Introduction to OAK-D and DepthAI

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OAK (https://learnopencv.com/category/oak/) Uncategorized (https://learnopencv.com/category/uncategorized/)

OAK Introduction | OAK Series

This is the first post of a series on programming OpenCV AI Kit with Depth (OAK-D) and it's little sister OpenCV AI Kit with Depth Lite (OAK-D-Lite). Both **OAK-D (https://store.opencv.ai/products/oak-d)** and **OAK-D Lite** (https://www.indiegogo.com/projects/opencv-ai-kit-lite#/)are spatial AI cameras.

Check out more articles from the OAK series.

- Stereo Vision and Depth Estimation using OpenCV AI Kit (https://learnopencv.com/object-detection-with-depth-measurement-with-oak-d/)
- Object detection with depth measurement using pre-trained models with OAK-D (/object-detection-with-depth-measurement-with-oak-d/)

What is Spatial AI?

Spatial AI is the ability of a visual AI system to make decisions based on two things.

1. **Visual Perception** : This is the ability of an AI to "see" and "interpret" its surrounding visually. For example, the system a camera connected to a processor running a neural network for object detection can detect a cat, a person, or a car in the scene the camera is looking at.
2. **Depth Perception :** This is the ability of the AI to understand how far objects are. In computer vision jargon, "depth" simply means "how far."

The idea of Spatial AI is inspired by human vision. We use our eyes to interpret our surroundings. In addition, we use our two eyes (i.e. stereo vision) to perceive how far things are from us.

OAK-D and OAK-D-Lite are Spatial AI Cameras

At a high-level OAK-D and OAK-D-Lite consist of the following important components.

1. **A 4K RGB Camera** : The RGB camera placed at the center can capture very high-resolution 4k footage. Typically, this camera is used for visual perception.
2. **A Stereo pair** : This is a system of two cameras (the word "stereo" means two) used for depth perception.
3. **Intel® Myriad™ X Visual Processing Unit (VPU) :** This is the "brain" of the OAKs. It is a powerful processor capable of running modern neural networks for visual perception, and simultaneously creating a depth map from the stereo pair of images in real time.

Applications of OAK-D and OAK-D-Lite

OAK-D is being used to develop applications in a wide variety of areas. The OpenCV AI Competition 2021 (https://opencv.org/opencv-ai-competition-2021/) showcases many of these applications.

You can see applications in education (https://youtu.be/N5nD6uFjJSk), neo-natal care (https://youtu.be/hEtcsiO-x1M), assistive technologies for the disabled (https://youtu.be/XS1FtWqXWQk), AR/VR (https://youtu.be/itsUtV7sSPU), warehouse inspection using drones (https://youtu.be/Nx77qQJLSkc), robotics (https://youtu.be/7GCIuG0-RqY), agriculture (https://youtu.be/3x2XOCtP7-4), sports analytics (https://youtu.be/cj-iDi-J05g), retail (https://youtu.be/YJ6GdwawdLE), and even advertising (https://youtu.be/OmJx5eCvcNo).

Check out the Indiegogo campaign page (https://www.indiegogo.com/projects/opencv-ai-kit-lite#/)to see many more amazing applications built using OAK-D and OAK-D-Lite

Excited to learn how to program this device? Let's get started.

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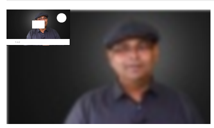


OAK-D vs OAK-D Lite

In terms of features, both devices are nearly identical. With an OAK-D Lite (https://www.kickstarter.com/projects/opencv/opencv-ai-kit-oak-depth-camera-4k-cv-edge-object-detection), you can do almost everything that an OAK-D is capable of. As a beginner, you should not notice much difference. However, there are a few specs that separate the two devices. OAK-D Lite is sleek, lighter, cheaper and uses less power. On the other hand, OAK-D (https://store.opencv.ai/products/oak-d) is slightly more power-user-oriented.

Features/Specs	**OAK-D**	**OAK-D Lite**
RGB camera	12 Megapixel, 4k, up to 60 fps	12 Megapixel, 4k, up to 60 fps
Mono cameras	1280x800p, 120 fps, Global Shutter	640x480p, 120 fps, Global Shutter
Inertial Measurement Unit	Yes	No
USB-C, Power Jack	Yes, Yes	Yes, No
VPU	Myriad-X, 4 trillion ops/s	Myriad-X, 4 trillion ops/s

Installation

DepthAI Installation | OAK Series

The best part of using an **OAK-D** or **OAK-D Lite** is that there are no external hardware or software dependencies. It has integrated hardware, firmware, and software resulting in a seamless experience. **Depth-AI** is the API (Application Programming Interface) through which we program the OAK-D. It's cross-platform, so you don't need to worry about what OS you have. So let's go ahead and install the API by firing up a terminal or Powershell. It should only take about 30 seconds, given that you have a good internet connection.

```
git clone https://github.com/luxonis/depthai.git (https://github.com/luxonis/depthai.git)
cd depthai
python3 install_requirements.py
python3 depthai_demo.py
```

You can also check out the DepthAI documentation (https://docs.luxonis.com/en/latest/) of Luxonis here.

The Depth-AI Pipeline

A pipeline is a collection of nodes and a node is a unit with some inputs and outputs. To understand the Depth-AI pipeline, let us go through the following illustrations. In the figures, we are showing what is happening inside the camera when the given command is executed. It's a very simple pipeline, through which we capture the frames from the left mono camera.

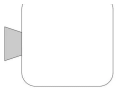
DepthAI - Step By Step tutorial For Using OAK-D

1. **Create a pipeline**

Here, we are instantiating the pipeline object.

```
import depthai as dai
pipeline = dai.Pipeline()
```

OAK-D

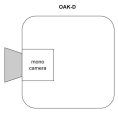


/https://learnopencv.com/wp-content/uploads/2021/11/instantiate-pipeline.jpg.jpg)

2. Create the camera node

With the instruction below, we create the mono camera node. It does not do anything visually. It just recognizes the mono cameras.

```
mono = pipeline.createMonoCamera()
```

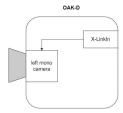


/https://learnopencv.com/wp-content/uploads/2021/11/initiate-mono-camera-node.jpg.jpg)

3. Select the camera

To access a camera, in our case the left camera, we need to select it. Which is done by the **setBoardSocket** method. Internally it also creates an input node, X-LinkIn. X-Link is a mechanism using which the camera communicates with the host (computer).

```
mono.setBoardSocket(dai.CameraBoardSocket.LEFT)
```

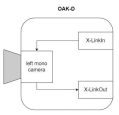


/https://learnopencv.com/wp-content/uploads/2021/11/Selecting-mono-camera.jpg.jpg)

4. Create XLinkOut node and acquire frames

To get the output, we need to create the X-Link output node. The camera can have several other outputs, say another stream from the right mono camera or from the RGB camera or some other output that we don't need to worry about as of now. Hence, it has been named as "left" so that it does not conflict with others. Finally, we link the output of the mono camera by putting it as an input to the X-LinkOut node.

```
xout = pipeline.createXLinkOut()
xout.setStreamName("left")
mono.out.link(xout.input)
```



/https://learnopencv.com/wp-content/uploads/2021/11/Linking-output-to-X-LinkOut-node.jpg)

Although we were showing that the previous instructions were readying the device, it was not really processing anything. All the commands were running **inside the host computer**. You can think of it as a pre-processing step. With the following snippet of code, we transfer the pipeline from the host computer to the camera.

Now, we can acquire the output frame from the X-LinkOut node. Note that the output of the X-LinkOut node is not a single frame. In fact, it creates a queue that can store several frames. Which may be useful for certain applications requiring multiple frames. Video encoding is such an example. But in our case, we do not need multiple frames. So, let's keep it as the default, single frame for now. As you can see, the queue is obtained using the **getOutputQueue** method, where we specify the stream.

Next, we query the queue to extract the frame. At this point, the frame is transferred from the device to the host computer. The frame is of the class depthai.ImgFrame /https://docs.luxonis.com/projects/api/en/latest/components/messages/img_frame/?highlight=imgframe#module-depthai.ImgFrame), which can have several types. To make it OpenCV friendly, we use the function **getCvFrame**, which returns the image as a numpy array. This concludes our basic pipeline.

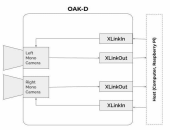
```
with dai.Device(pipeline) as device:
    queue = device.getOutputQueue(name="left")
    frame = queue.get()
    inSet = frame.getCvFrame()
```

Now let's build a complete pipeline for both left and right cameras. We will use the outputs from the mono cameras to display the separate views and also the merged view. Please download the complete code using the following link to get started.

Download Code To easily follow along this tutorial, please download code by clicking on the button below. It's FREE!

Download Code

A Complete pipeline for stereo vision



/https://learnopencv.com/wp-content/uploads/2021/11/Stereo-vision-pipeline-OAK-D.jpg)

Although the Depth-AI library provides support for both Python and C++ API, C++ API is not yet a stable release. Hence, in this blog post, we are focusing on the python code.

Import Libraries

```
import cv2
import depthai as dai
import numpy as np
```

Function to extract frame

It queries the frame from the queue, transfers it to the host and converts the frame to a numpy array.

```
def getFrame(queue):
    # Get frame from queue
    frame = queue.get()
    # Convert frame to OpenCV format and return
    return frame.getCvFrame()
```

Function to select mono camera

Here, a camera node is created for the pipeline. Then we set the camera resolution using the **setResolution** method. The **sensorResolution** class has the following attributes to choose from.

- THE_720_P (1280x720p)
- THE_800_P (1280x800p)
- THE_400_P (640x400p)
- THE_480_P (640x480p)

In our case, we are setting the resolution to 640x400p. The board socket is set to the left or right mono camera by using the **isLeft** boolean.

```
def getMonoCamera(pipeline, isLeft):
    # Configure mono camera
    mono = pipeline.createMonoCamera()

    # Set Camera Resolution
    mono.setResolution(dai.MonoCameraProperties.SensorResolution.THE_400_P)

    if isLeft:
        # Get left camera
        mono.setBoardSocket(dai.CameraBoardSocket.LEFT)
    else :
        # Get right camera
        mono.setBoardSocket(dai.CameraBoardSocket.RIGHT)
    return mono
```

Main Function

Pipeline and camera setup

We start by creating the pipeline and setting up left and right mono cameras. The predefined function **getMonoCamera** creates the X-LinkIn node internally and returns mono camera output. The outputs from the cameras are then tied to the X-LinkOut nodes.

```
if __name__ == '__main__':
    # Start pipeline
    pipeline = dai.Pipeline()

    # Set up left and right cameras
    monoLeft = getMonoCamera(pipeline, isLeft = True)
    monoRight = getMonoCamera(pipeline, isLeft = False)

    # Set output Xlink for left camera
    xoutLeft = pipeline.createXLinkOut()
    xoutLeft.setStreamName("left")

    # Set output Xlink for right camera
    xoutRight = pipeline.createXLinkOut()
    xoutRight.setStreamName("right")

    # Attach cameras to output Xlink
    monoLeft.out.link(xoutLeft.input)
    monoRight.out.link(xoutRight.input)
```

Transfer pipeline to the device

Once setup is ready, we transfer the pipeline into the device (camera). The queues for left and right camera outputs are defined with their respective names. The frame holding capacity is set with the **maxSize** argument, which is just a single frame in our case. A named window is also created to be used later for displaying the output. The **sideBySide** variables a boolean for toggling camera views (side by side or front view).

```
with dai.Device(pipeline) as device:
    # Get output queues.
    leftQueue = device.getOutputQueue(name="left", maxSize=1)
    rightQueue = device.getOutputQueue(name="right", maxSize=1)

    # Set display window name
    cv2.namedWindow("Stereo Pair")
    # Variable used to toggle between side by side view and one
    frame view.
    sideBySide = True
```

Main loop

Until now, we have created a pipeline, linked camera outputs to X-LinkOut nodes and obtained the queues. Now, it's time to query the frames and convert them to OpenCV-friendly numpy array format with the help of our predefined **getFrame** function. For side by side view, the frames are concatenated horizontally with the help of the numpy **hstack** (horizontal stack)function. For overlapping output, we are simply adding the frames by reducing the intensity by a factor of 2.

The keyboard input **q** breaks the loop and **t** toggles the display (Side by side view and front view).

```
while True:
    # Get left frame
    leftFrame = getFrame(leftQueue)
    # Get right frame
    rightFrame = getFrame(rightQueue)
```

```
    if sideBySide:
        # Show side by side view
        inOut = np.hstack((leftFrame, rightFrame))
    else:
        # Show overlapping frames
        inOut = np.uint8(leftFrame/2 + rightFrame/2)

    # Display output image
    cv2.imshow("Stereo Pair", inOut)

    # Check for keyboard input
    key = cv2.waitKey(1)
    if key == ord('q'):
        # Quit when q is pressed
        break
    elif key == ord('t'):
        # Toggle display when t is pressed
        sideBySide = not sideBySide
```

Output

/https://learnopencv.com/wp-content/uploads/2021/11/Mono-camera-outputs-side-by-side-view-1.gif)

fig: Side by side view

/https://learnopencv.com/wp-content/uploads/2021/11/Mono-camera-outputs-side-view.gif)

fig: Overlapped output

Conclusion

This concludes the introduction to OpenCV AI Kit with Depth. I hope you enjoyed the light read and got the idea of setting up an OAK-D. In the next blog post, we will cover the pipeline of getting the depth map out of an OAK-D.

References

DepthAI documentation (https://docs.luxonis.com/projects/api/en/latest/)

OpenCV Store. (https://store.opencv.ai/products/oak-d)

Kickstarter Page (https://www.kickstarter.com/projects/opencv/opencv-ai-kit-oak-depth-camera-4k-cv-edge-object-detection)