vx_delay                                    delay,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *delay* - The reference to a delay object.
- [in] *attribute* - The attribute to query. Use a vx_delay_attribute_e enumeration.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - delay is not a valid vx_delay reference.

vxReleaseDelay

Releases a reference to a delay object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseDelay(
    vx_delay*                                   delay);
```

Parameters

- [in] *delay* - The pointer to the delay object reference to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - delay is not a valid vx_delay reference.

6.5. Object: Kernel

Defines the Kernel Object and Interface.

A Kernel in OpenVX is the abstract representation of an computer vision function, such as a “Sobel Gradient” or “Lucas Kanade Feature Tracking”. A vision function may implement many similar or identical features from other functions, but it is still considered a single unique kernel as long as it is named by the same string and enumeration and conforms to the results specified by OpenVX. Kernels are similar to function signatures in this regard.

In each of the cases, a client of OpenVX could request the kernels in nearly the same manner. There are two main approaches, which depend on the method a client calls to get the kernel reference. The first uses enumerations.

```
vx_kernel kernel = vxGetKernelByEnum(context, VX_KERNEL_SOBEL_3x3);
vx_node node = vxCreateGenericNode(graph, kernel);
```

The second method depends on using strings to get the kernel reference.

```
vx_kernel kernel = vxGetKernelByName(context, "org.khronos.openvx.sobel_3x3");
vx_node node = vxCreateGenericNode(graph, kernel);
```

Data Structures

- vx_kernel_info_t

Macros

- VX_MAX_KERNEL_NAME

Typedefs

- vx_kernel

Enumerations

- vx_kernel_attribute_e
- vx_kernel_e
- vx_library_e

Functions

- vxGetKernelByEnum
- vxGetKernelByName
- vxQueryKernel
- vxReleaseKernel

6.5.1. Data Structures

vxReleaseKernel

The Kernel Information Structure. This is returned by the Context to indicate which kernels are available in the OpenVX implementation.

```
typedef struct _vx_kernel_info_t {
    vx_enum     enumeration;
    vx_char     name[VX_MAX_KERNEL_NAME];
} vx_kernel_info_t;
```

- enumeration - The kernel enumeration value from vx_kernel_e (or an extension thereof).

  See also: vxGetKernelByEnum.

- vx_char name - The kernel name in dotted hierarchical format. e.g. "org.khronos.openvx.sobel_3x3"

  See also: vxGetKernelByName.

6.5.2. Macros

VX_MAX_KERNEL_NAME

Defines the length of a kernel name string to be added to OpenVX, including the trailing zero.

```
#define VX_MAX_KERNEL_NAME                (256)
```

6.5.3. Typedefs

vx_kernel

An opaque reference to the descriptor of a kernel.

```
typedef struct _vx_kernel *vx_kernel;
```

See also: vxGetKernelByName, vxGetKernelByEnum

6.5.4. Enumerations

vx_kernel_attribute_e

The kernel attributes list.

```
enum vx_kernel_attribute_e {
    VX_KERNEL_PARAMETERS = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_KERNEL) + 0x0,
    VX_KERNEL_NAME = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_KERNEL) + 0x1,
    VX_KERNEL_ENUM = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_KERNEL) + 0x2,
    VX_KERNEL_LOCAL_DATA_SIZE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_KERNEL) +
0x3,
};
```

Enumerator

- VX_KERNEL_PARAMETERS - Queries a kernel for the number of parameters the kernel supports. Read-only. Use a vx_uint32 parameter.
- VX_KERNEL_NAME - Queries the name of the kernel. Not settable. Read-only. Use a vx_char [VX_MAX_KERNEL_NAME] array (not a vx_array).
- VX_KERNEL_ENUM - Queries the enum of the kernel. Not settable. Read-only. Use a vx_enum parameter.
- VX_KERNEL_LOCAL_DATA_SIZE - The local data area allocated with each kernel when it becomes a node. Read-write. Can be written only before user-kernel finalization. Use a vx_size parameter.

> *Note*
>
> If not set it will default to zero.

vx_kernel_e

The standard list of available vision kernels.

```
enum vx_kernel_e {
    VX_KERNEL_COLOR_CONVERT = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x1,
    VX_KERNEL_CHANNEL_EXTRACT = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x2,
    VX_KERNEL_CHANNEL_COMBINE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x3,
    VX_KERNEL_SOBEL_3x3 = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x4,
    VX_KERNEL_MAGNITUDE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x5,
    VX_KERNEL_PHASE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x6,
    VX_KERNEL_SCALE_IMAGE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x7,
    VX_KERNEL_TABLE_LOOKUP = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x8,
    VX_KERNEL_HISTOGRAM = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x9,
    VX_KERNEL_EQUALIZE_HISTOGRAM = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0xA,
    VX_KERNEL_ABSDIFF = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0xB,
    VX_KERNEL_MEAN_STDDEV = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0xC,
    VX_KERNEL_THRESHOLD = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0xD,
    VX_KERNEL_INTEGRAL_IMAGE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0xE,
    VX_KERNEL_DILATE_3x3 = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0xF,
    VX_KERNEL_ERODE_3x3 = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x10,
    VX_KERNEL_MEDIAN_3x3 = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x11,
    VX_KERNEL_BOX_3x3 = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x12,
    VX_KERNEL_GAUSSIAN_3x3 = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x13,
    VX_KERNEL_CUSTOM_CONVOLUTION = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0x14,
    VX_KERNEL_GAUSSIAN_PYRAMID = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x15,
    VX_KERNEL_ACCUMULATE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x16,
    VX_KERNEL_ACCUMULATE_WEIGHTED = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0x17,
    VX_KERNEL_ACCUMULATE_SQUARE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x18,
    VX_KERNEL_MINMAXLOC = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x19,
    VX_KERNEL_CONVERTDEPTH = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x1A,
    VX_KERNEL_CANNY_EDGE_DETECTOR = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0x1B,
    VX_KERNEL_AND = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x1C,
    VX_KERNEL_OR = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x1D,
    VX_KERNEL_XOR = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x1E,
    VX_KERNEL_NOT = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x1F,
    VX_KERNEL_MULTIPLY = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x20,
    VX_KERNEL_ADD = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x21,
    VX_KERNEL_SUBTRACT = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x22,
```

```
    VX_KERNEL_WARP_AFFINE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x23,
    VX_KERNEL_WARP_PERSPECTIVE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x24,
    VX_KERNEL_HARRIS_CORNERS = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x25,
    VX_KERNEL_FAST_CORNERS = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x26,
    VX_KERNEL_OPTICAL_FLOW_PYR_LK = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0x27,
    VX_KERNEL_REMAP = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x28,
    VX_KERNEL_HALFSCALE_GAUSSIAN = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0x29,
    VX_KERNEL_MAX_1_0 = VX_KERNEL_HALFSCALE_GAUSSIAN + 1,
    VX_KERNEL_LAPLACIAN_PYRAMID = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x2A,
    VX_KERNEL_LAPLACIAN_RECONSTRUCT = VX_KERNEL_BASE(VX_ID_KHRONOS,
VX_LIBRARY_KHR_BASE) + 0x2B,
    VX_KERNEL_NON_LINEAR_FILTER = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x2C,
    VX_KERNEL_MAX_1_1 = VX_KERNEL_NON_LINEAR_FILTER + 1,
    VX_KERNEL_MATCH_TEMPLATE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x2D,
    VX_KERNEL_LBP = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x2E,
    VX_KERNEL_HOUGH_LINES_P = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x2F,
    VX_KERNEL_TENSOR_MULTIPLY = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x30,
    VX_KERNEL_TENSOR_ADD = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x31,
    VX_KERNEL_TENSOR_SUBTRACT = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x32,
    VX_KERNEL_TENSOR_TABLE_LOOKUP = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0x33,
    VX_KERNEL_TENSOR_TRANSPOSE = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x34,
    VX_KERNEL_TENSOR_CONVERT_DEPTH = VX_KERNEL_BASE(VX_ID_KHRONOS,
VX_LIBRARY_KHR_BASE) + 0x35,
    VX_KERNEL_TENSOR_MATRIX_MULTIPLY = VX_KERNEL_BASE(VX_ID_KHRONOS,
VX_LIBRARY_KHR_BASE) + 0x36,
    VX_KERNEL_COPY = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x37,
    VX_KERNEL_NON_MAX_SUPPRESSION = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE)
+ 0x38,
    VX_KERNEL_SCALAR_OPERATION = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x39,
    VX_KERNEL_HOG_FEATURES = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x3A,
    VX_KERNEL_HOG_CELLS = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x3B,
    VX_KERNEL_BILATERAL_FILTER = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) +
0x3C,
    VX_KERNEL_SELECT = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x3D,
    VX_KERNEL_MAX_1_2 = VX_KERNEL_SELECT + 1,
    VX_KERNEL_MAX = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x3E,
```

```
    VX_KERNEL_MIN = VX_KERNEL_BASE(VX_ID_KHRONOS, VX_LIBRARY_KHR_BASE) + 0x3F,
};
```

Each kernel listed here can be used with the `vxGetKernelByEnum` call. When programming the parameters, use

- `VX_INPUT` for [in]
- `VX_OUTPUT` for [out]
- `VX_BIDIRECTIONAL` for [in,out]

When programming the parameters, use

- `VX_TYPE_IMAGE` for a `vx_image` in the *size* field of `vxGetParameterByIndex` or `vxSetParameterByIndex`
- `VX_TYPE_ARRAY` for a `vx_array` in the *size* field of `vxGetParameterByIndex` or `vxSetParameterByIndex`
- or other appropriate types in `vx_type_e`.

Enumerator

- `VX_KERNEL_COLOR_CONVERT` - The Color Space conversion kernel.

  The conversions are based on the `vx_df_image_e` code in the images.

  See also: Color Convert

- `VX_KERNEL_CHANNEL_EXTRACT` - The Generic Channel Extraction Kernel.

  This kernel can remove individual color channels from an interleaved or semi-planar, planar, sub-sampled planar image. A client could extract a red channel from an interleaved RGB image or do a Luma extract from a YUV format.

  See also: Channel Extract

- `VX_KERNEL_CHANNEL_COMBINE` - The Generic Channel Combine Kernel.

  This kernel combine multiple individual planes into a single multiplanar image of the type specified in the output image.

  See also: Channel Combine

- `VX_KERNEL_SOBEL_3x3` - The Sobel 3x3 Filter Kernel.

  See also: Sobel 3x3

- `VX_KERNEL_MAGNITUDE` - The Magnitude Kernel.

  This kernel produces a magnitude plane from two input gradients.

  See also: Magnitude

- `VX_KERNEL_PHASE` - The Phase Kernel.

This kernel produces a phase plane from two input gradients.

See also: Phase

- `VX_KERNEL_SCALE_IMAGE` - The Scale Image Kernel.

  This kernel provides resizing of an input image to an output image. The scaling factor is determined but the relative sizes of the input and output.

  See also: Scale Image

- `VX_KERNEL_TABLE_LOOKUP` - The Table Lookup kernel.

  See also: TableLookup

- `VX_KERNEL_HISTOGRAM` - The Histogram Kernel.

  See also: Histogram

- `VX_KERNEL_EQUALIZE_HISTOGRAM` - The Histogram Equalization Kernel.

  See also: Equalize Histogram

- `VX_KERNEL_ABSDIFF` - The Absolute Difference Kernel.

  See also: Absolute Difference

- `VX_KERNEL_MEAN_STDDEV` - The Mean and Standard Deviation Kernel.

  See also: Mean and Standard Deviation

- `VX_KERNEL_THRESHOLD` - The Threshold Kernel.

  See also: Thresholding

- `VX_KERNEL_INTEGRAL_IMAGE` - The Integral Image Kernel.

  See also: Integral Image

- `VX_KERNEL_DILATE_3x3` - The dilate kernel.

  See also: Dilate Image

- `VX_KERNEL_ERODE_3x3` - The erode kernel.

  See also: Erode Image

- `VX_KERNEL_MEDIAN_3x3` - The median image filter.

  See also: Median Filter

- `VX_KERNEL_BOX_3x3` - The box filter kernel.

  See also: Box Filter

- `VX_KERNEL_GAUSSIAN_3x3` - The gaussian filter kernel.

  See also: Gaussian Filter

- `VX_KERNEL_CUSTOM_CONVOLUTION` - The custom convolution kernel.

  See also: Custom Convolution

- `VX_KERNEL_GAUSSIAN_PYRAMID` - The gaussian image pyramid kernel.

  See also: Gaussian Image Pyramid

- `VX_KERNEL_ACCUMULATE` - The accumulation kernel.

  See also: Accumulate

- `VX_KERNEL_ACCUMULATE_WEIGHTED` - The weigthed accumulation kernel.

  See also: Accumulate Weighted

- `VX_KERNEL_ACCUMULATE_SQUARE` - The squared accumulation kernel.

  See also: Accumulate Squared

- `VX_KERNEL_MINMAXLOC` - The min and max location kernel.

  See also: Max Location

- `VX_KERNEL_CONVERTDEPTH` - The bit-depth conversion kernel.

  See also: [Convert Bit depth]

- `VX_KERNEL_CANNY_EDGE_DETECTOR` - The Canny Edge Detector.

  See also: Canny Edge Detector

- `VX_KERNEL_AND` - The Bitwise And Kernel.

  See also: Bitwise AND

- `VX_KERNEL_OR` - The Bitwise Inclusive Or Kernel.

  See also: Bitwise INCLUSIVE OR

- `VX_KERNEL_XOR` - The Bitwise Exclusive Or Kernel.

  See also: Bitwise EXCLUSIVE OR

- `VX_KERNEL_NOT` - The Bitwise Not Kernel.

  See also: Bitwise NOT

- `VX_KERNEL_MULTIPLY` - The Pixelwise Multiplication Kernel.

See also: Pixel-wise Multiplication

- VX_KERNEL_ADD - The Addition Kernel.

  See also: Arithmetic Addition

- VX_KERNEL_SUBTRACT - The Subtraction Kernel.

  See also: Arithmetic Subtraction

- VX_KERNEL_WARP_AFFINE - The Warp Affine Kernel.

  See also: Warp Affine

- VX_KERNEL_WARP_PERSPECTIVE - The Warp Perspective Kernel.

  See also: Warp Perspective

- VX_KERNEL_HARRIS_CORNERS - The Harris Corners Kernel.

  See also: Harris Corners

- VX_KERNEL_FAST_CORNERS - The FAST Corners Kernel.

  See also: Fast Corners

- VX_KERNEL_OPTICAL_FLOW_PYR_LK - The Optical Flow Pyramid (LK) Kernel.

  See also: Optical Flow Pyramid (LK)

- VX_KERNEL_REMAP - The Remap Kernel.

  See also: Remap

- VX_KERNEL_HALFSCALE_GAUSSIAN - The Half Scale Gaussian Kernel.

  See also: Scale Image

- VX_KERNEL_MAX_1_0
- VX_KERNEL_LAPLACIAN_PYRAMID - The Laplacian Image Pyramid Kernel.

  See also: Laplacian Image Pyramid

- VX_KERNEL_LAPLACIAN_RECONSTRUCT - The Laplacian Pyramid Reconstruct Kernel.

  See also: Laplacian Image Pyramid

- VX_KERNEL_NON_LINEAR_FILTER - The Non Linear Filter Kernel.

  See also: Non Linear Filter

- VX_KERNEL_MAX_1_1
- VX_KERNEL_MATCH_TEMPLATE - The Match Template Kernel.

See also: MatchTemplate

- `VX_KERNEL_LBP` - The LBP Kernel.

  See also: LBP

- `VX_KERNEL_HOUGH_LINES_P` - The hough lines probability Kernel.

  See also: HoughLinesP

- `VX_KERNEL_TENSOR_MULTIPLY` - The tensor multiply Kernel.

  See also: Tensor Multiply

- `VX_KERNEL_TENSOR_ADD` - The tensor add Kernel.

  See also: Tensor Add

- `VX_KERNEL_TENSOR_SUBTRACT` - The tensor subtract Kernel.

  See also: Tensor Subtract

- `VX_KERNEL_TENSOR_TABLE_LOOKUP` - The tensor table look up Kernel.

  See also: Tensor TableLookUp

- `VX_KERNEL_TENSOR_TRANSPOSE` - The tensor transpose Kernel.

  See also: Tensor Transpose

- `VX_KERNEL_TENSOR_CONVERT_DEPTH` - The tensor convert depth Kernel.

  See also: Tensor Convert Bit-Depth

- `VX_KERNEL_TENSOR_MATRIX_MULTIPLY`
  - The tensor matrix multiply Kernel.

    See also: Tensor Matrix Multiply

- `VX_KERNEL_COPY` - The data object copy kernel.

  See also: Data Object Copy

- `VX_KERNEL_NON_MAX_SUPPRESSION` - The non-max suppression kernel.

  See also: Non-Maxima Suppression

- `VX_KERNEL_SCALAR_OPERATION` - The scalar operation kernel.

  See also: Control Flow

- `VX_KERNEL_HOG_FEATURES` - The HOG features kernel.

See also: HOG

- `VX_KERNEL_HOG_CELLS` - The HOG Cells kernel.

  See also: HOG

- `VX_KERNEL_BILATERAL_FILTER` - The bilateral filter kernel.

  See also: Bilateral Filter

- `VX_KERNEL_SELECT` - The select kernel.

  See also: Control Flow

- `VX_KERNEL_MAX_1_2`
- `VX_KERNEL_MAX` - The max kernel.

  See also: Max

- `VX_KERNEL_MIN` - The min kernel.

  See also: Min

vx_library_e

The standard list of available libraries.

```
enum vx_library_e {
    VX_LIBRARY_KHR_BASE = 0x0,
};
```

Enumerator

- `VX_LIBRARY_KHR_BASE` - The base set of kernels as defined by Khronos.

6.5.5. Functions

vxGetKernelByEnum

Obtains a reference to the kernel using the `vx_kernel_e` enumeration.

```
vx_kernel vxGetKernelByEnum(
    vx_context                                  context,
    vx_enum                                     kernel);
```

Enum values above the standard set are assumed to apply to loaded libraries.

Parameters

* `[in]` *context* - The reference to the implementation context.
* `[in]` *kernel* - A value from `vx_kernel_e` or a vendor or client-defined value.

Returns: A `vx_kernel` reference. Any possible errors preventing a successful completion of the function should be checked using `vxGetStatus`.

Precondition: `vxLoadKernels` if the kernel is not provided by the OpenVX implementation.

vxGetKernelByName

Obtains a reference to a kernel using a string to specify the name.

```
vx_kernel vxGetKernelByName(
    vx_context                                  context,
    const vx_char*                              name);
```

User Kernels follow a "dotted" hierarchical syntax. For example: "com.company.example.xyz". The following are strings specifying the kernel names:

org.khronos.openvx.color_convert
org.khronos.openvx.channel_extract
org.khronos.openvx.channel_combine
org.khronos.openvx.sobel_3x3
org.khronos.openvx.magnitude
org.khronos.openvx.phase
org.khronos.openvx.scale_image
org.khronos.openvx.table_lookup
org.khronos.openvx.histogram
org.khronos.openvx.equalize_histogram
org.khronos.openvx.absdiff
org.khronos.openvx.mean_stddev
org.khronos.openvx.threshold
org.khronos.openvx.integral_image
org.khronos.openvx.dilate_3x3
org.khronos.openvx.erode_3x3
org.khronos.openvx.median_3x3
org.khronos.openvx.box_3x3
org.khronos.openvx.gaussian_3x3
org.khronos.openvx.custom_convolution
org.khronos.openvx.gaussian_pyramid
org.khronos.openvx.accumulate

org.khronos.openvx.accumulate_weighted
org.khronos.openvx.accumulate_square
org.khronos.openvx.minmaxloc
org.khronos.openvx.convertdepth
org.khronos.openvx.canny_edge_detector
org.khronos.openvx.and
org.khronos.openvx.or
org.khronos.openvx.xor
org.khronos.openvx.not
org.khronos.openvx.multiply
org.khronos.openvx.add
org.khronos.openvx.subtract
org.khronos.openvx.warp_affine
org.khronos.openvx.warp_perspective
org.khronos.openvx.harris_corners
org.khronos.openvx.fast_corners
org.khronos.openvx.optical_flow_pyr_lk
org.khronos.openvx.remap
org.khronos.openvx.halfscale_gaussian
org.khronos.openvx.laplacian_pyramid
org.khronos.openvx.laplacian_reconstruct
org.khronos.openvx.non_linear_filter
org.khronos.openvx.match_template
org.khronos.openvx.lbp
org.khronos.openvx.hough_lines_p
org.khronos.openvx.tensor_multiply
org.khronos.openvx.tensor_add
org.khronos.openvx.tensor_subtract
org.khronos.openvx.tensor_table_lookup
org.khronos.openvx.tensor_transpose
org.khronos.openvx.tensor_convert_depth
org.khronos.openvx.tensor_matrix_multiply
org.khronos.openvx.copy
org.khronos.openvx.non_max_suppression
org.khronos.openvx.scalar_operation
org.khronos.openvx.hog_features
org.khronos.openvx.hog_cells

org.khronos.openvx.bilateral_filter
org.khronos.openvx.select
org.khronos.openvx.min
org.khronos.openvx.max

Parameters

- `[in]` *context* - The reference to the implementation context.
- `[in]` *name* - The string of the name of the kernel to get.

Returns: A kernel reference. Any possible errors preventing a successful completion of the function should be checked using `vxGetStatus`.

Precondition: `vxLoadKernels` if the kernel is not provided by the OpenVX implementation.

> *Note*
>
> User Kernels should follow a “dotted” hierarchical syntax. For example: "com.company.example.xyz".

vxQueryKernel

This allows the client to query the kernel to get information about the number of parameters, enum values, etc.

```
vx_status vxQueryKernel(
    vx_kernel                                   kernel,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- `[in]` *kernel* - The kernel reference to query.
- `[in]` *attribute* - The attribute to query. Use a `vx_kernel_attribute_e`.
- `[out]` *ptr* - The pointer to the location at which to store the resulting value.
- `[in]` *size* - The size of the container to which *ptr* points.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - kernel is not a valid `vx_kernel` reference.
- `VX_ERROR_INVALID_PARAMETERS` - If any of the other parameters are incorrect.
- `VX_ERROR_NOT_SUPPORTED` - If the attribute value is not supported in this implementation.

vxReleaseKernel

Release the reference to the kernel. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseKernel(
    vx_kernel*                                  kernel);
```

Parameters

- `[in]` *kernel* - The pointer to the kernel reference to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - kernel is not a valid `vx_kernel` reference.

6.6. Object: Parameter

Defines the Parameter Object interface.

An abstract input, output, or bidirectional data object passed to a computer vision function. This object contains the signature of that parameter's usage from the kernel description. This information includes:

- *Signature Index* - The numbered index of the parameter in the signature.
- *Object Type* - e.g., `VX_TYPE_IMAGE` or `VX_TYPE_ARRAY` or some other object type from `vx_type_e`.
- *Usage Model* - e.g., `VX_INPUT`, `VX_OUTPUT`, or `VX_BIDIRECTIONAL`.
- *Presence State* - e.g., `VX_PARAMETER_STATE_REQUIRED` or `VX_PARAMETER_STATE_OPTIONAL`.

Typedefs

- `vx_parameter`

Enumerations

- `vx_direction_e`
- `vx_parameter_attribute_e`
- `vx_parameter_state_e`

Functions

- `vxGetKernelParameterByIndex`
- `vxGetParameterByIndex`

- vxQueryParameter
- vxReleaseParameter
- vxSetParameterByIndex
- vxSetParameterByReference

6.6.1. Typedefs

vx_parameter

An opaque reference to a single parameter.

```
typedef struct _vx_parameter *vx_parameter;
```

See also: vxGetParameterByIndex

6.6.2. Enumerations

vx_direction_e

An indication of how a kernel will treat the given parameter.

```
enum vx_direction_e {
    VX_INPUT = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_DIRECTION) + 0x0,
    VX_OUTPUT = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_DIRECTION) + 0x1,
    VX_BIDIRECTIONAL = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_DIRECTION) + 0x2,
};
```

Enumerator

- VX_INPUT - The parameter is an input only.
- VX_OUTPUT - The parameter is an output only.
- VX_BIDIRECTIONAL - The parameter is both an input and output.

vx_parameter_attribute_e

The parameter attributes list.

```
enum vx_parameter_attribute_e {
    VX_PARAMETER_INDEX = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PARAMETER) + 0x0,
    VX_PARAMETER_DIRECTION = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PARAMETER) +
0x1,
    VX_PARAMETER_TYPE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PARAMETER) + 0x2,
    VX_PARAMETER_STATE = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PARAMETER) + 0x3,
    VX_PARAMETER_REF = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_PARAMETER) + 0x4,
};
```

Enumerator

- VX_PARAMETER_INDEX - Queries a parameter for its index value on the kernel with which it is associated. Read-only. Use a vx_uint32 parameter.
- VX_PARAMETER_DIRECTION - Queries a parameter for its direction value on the kernel with which it is associated. Read-only. Use a vx_enum parameter.
- VX_PARAMETER_TYPE - Queries a parameter for its type, vx_type_e is returned. Read-only. The size of the parameter is implied for plain data objects. For opaque data objects like images and arrays a query to their attributes has to be called to determine the size.
- VX_PARAMETER_STATE - Queries a parameter for its state. A value in vx_parameter_state_e is returned. Read-only. Use a vx_enum parameter.
- VX_PARAMETER_REF - Use to extract the reference contained in the parameter. Read-only. Use a vx_reference parameter.

vx_parameter_state_e

The parameter state type.

```
enum vx_parameter_state_e {
    VX_PARAMETER_STATE_REQUIRED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_PARAMETER_STATE)
+ 0x0,
    VX_PARAMETER_STATE_OPTIONAL = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_PARAMETER_STATE)
+ 0x1,
};
```

Enumerator

- VX_PARAMETER_STATE_REQUIRED - Default. The parameter must be supplied. If not set, during Verify, an error is returned.
- VX_PARAMETER_STATE_OPTIONAL - The parameter may be unspecified. The kernel takes care not to deference optional parameters until it is certain they are valid.

6.6.3. Functions

vxGetKernelParameterByIndex

Retrieves a vx_parameter from a vx_kernel.

```
vx_parameter vxGetKernelParameterByIndex(
    vx_kernel                                   kernel,
    vx_uint32                                   index);
```

Parameters

- [in] *kernel* - The reference to the kernel.

- [in] *index* - The index of the parameter.

Returns: A vx_parameter reference. Any possible errors preventing a successful completion of the function should be checked using vxGetStatus.

vxGetParameterByIndex

Retrieves a vx_parameter from a vx_node.

```
vx_parameter vxGetParameterByIndex(
    vx_node                                     node,
    vx_uint32                                   index);
```

Parameters

- [in] *node* - The node from which to extract the parameter.
- [in] *index* - The index of the parameter to which to get a reference.

Returns: A parameter reference vx_parameter. Any possible errors preventing a successful completion of the function should be checked using vxGetStatus.

vxQueryParameter

Allows the client to query a parameter to determine its meta-information.

```
vx_status vxQueryParameter(
    vx_parameter                                parameter,
    vx_enum                                     attribute,
    void*                                       ptr,
    vx_size                                     size);
```

Parameters

- [in] *parameter* - The reference to the parameter.
- [in] *attribute* - The attribute to query. Use a vx_parameter_attribute_e.
- [out] *ptr* - The location at which to store the resulting value.
- [in] *size* - The size in bytes of the container to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - parameter is not a valid vx_parameter reference.

vxReleaseParameter

Releases a reference to a parameter object. The object may not be garbage collected until its total reference count is zero.

```
vx_status vxReleaseParameter(
    vx_parameter*                               param);
```

Parameters

- [in] *param* - The pointer to the parameter to release.

Postcondition: After returning from this function the reference is zeroed.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - param is not a valid vx_parameter reference.

vxSetParameterByIndex

Sets the specified parameter data for a kernel on the node.

```
vx_status vxSetParameterByIndex(
    vx_node                                     node,
    vx_uint32                                   index,
    vx_reference                                value);
```

Parameters

- [in] *node* - The node that contains the kernel.
- [in] *index* - The index of the parameter desired.
- [in] *value* - The desired value of the parameter.

> *Note*
>
> A user may not provide a NULL value for a mandatory parameter of this API.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - node is not a valid vx_node reference, or value is not a valid vx_reference reference.

See also: vxSetParameterByReference

vxSetParameterByReference

Associates a parameter reference and a data reference with a kernel on a node.

```
vx_status vxSetParameterByReference(
    vx_parameter                                parameter,
    vx_reference                                value);
```

Parameters

- [in] *parameter* - The reference to the kernel parameter.
- [in] *value* - The value to associate with the kernel parameter.

> *Note*
>
> A user may not provide a NULL value for a mandatory parameter of this API.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - parameter is not a valid vx_parameter reference, or value is not a valid vx_reference reference..

See also: vxGetParameterByIndex

Chapter 7. Advanced Framework API

Describes components that are considered to be advanced.

Advanced topics include: extensions through User Kernels; Reflection and Introspection; Performance Tweaking through Hinting and Directives; and Debugging Callbacks.

Modules

- Framework: Directives
- Framework: Graph Parameters
- Framework: Hints
- Framework: Log
- Framework: Node Callbacks
- Framework: Performance Measurement
- Framework: User Kernels

7.1. Framework: Node Callbacks

Allows Clients to receive a callback after a specific node has completed execution.

Callbacks are not guaranteed to be called *immediately* after the Node completes. Callbacks are intended to be used to create simple *early exit* conditions for Vision graphs using `vx_action_e` return values. An example of setting up a callback can be seen below:

```
vx_graph graph = vxCreateGraph(context);
status = vxGetStatus((vx_reference)graph);
if (status == VX_SUCCESS) {
    vx_uint8 lmin = 0, lmax = 0;
    vx_uint32 minCount = 0, maxCount = 0;
    vx_scalar scalars[] = {
        vxCreateScalar(context, VX_TYPE_UINT8, &lmin),
        vxCreateScalar(context, VX_TYPE_UINT8, &lmax),
        vxCreateScalar(context, VX_TYPE_UINT32, &minCount),
        vxCreateScalar(context, VX_TYPE_UINT32, &maxCount),
    };
    vx_array arrays[] = {
        vxCreateArray(context, VX_TYPE_COORDINATES2D, 1),
        vxCreateArray(context, VX_TYPE_COORDINATES2D, 1)
    };
    vx_node nodes[] = {
        vxMinMaxLocNode(graph, input, scalars[0], scalars[1], arrays[0], arrays[1],
scalars[2], scalars[3]),
        /// other nodes
    };
    status = vxAssignNodeCallback(nodes[0], &analyze_brightness);
    // do other
}
```

Once the graph has been initialized and the callback has been installed then the callback itself will be called during graph execution.

```
#define MY_DESIRED_THRESHOLD (10)
vx_action analyze_brightness(vx_node node) {
    // extract the max value
    vx_action action = VX_ACTION_ABANDON;
    vx_parameter pmax = vxGetParameterByIndex(node, 2); // Max Value
    if (pmax) {
        vx_scalar smax = 0;
        vxQueryParameter(pmax, VX_PARAMETER_REF, &smax, sizeof(smax));
        if (smax) {
            vx_uint8 value = 0u;
            vxCopyScalar(smax, &value, VX_READ_ONLY, VX_MEMORY_TYPE_HOST);
            if (value >= MY_DESIRED_THRESHOLD) {
                action = VX_ACTION_CONTINUE;
            }
            vxReleaseScalar(&smax);
        }
        vxReleaseParameter(&pmax);
    }
    return action;
}
```

> *Warning*
>
> This should be used with ***extreme*** caution as it can *ruin* optimizations in the power/performance efficiency of a graph.

The callback must return a `vx_action` code indicating how the graph processing should proceed.

- If `VX_ACTION_CONTINUE` is returned, the graph will continue execution with no changes.
- If `VX_ACTION_ABANDON` is returned, execution is unspecified for all nodes for which this node is a dominator. Nodes that are dominators of this node will have executed. Execution of any other node is unspecified.

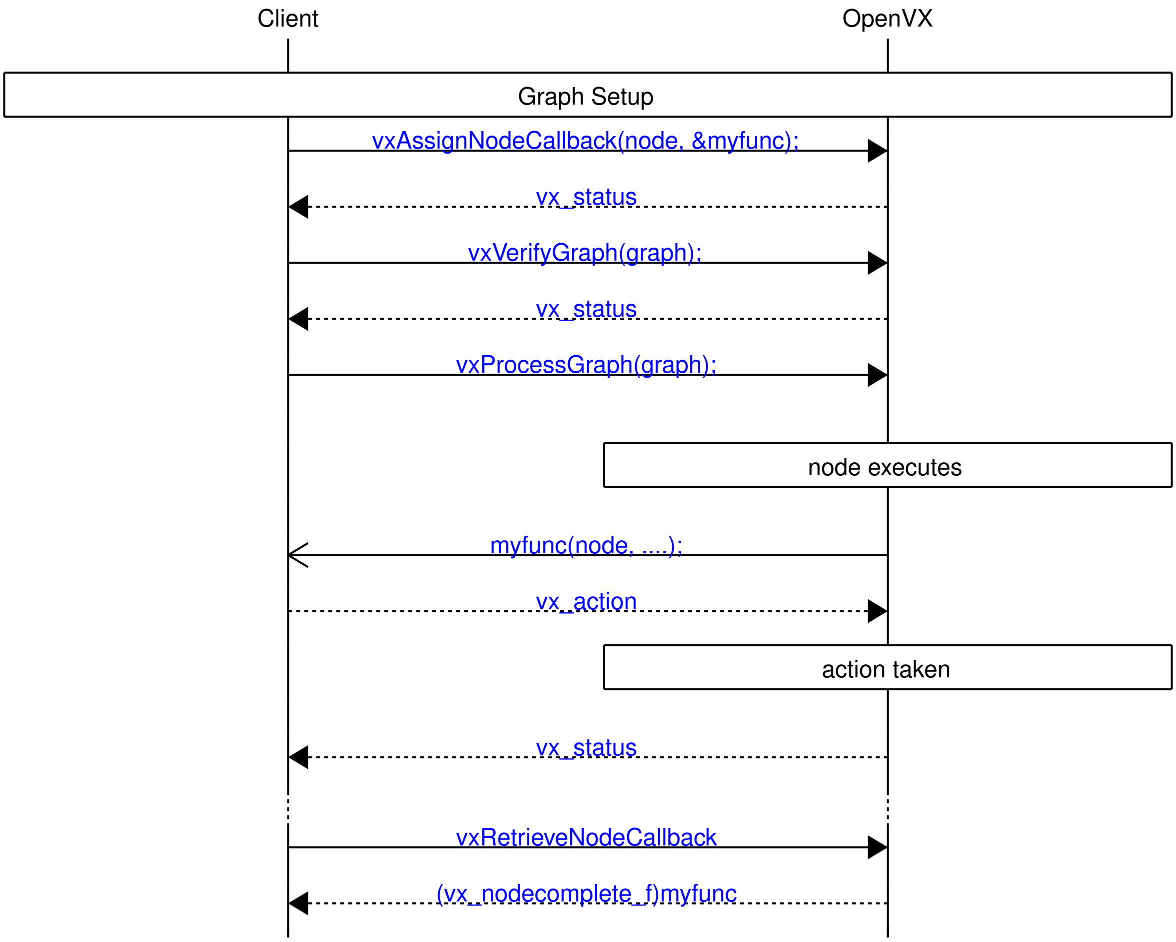


Figure 11. Node Callback Sequence

Typedefs

- `vx_action`
- `vx_nodecomplete_f`

Enumerations

- `vx_action_e`

Functions

- `vxAssignNodeCallback`
- `vxRetrieveNodeCallback`

7.1.1. Typedefs

vx_action

The formal typedef of the response from the callback.

```
typedef vx_enum   vx_action;
```

See also: vx_action_e

vx_nodecomplete_f

A callback to the client after a particular node has completed.

```
typedef vx_action (*vx_nodecomplete_f)(vx_node node);
```

See also: vx_action, vxAssignNodeCallback

Parameters

- [in] *node* - The node to which the callback was attached.

Returns: An action code from vx_action_e.

7.1.2. Enumerations

vx_action_e

A return code enumeration from a vx_nodecomplete_f during execution.

```
enum vx_action_e {
    VX_ACTION_CONTINUE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_ACTION) + 0x0,
    VX_ACTION_ABANDON = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_ACTION) + 0x1,
};
```

See also: vxAssignNodeCallback

Enumerator

- VX_ACTION_CONTINUE - Continue executing the graph with no changes.
- VX_ACTION_ABANDON - Stop executing the graph.

7.1.3. Functions

vxAssignNodeCallback

Assigns a callback to a node. If a callback already exists in this node, this function must return an error and the user may clear the callback by passing a NULL pointer as the callback.

```
vx_status vxAssignNodeCallback(
    vx_node                                      node,
    vx_nodecomplete_f                            callback);
```

Parameters

- [in] *node* - The reference to the node.
- [in] *callback* - The callback to associate with completion of this specific node.

> *Warning*
>
> This must be used with ***extreme*** caution as it can *ruin* optimizations in the power/performance efficiency of a graph.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Callback assigned; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - node is not a valid vx_node reference.

vxRetrieveNodeCallback

Retrieves the current node callback function pointer set on the node.

```
vx_nodecomplete_f vxRetrieveNodeCallback(
    vx_node                                      node);
```

Parameters

- [in] *node* - The reference to the vx_node object.

Returns: vx_nodecomplete_f The pointer to the callback function.

Return Values

- NULL - No callback is set.
- * - The node callback function.

7.2. Framework: Performance Measurement

Defines Performance measurement and reporting interfaces.

In OpenVX, both vx_graph objects and vx_node objects track performance information. A client can query either object type using their respective vxQuery<Object> function with their attribute enumeration VX_<OBJECT>_PERFORMANCE along with a vx_perf_t structure to obtain the performance information.

```
vx_perf_t perf;
vxQueryNode(node, VX_NODE_PERFORMANCE, &perf, sizeof(perf));
```

Data Structures

- vx_perf_t

7.2.1. Data Structures

vxSetParameterByReference

The performance measurement structure. The time or durations are in units of nano seconds.

```
typedef struct _vx_perf_t {
    vx_uint64    tmp;
    vx_uint64    beg;
    vx_uint64    end;
    vx_uint64    sum;
    vx_uint64    avg;
    vx_uint64    min;
    vx_uint64    num;
    vx_uint64    max;
} vx_perf_t;
```

- tmp - Holds the last measurement.
- beg - Holds the first measurement in a set.
- end - Holds the last measurement in a set.
- sum - Holds the summation of durations.
- avg - Holds the average of the durations.
- min - Holds the minimum of the durations.
- num - Holds the number of measurements.
- max - Holds the maximum of the durations.

7.3. Framework: Log

Defines the debug logging interface.

The functions of the debugging interface allow clients to receive important debugging information about OpenVX. See vx_status_e for the list of possible errors.

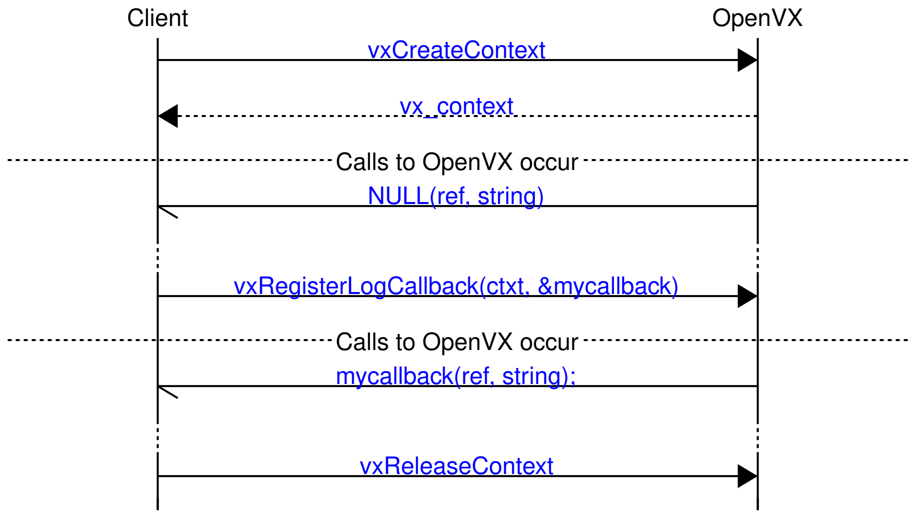


Figure 12. Log messages only can be received after the callback is installed

Typedefs

- vx_log_callback_f

Functions

- vxAddLogEntry
- vxRegisterLogCallback

7.3.1. Typedefs

vx_log_callback_f

The log callback function.

```
typedef void (*vx_log_callback_f)(
            vx_context context,
            vx_reference ref,
            vx_status status,
            const vx_char string[]);
```

7.3.2. Functions

vxAddLogEntry

Adds a line to the log.

```
void vxAddLogEntry(
    vx_reference                                ref,
    vx_status                                   status,
    const char*                                 message,
    );
```

Parameters

- [in] *ref* - The reference to add the log entry against. Some valid value must be provided.
- [in] *status* - The status code. VX_SUCCESS status entries are ignored and not added.
- [in] *message* - The human readable message to add to the log.
- [in] ... - a list of variable arguments to the message.

> *Note*
>
> Messages may not exceed VX_MAX_LOG_MESSAGE_LEN bytes and will be truncated in the log if they exceed this limit.

vxRegisterLogCallback

Registers a callback facility to the OpenVX implementation to receive error logs.

```
void vxRegisterLogCallback(
    vx_context                                  context,
    vx_log_callback_f                           callback,
    vx_bool                                     reentrant);
```

Parameters

- [in] *context* - The overall context to OpenVX.
- [in] *callback* - The callback function. If NULL, the previous callback is removed.
- [in] *reentrant* - If reentrancy flag is vx_true_e, then the callback may be entered from multiple simultaneous tasks or threads (if the host OS supports this).

7.4. Framework: Hints

Defines the Hints Interface.

Hints are messages given to the OpenVX implementation that it may support. (These are optional.)

Enumerations

- vx_hint_e

Functions

- vxHint

7.4.1. Enumerations

vx_hint_e

These enumerations are given to the vxHint API to enable/disable platform optimizations and/or features. Hints are optional and usually are vendor-specific.

```
enum vx_hint_e {
    VX_HINT_PERFORMANCE_DEFAULT = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_HINT) + 0x1,
    VX_HINT_PERFORMANCE_LOW_POWER = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_HINT) + 0x2,
    VX_HINT_PERFORMANCE_HIGH_SPEED = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_HINT) + 0x3,
};
```

See also: `vxHint`

Enumerator

- `VX_HINT_PERFORMANCE_DEFAULT` - Indicates to the implementation that user do not apply any specific requirements for performance.
- `VX_HINT_PERFORMANCE_LOW_POWER` - Indicates the user preference is low power consumption versus highest performance.
- `VX_HINT_PERFORMANCE_HIGH_SPEED` - Indicates the user preference for highest performance over low power consumption.

7.4.2. Functions

vxHint

Provides a generic API to give platform-specific hints to the implementation.

```
vx_status vxHint(
    vx_reference                                reference,
    vx_enum                                     hint,
    const void*                                 data,
    vx_size                                     data_size);
```

Parameters

- `[in]` *reference* - The reference to the object to hint at. This could be `vx_context`, `vx_graph`, `vx_node`, `vx_image`, `vx_array`, or any other reference.
- `[in]` *hint* - A `vx_hint_e` *hint* to give to a `vx_context`. This is a platform-specific optimization or implementation mechanism.
- `[in]` *data* - Optional vendor specific data.
- `[in]` *data_size* - Size of the data structure *data*.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - reference is not a valid `vx_reference` reference.
- `VX_ERROR_NOT_SUPPORTED` - If the hint is not supported.

7.5. Framework: Directives

Defines the Directives Interface.

Directives are messages given the OpenVX implementation that it must support. (These are required, i.e., non-optional.)

Enumerations

- `vx_directive_e`

Functions

- `vxDirective`

7.5.1. Enumerations

vx_directive_e

These enumerations are given to the `vxDirective` API to enable/disable platform optimizations and/or features. Directives are not optional and usually are vendor-specific, by defining a vendor range of directives and starting their enumeration from there.

```
enum vx_directive_e {
    VX_DIRECTIVE_DISABLE_LOGGING = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_DIRECTIVE) +
0x0,
    VX_DIRECTIVE_ENABLE_LOGGING = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_DIRECTIVE) +
0x1,
    VX_DIRECTIVE_DISABLE_PERFORMANCE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_DIRECTIVE)
+ 0x2,
    VX_DIRECTIVE_ENABLE_PERFORMANCE = VX_ENUM_BASE(VX_ID_KHRONOS, VX_ENUM_DIRECTIVE) +
0x3,
};
```

See also: `vxDirective`

Enumerator

- `VX_DIRECTIVE_DISABLE_LOGGING` - Disables recording information for graph debugging.
- `VX_DIRECTIVE_ENABLE_LOGGING` - Enables recording information for graph debugging.
- `VX_DIRECTIVE_DISABLE_PERFORMANCE`
    - Disables performance counters for the context. By default performance counters are disabled.
- `VX_DIRECTIVE_ENABLE_PERFORMANCE` - Enables performance counters for the context.

7.5.2. Functions

vxDirective

Provides a generic API to give platform-specific directives to the implementations.

```
vx_status vxDirective(
    vx_reference                                reference,
    vx_enum                                     directive);
```

Parameters

- `[in]` *reference* - The reference to the object to set the directive on. This could be `vx_context`, `vx_graph`, `vx_node`, `vx_image`, `vx_array`, or any other reference.
- `[in]` *directive* - The directive to set. See `vx_directive_e`.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - reference is not a valid `vx_reference` reference.
- `VX_ERROR_NOT_SUPPORTED` - If the directive is not supported.

> *Note*
>
> The performance counter directives are only available for the reference `vx_context`. Error `VX_ERROR_NOT_SUPPORTED` is returned when used with any other reference.

7.6. Framework: User Kernels

Defines the User Kernels, which are a method to extend OpenVX with new vision functions.

User Kernels can be loaded by OpenVX and included as nodes in the graph or as immediate functions (if the Client supplies the interface). User Kernels will typically be loaded and executed on High Level Operating System/CPU compatible targets, not on remote processors or other accelerators. This specification does not mandate what constitutes compatible platforms.

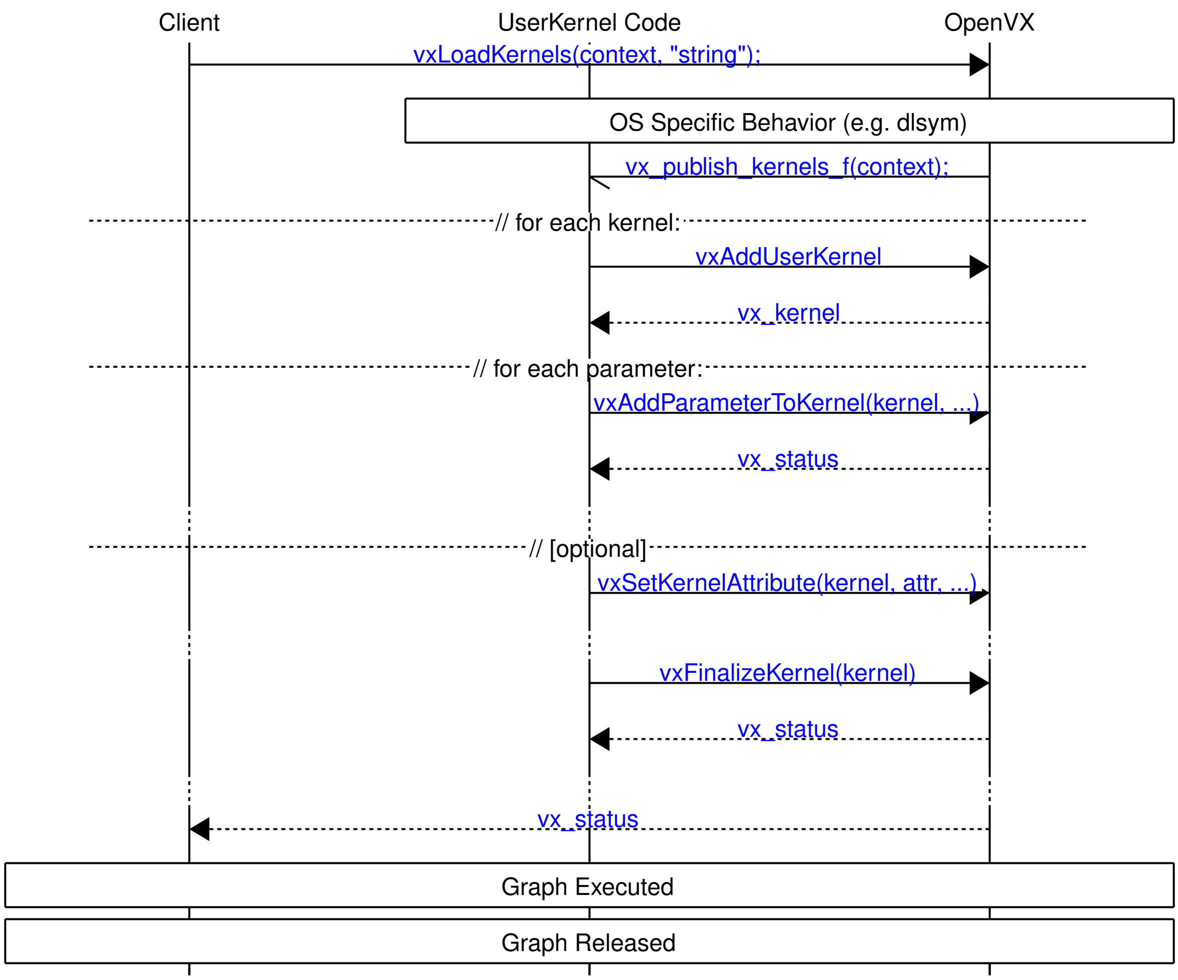


Figure 13. Call sequence of User Kernels Installation

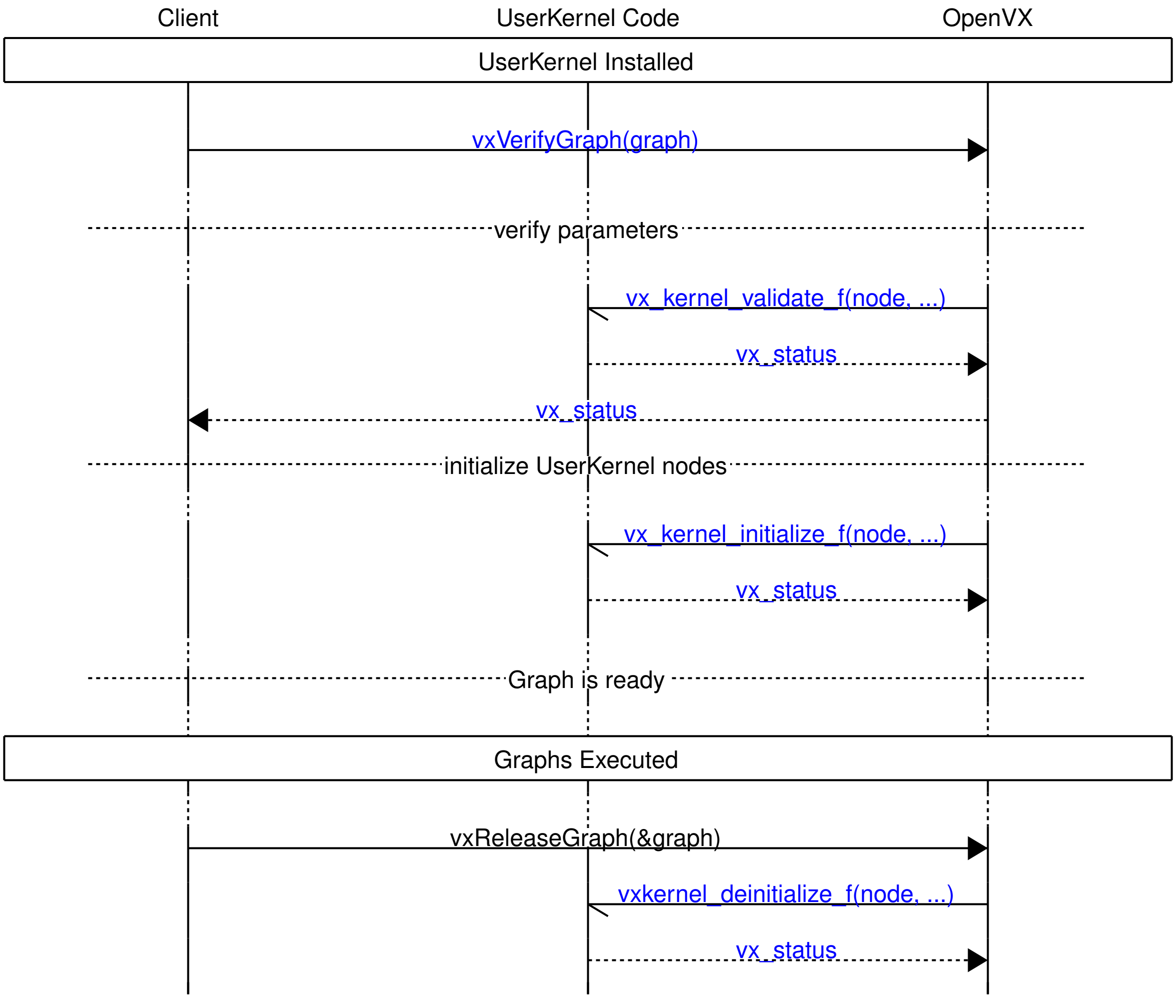


Figure 14. Call sequence of a Graph Verify and Release with User Kernels

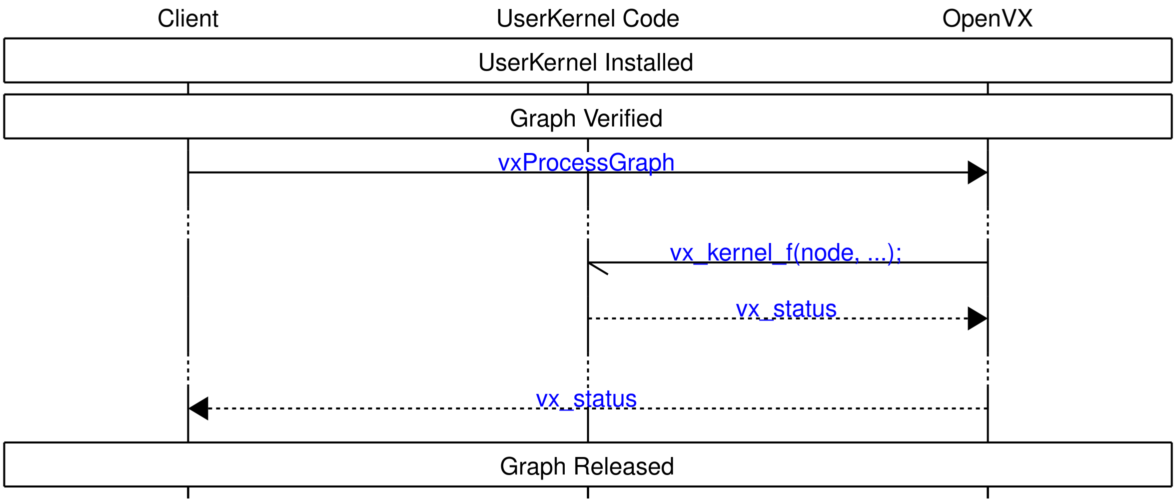


Figure 15. Call sequence of a Graph Execution with User Kernels

During the first graph verification, the implementation will perform the following action sequence:

1. Initialize local data node attributes
   - If `VX_KERNEL_LOCAL_DATA_SIZE` == 0, then set `VX_NODE_LOCAL_DATA_SIZE` to 0 and set `VX_NODE_LOCAL_DATA_PTR` to `NULL`.
   - If `VX_KERNEL_LOCAL_DATA_SIZE` != 0, set `VX_NODE_LOCAL_DATA_SIZE` to `VX_KERNEL_LOCAL_DATA_SIZE` and set `VX_NODE_LOCAL_DATA_PTR` to the address of a buffer of `VX_KERNEL_LOCAL_DATA_SIZE` bytes.

2. Call the vx_kernel_validate_f callback.
3. Call the vx_kernel_initialize_f callback (if not NULL):
   - If VX_KERNEL_LOCAL_DATA_SIZE == 0, the callback is allowed to set VX_NODE_LOCAL_DATA_SIZE and VX_NODE_LOCAL_DATA_PTR.
   - If VX_KERNEL_LOCAL_DATA_SIZE != 0, then any attempt by the callback to set VX_NODE_LOCAL_DATA_SIZE or VX_NODE_LOCAL_DATA_PTR attributes will generate an error.
4. Provide the buffer optionally requested by the application
   - If VX_KERNEL_LOCAL_DATA_SIZE == 0 and VX_NODE_LOCAL_DATA_SIZE != 0, and VX_NODE_LOCAL_DATA_PTR == NULL, then the implementation will set VX_NODE_LOCAL_DATA_PTR to the address of a buffer of VX_NODE_LOCAL_DATA_SIZE bytes.

At node destruction time, the implementation will perform the following action sequence:

1. Call vx_kernel_deinitialize_f callback (if not NULL): If the VX_NODE_LOCAL_DATA_PTR was set earlier by the implementation, then any attempt by the callback to set the VX_NODE_LOCAL_DATA_PTR attributes will generate an error.
2. If the VX_NODE_LOCAL_DATA_PTR was set earlier by the implementation, then the pointed memory must not be used anymore by the application after the vx_kernel_deinitialize_f callback completes.

A user node requires re-verification, if any changes below occurred after the last node verification:

1. The VX_NODE_BORDER node attribute was modified.
2. At least one of the node parameters was replaced by a data object with different meta-data, or was replaced by the 0 reference for optional parameters, or was set to a data object if previously not set because optional.

The node re-verification can by triggered explicitly by the application by calling vxVerifyGraph that will perform a complete graph verification. Otherwise, it will be triggered automatically at the next graph execution.

During user node re-verification, the following action sequence will occur:

1. Call the vx_kernel_deinitialize_f callback (if not NULL): If the VX_NODE_LOCAL_DATA_PTR was set earlier by the OpenVX implementation, then any attempt by the callback to set the VX_NODE_LOCAL_DATA_PTR attributes will generate an error.
2. Reinitialize local data node attributes if needed If VX_KERNEL_LOCAL_DATA_SIZE == 0:
   - set VX_NODE_LOCAL_DATA_PTR to NULL.
   - set VX_NODE_LOCAL_DATA_SIZE to 0.
3. Call the vx_kernel_validate_f callback.
4. Call the vx_kernel_initialize_f callback (if not NULL):
   - If VX_KERNEL_LOCAL_DATA_SIZE == 0, the callback is allowed to set VX_NODE_LOCAL_DATA_SIZE and VX_NODE_LOCAL_DATA_PTR.
   - If VX_KERNEL_LOCAL_DATA_SIZE is != 0, then any attempt by the callback to set

`VX_NODE_LOCAL_DATA_SIZE` or `VX_NODE_LOCAL_DATA_PTR` attributes will generate an error.

5. Provide the buffer optionally requested by the application
   - If `VX_KERNEL_LOCAL_DATA_SIZE` == 0 and `VX_NODE_LOCAL_DATA_SIZE` != 0, and `VX_NODE_LOCAL_DATA_PTR` == `NULL`, then the OpenVX implementation will set `VX_NODE_LOCAL_DATA_PTR` to the address of a buffer of `VX_NODE_LOCAL_DATA_SIZE` bytes.

When an OpenVX implementation sets the `VX_NODE_LOCAL_DATA_PTR`, the data inside the buffer will not be persistent between kernel executions.

Typedefs

- `vx_kernel_deinitialize_f`
- `vx_kernel_f`
- `vx_kernel_image_valid_rectangle_f`
- `vx_kernel_initialize_f`
- `vx_kernel_validate_f`
- `vx_meta_format`
- `vx_publish_kernels_f`
- `vx_unpublish_kernels_f`

Enumerations

- `vx_meta_valid_rect_attribute_e`

Functions

- `vxAddParameterToKernel`
- `vxAddUserKernel`
- `vxAllocateUserKernelId`
- `vxAllocateUserKernelLibraryId`
- `vxFinalizeKernel`
- `vxLoadKernels`
- `vxRemoveKernel`
- `vxSetKernelAttribute`
- `vxSetMetaFormatAttribute`
- `vxSetMetaFormatFromReference`
- `vxUnloadKernels`

7.6.1. Typedefs

vx_kernel_deinitialize_f

The pointer to the kernel deinitializer. If the host code requires a call to deinitialize data during a node garbage collection, this function is called if not `NULL`.

```
typedef vx_status (*vx_kernel_deinitialize_f)(
            vx_node node,
            const vx_reference *parameters,
            vx_uint32 num);
```

Parameters

- `[in]` *node* - The handle to the node that contains this kernel.
- `[in]` *parameters* - The array of parameter references.
- `[in]` *num* - The number of parameters.

vx_kernel_f

The pointer to the Host side kernel.

```
typedef vx_status (*vx_kernel_f)(
            vx_node node,
            const vx_reference *parameters,
            vx_uint32 num);
```

Parameters

- `[in]` *node* - The handle to the node that contains this kernel.
- `[in]` *parameters* - The array of parameter references.
- `[in]` *num* - The number of parameters.

vx_kernel_image_valid_rectangle_f

A user-defined callback function to set the valid rectangle of an output image.

```
typedef vx_status (*vx_kernel_image_valid_rectangle_f)(
            vx_node node,
            vx_uint32 index,
            const vx_rectangle_t* const input_valid[],
            vx_rectangle_t* const output_valid[]);
```

The `VX_VALID_RECT_CALLBACK` attribute in the `vx_meta_format` object should be set to the desired callback during user node's output validator. The callback must not call `vxGetValidRegionImage` or `vxSetImageValidRectangle`. Instead, an array of the valid rectangles of all the input images is supplied to the callback to calculate the output valid rectangle. The output of the user node may be a pyramid, or just an image. If it is just an image, the 'Out' array associated with that output only has one element. If the output is a pyramid, the array size is equal to the number of pyramid levels. Notice that the array memory allocation passed to the callback is managed by the framework, the application must not allocate or deallocate those pointers.

The behavior of the callback function vx_kernel_image_valid_rectangle_f is undefined if one of the following is true:

- One of the input arguments of a user node is a pyramid or an array of images.
- Either input or output argument of a user node is an array of pyramids.

Parameters

- `[inout]` *node* - The handle to the node that is being validated.
- `[in]` *index* - The index of the output parameter for which a valid region should be set.
- `[in]` *input_valid* - A pointer to an array of valid regions of input images or images contained in image container (e.g. pyramids). They are provided in same order as the parameter list of the kernel's declaration.
- `[out]` *output_valid* - An array of valid regions that should be set for the output images or image containers (e.g. pyramid) after graph processing. The length of the array should be equal to the size of the image container (e.g. number of levels in the pyramid). For a simple output image the array size is always one. Each rectangle supplies the valid region for one image. The array memory allocation is managed by the framework.

Returns: An error code describing the validation status on parameters.

vx_kernel_initialize_f

The pointer to the kernel initializer. If the host code requires a call to initialize data once all the parameters have been validated, this function is called if not `NULL`.

```
typedef vx_status (*vx_kernel_initialize_f)(
            vx_node node,
            const vx_reference *parameters,
            vx_uint32 num);
```

Parameters

- `[in]` *node* - The handle to the node that contains this kernel.
- `[in]` *parameters* - The array of parameter references.
- `[in]` *num* - The number of parameters.

vx_kernel_validate_f

The user-defined kernel node parameters validation function. The function only needs to fill in the meta data structure(s).

```
typedef vx_status (*vx_kernel_validate_f)(
            vx_node node,
            const vx_reference parameters[],
            vx_uint32 num,
            vx_meta_format metas[]);
```

Note

This function is called once for whole set of parameters.

Parameters

- [in] *node* - The handle to the node that is being validated.
- [in] *parameters* - The array of parameters to be validated.
- [in] *num* - Number of parameters to be validated.
- [in] *metas* - A pointer to a pre-allocated array of structure references that the system holds. The system pre-allocates a number of vx_meta_format structures for the output parameters only, indexed by the same indices as *parameters*[]. The validation function fills in the correct type, format, and dimensionality for the system to use either to create memory or to check against existing memory.

Returns: An error code describing the validation status on parameters.

vx_meta_format

This object is used by output validation functions to specify the meta data of the expected output data object.

```
typedef struct _vx_meta_format *vx_meta_format;
```

Note

When the actual output object of the user node is virtual, the information given through the vx_meta_format object allows the OpenVX framework to automatically create the data object when meta data were not specified by the application at object creation time.

vx_publish_kernels_f

The type of the vxPublishKernels entry function of modules loaded by vxLoadKernels and unloaded by vxUnloadKernels.

```
typedef vx_status (*vx_publish_kernels_f)(vx_context context);
```

Parameters

* `[in]` *context* - The reference to the context kernels must be added to.

vx_unpublish_kernels_f

The type of the `vxUnpublishKernels` entry function of modules loaded by `vxLoadKernels` and unloaded by `vxUnloadKernels`.

```
typedef vx_status (*vx_unpublish_kernels_f)(vx_context context);
```

Parameters

* `[in]` *context* - The reference to the context kernels have been added to.

7.6.2. Enumerations

vx_meta_valid_rect_attribute_e

The meta valid rectangle attributes.

```
enum vx_meta_valid_rect_attribute_e {
    VX_VALID_RECT_CALLBACK = VX_ATTRIBUTE_BASE(VX_ID_KHRONOS, VX_TYPE_META_FORMAT) +
0x1,
};
```

Enumerator

* `VX_VALID_RECT_CALLBACK` - Valid rectangle callback during output parameter validation. Write-only.

7.6.3. Functions

vxAddParameterToKernel

Allows users to set the signatures of the custom kernel.

```
vx_status vxAddParameterToKernel(
    vx_kernel                                    kernel,
    vx_uint32                                    index,
    vx_enum                                      dir,
    vx_enum                                      data_type,
    vx_enum                                      state);
```

Parameters

* `[in]` *kernel* - The reference to the kernel added with `vxAddUserKernel`.
* `[in]` *index* - The index of the parameter to add.

- [in] *dir* - The direction of the parameter. This must be either VX_INPUT or VX_OUTPUT. VX_BIDIRECTIONAL is not supported for this function.
- [in] *data_type* - The type of parameter. This must be a value from vx_type_e.
- [in] *state* - The state of the parameter (required or not). This must be a value from vx_parameter_state_e.

Returns: A vx_status_e enumerated value.

Return Values

- VX_SUCCESS - Parameter is successfully set on kernel; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - kernel is not a valid vx_kernel reference.
- VX_ERROR_INVALID_PARAMETERS - If the parameter is not valid for any reason.

Precondition: vxAddUserKernel

vxAddUserKernel

Allows users to add custom kernels to a context at run-time.

```
vx_kernel vxAddUserKernel(
    vx_context                                  context,
    const vx_char                               name[VX_MAX_KERNEL_NAME],
    vx_enum                                     enumeration,
    vx_kernel_f                                 func_ptr,
    vx_uint32                                   numParams,
    vx_kernel_validate_f                        validate,
    vx_kernel_initialize_f                      init,
    vx_kernel_deinitialize_f                    deinit);
```

Parameters

- [in] *context* - The reference to the context the kernel must be added to.
- [in] *name* - The string to use to match the kernel.
- [in] *enumeration* - The enumerated value of the kernel to be used by clients.
- [in] *func_ptr* - The process-local function pointer to be invoked.
- [in] *numParams* - The number of parameters for this kernel.
- [in] *validate* - The pointer to vx_kernel_validate_f, which validates parameters to this kernel.
- [in] *init* - The kernel initialization function.
- [in] *deinit* - The kernel de-initialization function.

Returns: A vx_kernel reference. Any possible errors preventing a successful creation should be checked using vxGetStatus.

vxAllocateUserKernelId

Allocates and registers user-defined kernel enumeration to a context. The allocated enumeration is from available pool of 4096 enumerations reserved for dynamic allocation from `0)`.

```
vx_status vxAllocateUserKernelId(
    vx_context                                  context,
    vx_enum*                                    pKernelEnumId);
```

Parameters

- `[in]` *context* - The reference to the implementation context.
- `[out]` *pKernelEnumId* - pointer to return `vx_enum` for user-defined kernel.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - If the context is not a valid `vx_context` reference.
- `VX_ERROR_NO_RESOURCES` - The enumerations has been exhausted.

vxAllocateUserKernelLibraryId

Allocates and registers user-defined kernel library ID to a context.

```
vx_status vxAllocateUserKernelLibraryId(
    vx_context                                  context,
    vx_enum*                                    pLibraryId);
```

The allocated library ID is from available pool of library IDs (1..255) reserved for dynamic allocation. The returned libraryId can be used by user-kernel library developer to specify individual kernel enum IDs in a header file, shown below:

```
#define MY_KERNEL_ID1(libraryId) (VX_KERNEL_BASE(VX_ID_USER,libraryId) + 0);
#define MY_KERNEL_ID2(libraryId) (VX_KERNEL_BASE(VX_ID_USER,libraryId) + 1);
#define MY_KERNEL_ID3(libraryId) (VX_KERNEL_BASE(VX_ID_USER,libraryId) + 2);
```

Parameters

- `[in]` *context* - The reference to the implementation context.
- `[out]` *pLibraryId* - pointer to `vx_enum` for user-kernel libraryId.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_NO_RESOURCES` - The enumerations has been exhausted.

vxFinalizeKernel

This API is called after all parameters have been added to the kernel and the kernel is *ready* to be used. Notice that the reference to the kernel created by vxAddUserKernel is still valid after the call to vxFinalizeKernel. If an error occurs, the kernel is not available for usage by the clients of OpenVX. Typically this is due to a mismatch between the number of parameters requested and given.

```
vx_status vxFinalizeKernel(
    vx_kernel                                   kernel);
```

Parameters

- [in] *kernel* - The reference to the loaded kernel from vxAddUserKernel.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - kernel is not a valid vx_kernel reference.

Precondition: vxAddUserKernel and vxAddParameterToKernel

vxLoadKernels

Loads a library of kernels, called module, into a context.

```
vx_status vxLoadKernels(
    vx_context                                  context,
    const vx_char*                              module);
```

The module must be a dynamic library with by convention, two exported functions named vxPublishKernels and vxUnpublishKernels.

vxPublishKernels must have type vx_publish_kernels_f, and must add kernels to the context by calling vxAddUserKernel for each new kernel. vxPublishKernels is called by vxLoadKernels.

vxUnpublishKernels must have type vx_unpublish_kernels_f, and must remove kernels from the context by calling vxRemoveKernel for each kernel the vxPublishKernels has added. vxUnpublishKernels is called by vxUnloadKernels.

> *Note*
>
> When all references to loaded kernels are released, the module may be automatically unloaded.

Parameters

- [in] *context* - The reference to the context the kernels must be added to.
- [in] *module* - The short name of the module to load. On systems where there are specific naming conventions for modules, the name passed should ignore such conventions. For example: `libxyz.so` should be passed as just `xyz` and the implementation will *do the right thing* that the platform requires.

> *Note*
>
> This API uses the system pre-defined paths for modules.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - context is not a valid `vx_context` reference.
- `VX_ERROR_INVALID_PARAMETERS` - If any of the other parameters are incorrect.

See also: `vxGetKernelByName`

vxRemoveKernel

Removes a custom kernel from its context and releases it.

```
vx_status vxRemoveKernel(
    vx_kernel                                   kernel);
```

Parameters

- [in] *kernel* - The reference to the kernel to remove. Returned from `vxAddUserKernel`.

> *Note*
>
> Any kernel enumerated in the base standard cannot be removed; only kernels added through `vxAddUserKernel` can be removed.

Returns: A `vx_status_e` enumeration. The function returns to the application full control over the memory resources provided at the kernel creation time.

Return Values

- `VX_SUCCESS` - No errors; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - kernel is not a valid `vx_kernel` reference.
- `VX_ERROR_INVALID_PARAMETERS` - If a base kernel is passed in.
- `VX_FAILURE` - If the application has not released all references to the kernel object OR if the application has not released all references to a node that is using this kernel OR if the application has not released all references to a graph which has nodes that is using this kernel.

vxSetKernelAttribute

Sets kernel attributes.

```
vx_status vxSetKernelAttribute(
    vx_kernel                                    kernel,
    vx_enum                                      attribute,
    const void*                                  ptr,
    vx_size                                      size);
```

Parameters

- [in] *kernel* - The reference to the kernel.
- [in] *attribute* - The enumeration of the attributes. See vx_kernel_attribute_e.
- [in] *ptr* - The pointer to the location from which to read the attribute.
- [in] *size* - The size in bytes of the data area indicated by *ptr* in bytes.

> *Note*
>
> After a kernel has been passed to vxFinalizeKernel, no attributes can be altered.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - kernel is not a valid vx_kernel reference.

vxSetMetaFormatAttribute

This function allows a user to set the attributes of a vx_meta_format object in a kernel output validator.

```
vx_status vxSetMetaFormatAttribute(
    vx_meta_format                               meta,
    vx_enum                                      attribute,
    const void*                                  ptr,
    vx_size                                      size);
```

The vx_meta_format object contains two types of information: data object meta data and some specific information that defines how the valid region of an image changes

The meta data attributes that can be set are identified by this list:

- vx_image : VX_IMAGE_FORMAT, VX_IMAGE_HEIGHT, VX_IMAGE_WIDTH
- vx_array : VX_ARRAY_CAPACITY, VX_ARRAY_ITEMTYPE
- vx_pyramid : VX_PYRAMID_FORMAT, VX_PYRAMID_HEIGHT, VX_PYRAMID_WIDTH, VX_PYRAMID_LEVELS,

VX_PYRAMID_SCALE

- vx_scalar : VX_SCALAR_TYPE
- vx_matrix : VX_MATRIX_TYPE, VX_MATRIX_ROWS, VX_MATRIX_COLUMNS
- vx_distribution : VX_DISTRIBUTION_BINS, VX_DISTRIBUTION_OFFSET, VX_DISTRIBUTION_RANGE
- vx_remap : VX_REMAP_SOURCE_WIDTH, VX_REMAP_SOURCE_HEIGHT, VX_REMAP_DESTINATION_WIDTH, VX_REMAP_DESTINATION_HEIGHT
- vx_lut : VX_LUT_TYPE, VX_LUT_COUNT
- vx_threshold : VX_THRESHOLD_TYPE, VX_THRESHOLD_INPUT_FORMAT, VX_THRESHOLD_INPUT_FORMAT
- vx_object_array : VX_OBJECT_ARRAY_NUMITEMS, VX_OBJECT_ARRAY_ITEMTYPE
- vx_tensor : VX_TENSOR_NUMBER_OF_DIMS>>, VX_TENSOR_DIMS, VX_TENSOR_DATA_TYPE, VX_TENSOR_FIXED_POINT_POSITION
- VX_VALID_RECT_CALLBACK

> *Note*
>
> For vx_image, a specific attribute can be used to specify the valid region evolution. This information is not a meta data.

Parameters

- [in] *meta* - The reference to the vx_meta_format struct to set
- [in] *attribute* - Use the subset of data object attributes that define the meta data of this object or attributes from vx_meta_format.
- [in] *ptr* - The input pointer of the value to set on the meta format object.
- [in] *size* - The size in bytes of the object to which *ptr* points.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - The attribute was set; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - meta is not a valid vx_meta_format reference.
- VX_ERROR_INVALID_PARAMETERS - size was not correct for the type needed.
- VX_ERROR_NOT_SUPPORTED - the object attribute was not supported on the meta format object.
- VX_ERROR_INVALID_TYPE - attribute type did not match known meta format type.

vxSetMetaFormatFromReference

Set a meta format object from an exemplar data object reference.

```
vx_status vxSetMetaFormatFromReference(
    vx_meta_format                              meta,
    vx_reference                                exemplar);
```

This function sets a vx_meta_format object from the meta data of the exemplar

Parameters

- [in] *meta* - The meta format object to set
- [in] *exemplar* - The exemplar data object.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - The meta format was correctly set; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - meta is not a valid vx_meta_format reference, or exemplar is not a valid vx_reference reference.

vxUnloadKernels

Unloads all kernels from the OpenVX context that had been loaded from the module using the vxLoadKernels function.

```
vx_status vxUnloadKernels(
    vx_context                                  context,
    const vx_char*                              module);
```

The kernel unloading is performed by calling the vxUnpublishKernels exported function of the module.

> *Note*
>
> vxUnpublishKernels is defined in the description of vxLoadKernels.

Parameters

- [in] *context* - The reference to the context the kernels must be removed from.
- [in] *module* - The short name of the module to unload. On systems where there are specific naming conventions for modules, the name passed should ignore such conventions. For example: libxyz.so should be passed as just xyz and the implementation will *do the right thing* that the platform requires.

> *Note*
>
> This API uses the system pre-defined paths for modules.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - No errors; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - context is not a valid vx_context reference.

- VX_ERROR_INVALID_PARAMETERS - If any of the other parameters are incorrect.

See also: vxLoadKernels

7.7. Framework: Graph Parameters

Defines the Graph Parameter API.

Graph parameters allow Clients to create graphs with Client settable parameters. Clients can then create Graph creation methods (a.k.a. *Graph Factories*). When creating these factories, the client will typically not be able to use the standard Node creator functions such as vxSobel3x3Node but instead will use the *manual* method via vxCreateGenericNode.

```
/*! \brief An example of Corner Detection Graph Factory.
 * \ingroup group_example
 */
vx_graph vxCornersGraphFactory(vx_context context)
{
    vx_status  status = VX_SUCCESS;
    vx_uint32  i;
    vx_float32 strength_thresh = 10000.0f;
    vx_float32 r = 1.5f;
    vx_float32 sensitivity = 0.14f;
    vx_int32 window_size = 3;
    vx_int32 block_size = 3;
    vx_enum channel = VX_CHANNEL_Y;
    vx_graph graph = vxCreateGraph(context);
    if (vxGetStatus((vx_reference)graph) == VX_SUCCESS)
    {
        vx_image virts[] = {
            vxCreateVirtualImage(graph, 0, 0, VX_DF_IMAGE_VIRT),
            vxCreateVirtualImage(graph, 0, 0, VX_DF_IMAGE_VIRT),
        };
        vx_kernel kernels[] = {
            vxGetKernelByEnum(context, VX_KERNEL_CHANNEL_EXTRACT),
            vxGetKernelByEnum(context, VX_KERNEL_MEDIAN_3x3),
            vxGetKernelByEnum(context, VX_KERNEL_HARRIS_CORNERS),
        };
        vx_node nodes[dimof(kernels)] = {
            vxCreateGenericNode(graph, kernels[0]),
            vxCreateGenericNode(graph, kernels[1]),
            vxCreateGenericNode(graph, kernels[2]),
        };
        vx_scalar scalars[] = {
            vxCreateScalar(context, VX_TYPE_ENUM, &channel),
            vxCreateScalar(context, VX_TYPE_FLOAT32, &strength_thresh),
            vxCreateScalar(context, VX_TYPE_FLOAT32, &r),
            vxCreateScalar(context, VX_TYPE_FLOAT32, &sensitivity),
            vxCreateScalar(context, VX_TYPE_INT32, &window_size),
            vxCreateScalar(context, VX_TYPE_INT32, &block_size),
```

```
        };
        vx_parameter parameters[] = {
            vxGetParameterByIndex(nodes[0], 0),
            vxGetParameterByIndex(nodes[2], 6)
        };
        // Channel Extract
        status |= vxAddParameterToGraph(graph, parameters[0]);
        status |= vxSetParameterByIndex(nodes[0], 1, (vx_reference)scalars[0]);
        status |= vxSetParameterByIndex(nodes[0], 2, (vx_reference)virts[0]);
        // Median Filter
        status |= vxSetParameterByIndex(nodes[1], 0, (vx_reference)virts[0]);
        status |= vxSetParameterByIndex(nodes[1], 1, (vx_reference)virts[1]);
        // Harris Corners
        status |= vxSetParameterByIndex(nodes[2], 0, (vx_reference)virts[1]);
        status |= vxSetParameterByIndex(nodes[2], 1, (vx_reference)scalars[1]);
        status |= vxSetParameterByIndex(nodes[2], 2, (vx_reference)scalars[2]);
        status |= vxSetParameterByIndex(nodes[2], 3, (vx_reference)scalars[3]);
        status |= vxSetParameterByIndex(nodes[2], 4, (vx_reference)scalars[4]);
        status |= vxSetParameterByIndex(nodes[2], 5, (vx_reference)scalars[5]);
        status |= vxAddParameterToGraph(graph, parameters[1]);

        for (i = 0; i < dimof(scalars); i++)
        {
            vxReleaseScalar(&scalars[i]);
        }
        for (i = 0; i < dimof(virts); i++)
        {
            vxReleaseImage(&virts[i]);
        }
        for (i = 0; i < dimof(kernels); i++)
        {
            vxReleaseKernel(&kernels[i]);
        }
        for (i = 0; i < dimof(nodes);i++)
        {
            vxReleaseNode(&nodes[i]);
        }
        for (i = 0; i < dimof(parameters); i++)
        {
            vxReleaseParameter(&parameters[i]);
        }
    }
    return graph;
}
```

Some data are contained in these Graphs and do not become exposed to Clients of the factory. This allows ISVs or Vendors to create custom IP or IP-sensitive factories that Clients can use but may not be able to determine what is inside the factory. As the graph contains internal references to the data, the objects will not be freed until the graph itself is released.

Functions

- vxAddParameterToGraph
- vxGetGraphParameterByIndex
- vxSetGraphParameterByIndex

7.7.1. Functions

vxAddParameterToGraph

Adds the given parameter extracted from a vx_node to the graph.

```
vx_status vxAddParameterToGraph(
    vx_graph                                    graph,
    vx_parameter                                parameter);
```

Parameters

- [in] *graph* - The graph reference that contains the node.
- [in] *parameter* - The parameter reference to add to the graph from the node.

Returns: A vx_status_e enumeration.

Return Values

- VX_SUCCESS - Parameter added to Graph; any other value indicates failure.
- VX_ERROR_INVALID_REFERENCE - graph is not a valid vx_graph reference or parameter is not a valid vx_parameter reference.
- VX_ERROR_INVALID_PARAMETERS - The parameter is of a node not in this graph.

vxGetGraphParameterByIndex

Retrieves a vx_parameter from a vx_graph.

```
vx_parameter vxGetGraphParameterByIndex(
    vx_graph                                    graph,
    vx_uint32                                   index);
```

Parameters

- [in] *graph* - The graph.
- [in] *index* - The index of the parameter.

Returns: vx_parameter reference. Any possible errors preventing a successful function completion should be checked using vxGetStatus.

vxSetGraphParameterByIndex

Sets a reference to the parameter on the graph. The implementation must set this parameter on the originating node as well.

```
vx_status vxSetGraphParameterByIndex(
    vx_graph                                    graph,
    vx_uint32                                   index,
    vx_reference                                value);
```

Parameters

- `[in]` *graph* - The graph reference.
- `[in]` *index* - The parameter index.
- `[in]` *value* - The reference to set to the parameter.

Returns: A `vx_status_e` enumeration.

Return Values

- `VX_SUCCESS` - Parameter set to Graph; any other value indicates failure.
- `VX_ERROR_INVALID_REFERENCE` - graph is not a valid `vx_graph` reference or value is not a valid `vx_reference`.
- `VX_ERROR_INVALID_PARAMETERS` - The parameter index is out of bounds or the dir parameter is incorrect.

Chapter 8. Bibliography

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