TOPOGRAPHY OF ROS2 COMPUTER VISION

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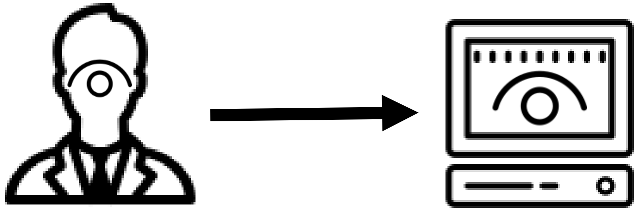
Summary of Content

- What is Computer Vision (CV)?
- Why need CV?
- What ROS2 Packages provides CV?
  - Evaluation Metrics
  - Summary Table
- Where is CV headed in ROS2?

What is Computer Vision (CV)?

What is Computer Vision (CV)? [1/2]



- In one sentence:

It is the **automation** of tasks **achievable** by the **human visual system**.

Image courtesy of icons8.com

What is Computer Vision (CV)? [2/2]

- More specifically:

It is a **function** that takes in **2D/3D visual information** of an object and outputs **identity/location** of the object.

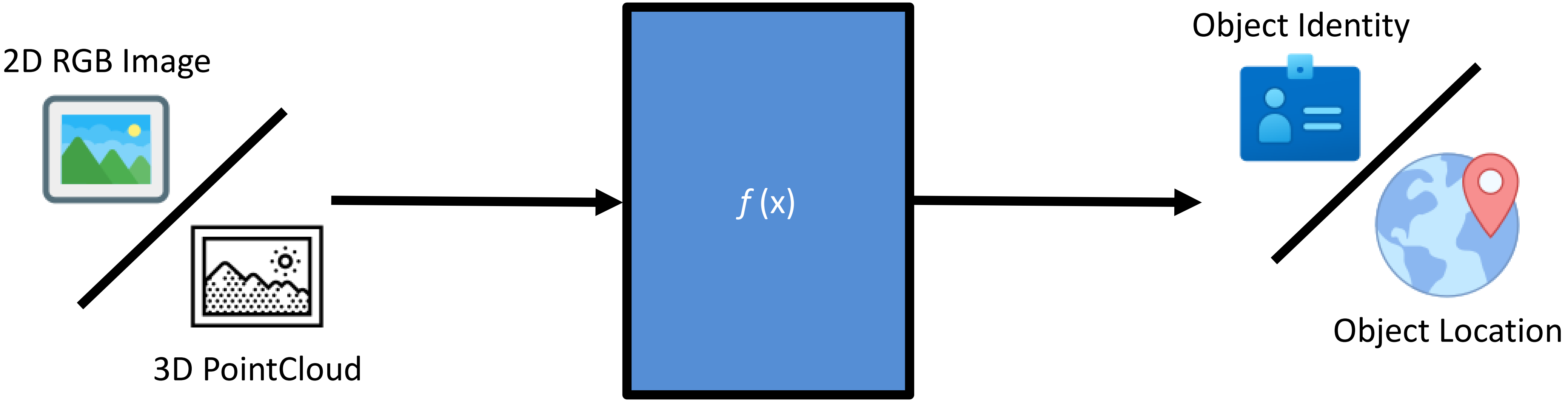


Image courtesy of icons8.com

Why need CV? _(ツ)_/

Image courtesy of icons8.com

Why need CV? [1/6]

Within industries, CV contributes to the development of smarter production lines worldwide, enhancing efficiency as well as the safety of its human operators.

Q: In what **specific aspects** does CV help to achieve that?

A: In the context of industrial robotics, we need CV for **5 common industrial tasks**, namely:

1. Classification
2. Counting
3. Localization
4. Color-Matching
5. Measurement

Why need CV? [2/6]

Classification

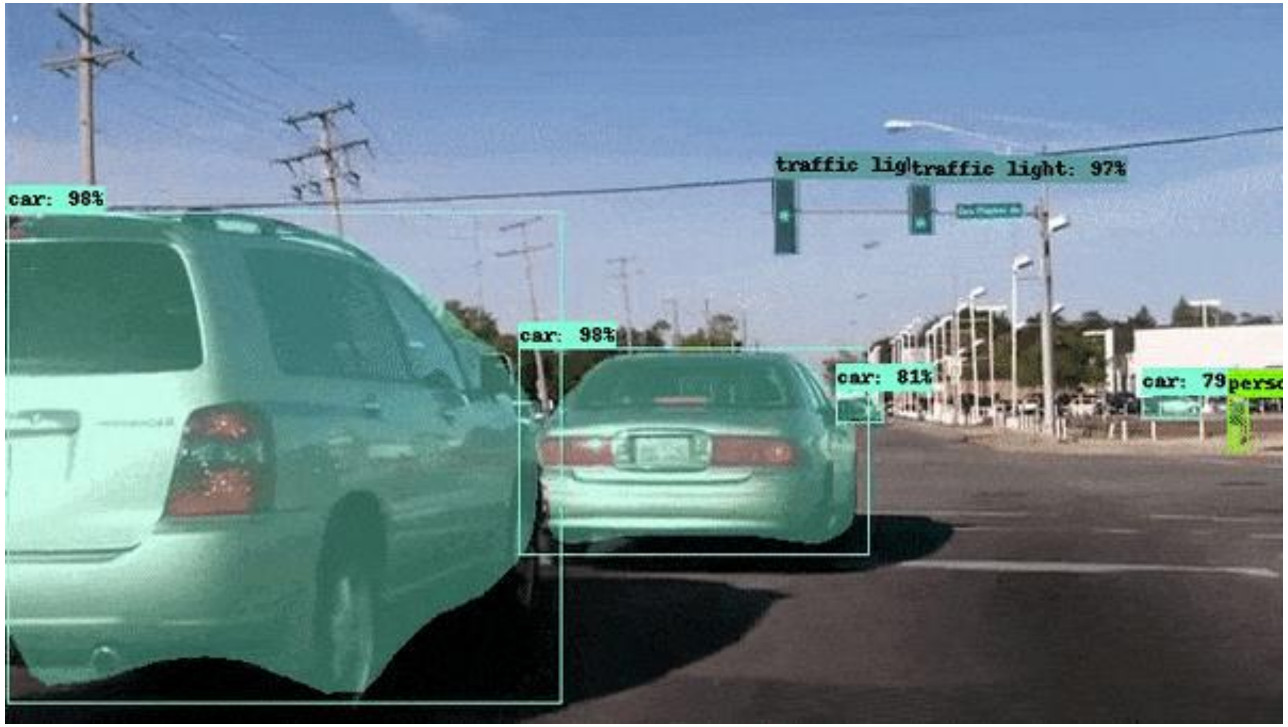


Image courtesy of Priya Dwivedi, towardsdatascience.com
(https://towardsdatascience.com/using-tensorflow-object-detection-to-do-pixel-wise-classification-702bf2605182)

Why need CV? [3/6]

Counting

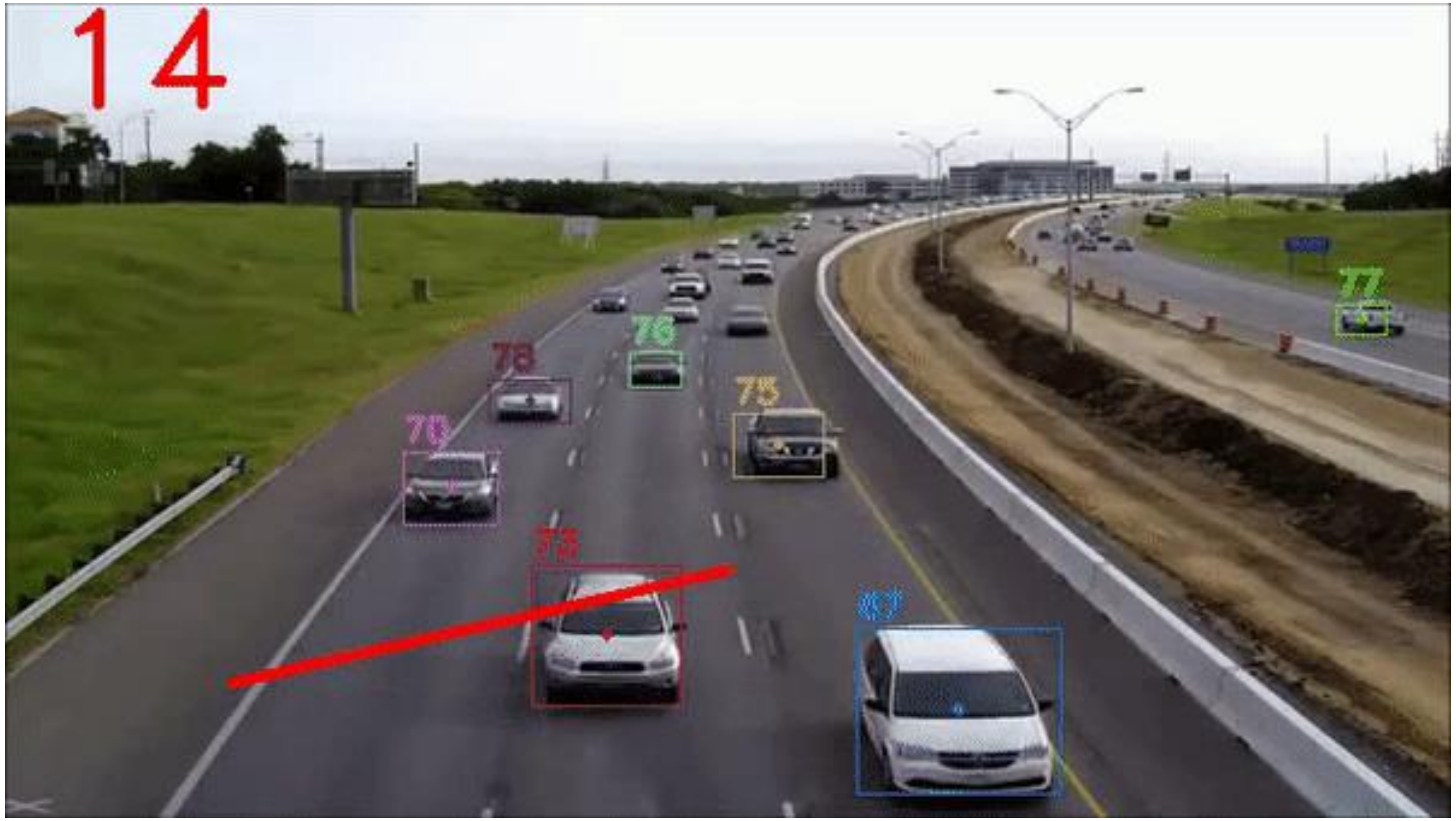


Image courtesy of tugot17, github.com
(https://github.com/tugot17/YOLO-Object-Counting-API)

Why need CV? [4/6]

Localization

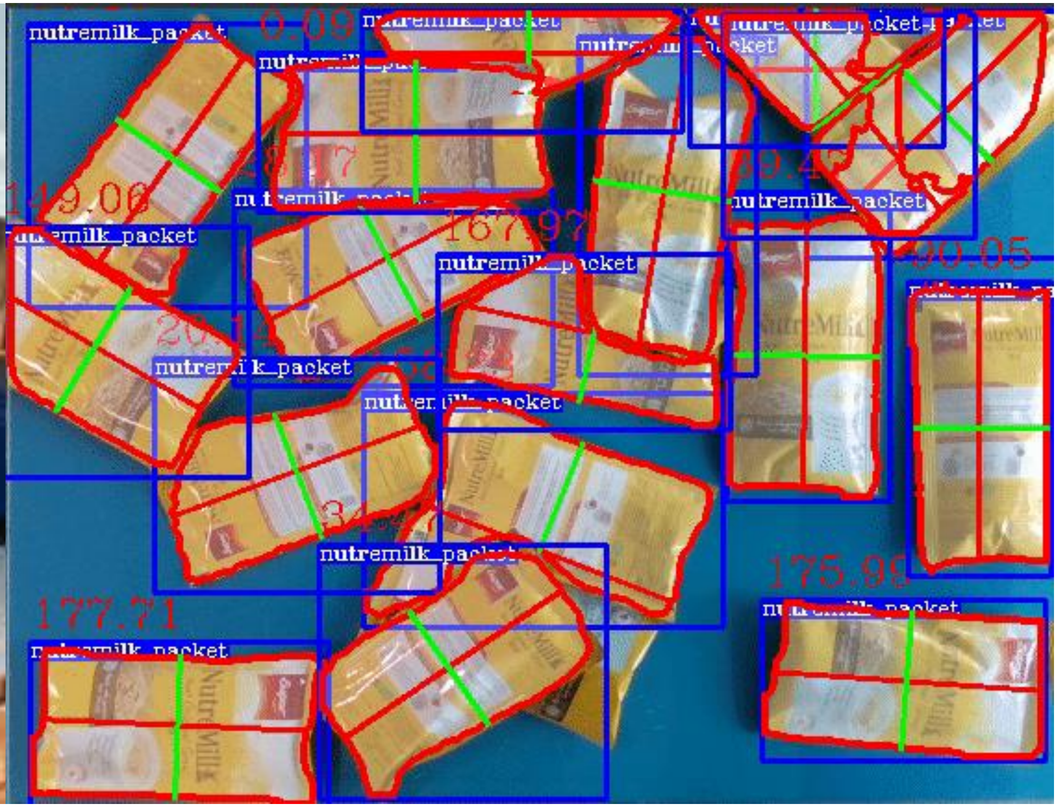


Image copyright ©2021 ROS-Industrial Consortium Asia Pacific

Why need CV? [5/6]

Color-Matching

Image courtesy of KentG13, instructables.com
(https://www.instructables.com/Solving-the-Rubiks-Cube-Gif-Challenge/)

Why need CV? [6/6]

Measurement

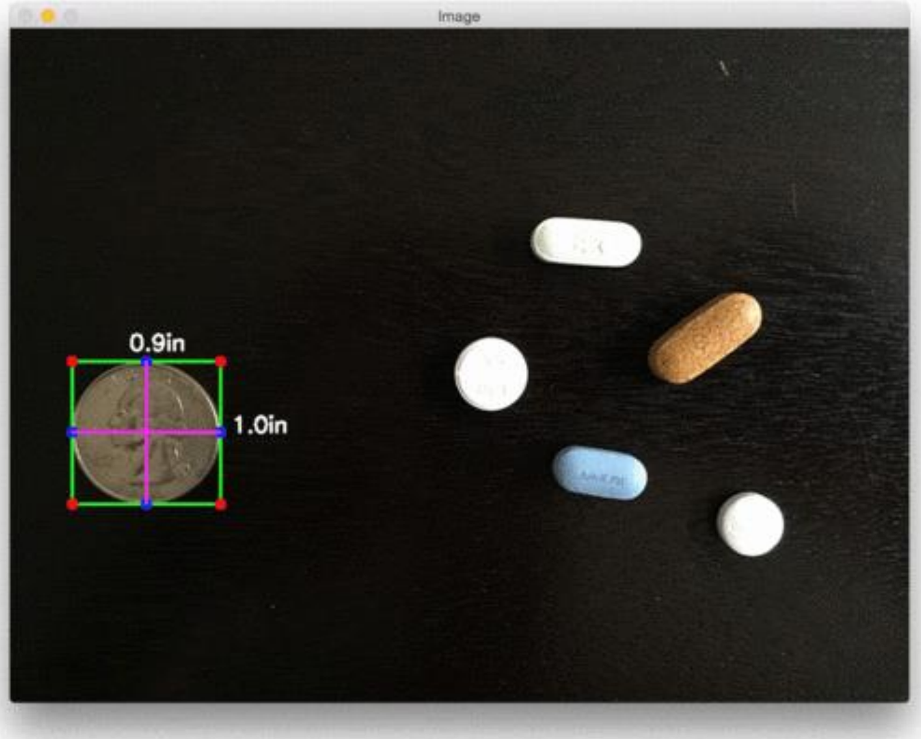
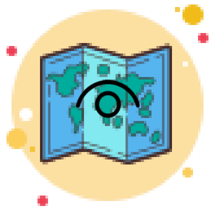


Image courtesy of Adrian Rosebrock, pyimagesearch.com
(https://www.pyimagesearch.com/2016/03/28/measuring-size-of-objects-in-an-image-with-opencv/)



What ROS2 packages provides CV?

The Topography

Image courtesy of icons8.com

Evaluation Metrics

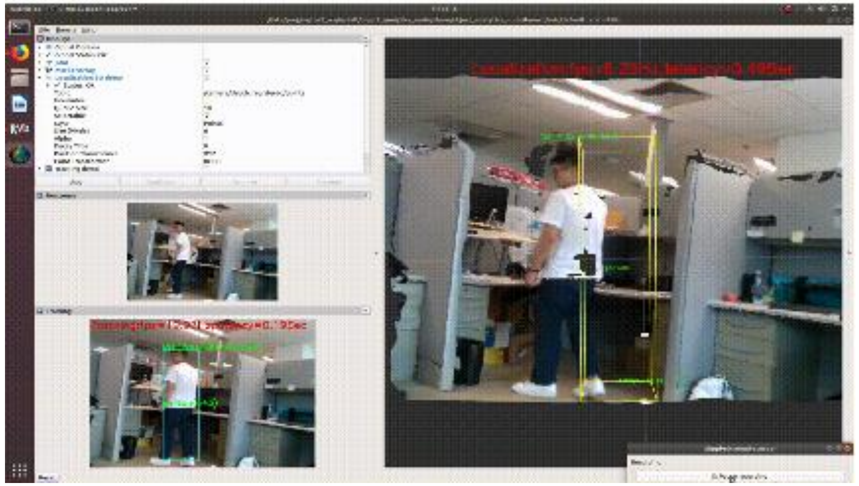
The following **7 indicators** are used to address stereotypical shortcomings of open-source projects.

1. **Recently Maintained**?
   - Has it been updated in the last 6 months / supports ROS2 Foxy? [Y/N]
2. **Permissive Licensed**?
   - Is it permissively licensed? [Y/N]
3. **Output**?
   - What output does it produce? [-]
4. **Ease of Setup**?
   - Are installation of dependencies handled automatically? [Y/N]
5. **Recent Documentation**?
   - Are its docs comprehensive and updated in the last 6 months? [Y/N]
6. **Hardware**?
   - What specific hardware does it require? [-]
7. **ML-Framework Specific**?
   - Is it reliant on only one Machine-Learning Framework/Library? [Y/N]

intel/ros2_object_analytics

Please click on the name to access the GitHub repository.

Timestamped: 9th March 2021



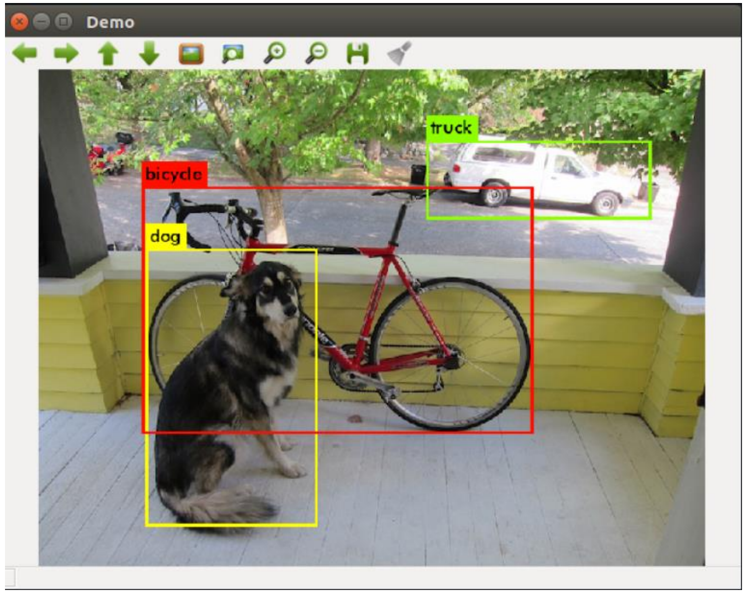
Metric	Result / Explaination
Recently Maintained?	No. / Last updated at Dec 4th 2019 and only supports ROS2 eloquent.
Permissively Licensed?	Yes. / Apache-2.0 License.
Output?	2D bounding boxes, 3D bounding boxes
Ease Of Setup?	No. / However, dependencies are clearly listed.
Recent Docs?	No. / Last updated at Dec 4th 2019.
Hardware?	Intel NUC + Intel Realsense
ML-Framework Specific?	No. / There is no use of external ML libraries in the source code.

Image courtesy of intel, github.com
(https://github.com/intel/ros2_object_analytics)

leggedrobotics/darknet_ros

Please click on the names to access the GitHub repository.

Timestamped: 9th March 2021



Metric	Result / Explaination
Recently Maintained?	Yes and No. / No for last updated at 22nd Aug 2020. Yes for ROS2 Foxy support.
Permissively Licensed?	Yes. / BSD-3-Clause License.
Output?	2D bounding boxes.
Ease Of Setup?	Yes. / It uses colcon build to automate much of its dependencies' installation.
Recent Docs?	Yes. / Despite not updated, the instructions are still valid in helping to set up the package.
Hardware?	No reliance on any specific hardware. Ideal on Nvidia GPUs. / It mentions the use of CUDA.
ML-Framework Specific?	Yes. / It is restricted to its use of Darknet's YOLO family of models.

Image courtesy of leggedrobotics, github.com (https://github.com/leggedrobotics/darknet_ros)

ros_industrial/easy_perception_deployment

Timestamped: 9th March 2021

Please click on the names to access the GitHub repository.

Metric	Result / Explaination
Recently Maintained?	Yes. / Last updated on 5th Feb 2021 and supports ROS2 Foxy.
Permissively Licensed?	Yes. / Apache-2.0 License.
Output?	String object name, 2D bounding boxes, 2D segmentation mask, 3D object localization.
Ease Of Setup?	Yes. / Users can opt for Docker builds where installation of all dependencies are handled automatically.
Recent Docs?	Yes. / Last updated on 5th Feb 2021.
Hardware?	No reliance on any specific hardware. Ideal on Nvidia GPUs.
ML-Framework Specific?	Yes and No. / **Yes** for Deployment of model using .onnx. **No** for Training which is reliant on PyTorch.

Summary Table [1/2]

Please click on the names to access the GitHub repository.

Timestamped: 9th March 2021

Package Name	Recently Maintained?	Permissive Licensed?	Output?	Ease of Setup?	Recent Docs?	Hardware-specific?	ML-Framework Specific?
ros2_tensorflow	No	Yes	2D bounding boxes	Yes	Yes	None. Ideally with Nvidia.	Yes. Tensorflow.
ros2_tflite	Yes and No	Yes	String object name, 2D bounding boxes, 2D semantic segmentation	Yes	Yes	None. Ideally with Nvidia.	Yes. Tensorflow.
ros2_object_analytics	No	Yes	2D bounding boxes	No	No	Intel NUC + Intel Realsense	No
ros2_pytorch	No	Yes	String object name	No	No	None. Ideally with Nvidia.	Yes. Pytorch
darknet_ros	Yes and No	Yes	2D bounding boxes	Yes	Yes	None. Ideally with Nvidia.	No

This list has been compiled based on 2 sources: fkromer/awesome_ros2 & Google search of the following keywords: "ros2" /+ "computer vision" /+ "object detection"

Summary Table [2/2]

Please click on the names to access the GitHub repository.

Timestamped: 9th March 2021

Package Name	Recently Maintained?	Permissive Licensed?	Output?	Ease of Setup?	Recent Docs?	Hardware-specific?	ML-Framework Specific?
openrobotics_darknet_ros	No	Yes	2D bounding boxes.	No	No	Nvidia.	Yes. Darknet.
ros_deep_learning	No	Yes	Object string name, 2D bounding boxes, 3d object localization	No	Yes	Nvidia.	Yes. Darknet.
ros2_torch_trt	Yes	Yes	Object string name, 2D bounding boxes.	Yes	No	Nvidia.	Yes. Pytorch.
zed-ros2-wrapper	Yes and No	Yes	, 3D object localization	Yes	Yes	Nvidia	Yes. Tensorflow and Pytorch.
easy_perception_deployment	Yes	Yes	String object name, 2D bounding boxes, 2D mask segmentation, 3D object localization	Yes	Yes	None. Ideally with Nvidia.	Yes and No.

This list has been compiled based on 2 sources: fkromer/awesome_ros2 & Google search of the following keywords: "ros2" /+ "computer vision" /+ "object detection"

Where is CV headed in ROS2?

Where is CV headed in ROS2? [1/2]

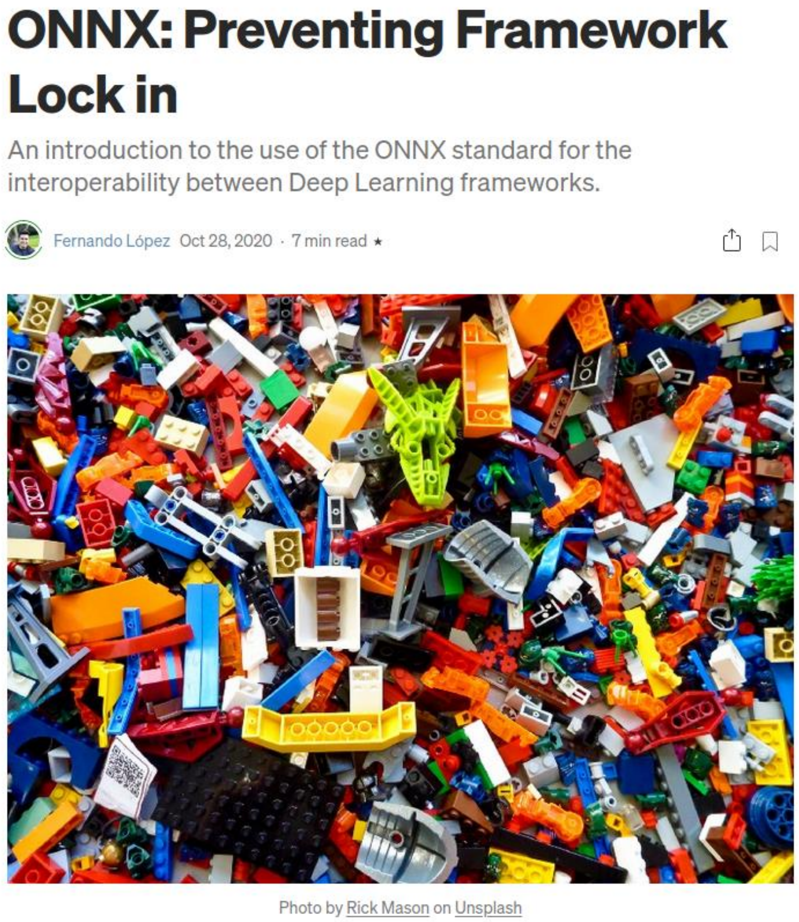
- High-performing CV implementations revolve around **specific model versions**.
- There is **no one ML-framework** that contains all the State-Of-The-Art (SOTA) model.
- The **best SOTA model** is **constantly in flux** and **suits varied specific use-case**.
  - Each use case strikes a balance between **Speed** and **Accuracy**.
- Development of specific CV models is **highly uncertain**.
  - Eg. YOLO is no longer being developed by its creator due to ethical concerns. Darknet's YOLO is currently maintained and developed further by third-party vendors like **Alexey Bochkovskiy** and **Ultralytics**.
  - Eg. ImageNet ILSRVC is halted since 2019 due to gender, race and age biases. ImageNet is commonly used as an evaluation benchmark for a model's accuracy.

Naïve Prediction:

ROS2 CV-enabling packages will value **highly portable CV ML deployment-friendly models**.

Where is CV headed in ROS2? [2/2]

- There is already progress on that front:



ONNX: Preventing Framework Lock in

An introduction to the use of the ONNX standard for the interoperability between Deep Learning frameworks.

Fernando López Oct 28, 2020 · 7 min read ★

Photo by Rick Mason on Unsplash

https://towardsdatascience.com/onnx-preventing-framework-lock-in-9a798fb34c92

Thank you.

Hope this helps.