CEVA

LIPS
Sense The World

12th YEAR

CEVA TECHNOLOGY
SYMPOSIUM SERIES

Sensing The World With Depth Cameras

An introduction to 3D Sensing

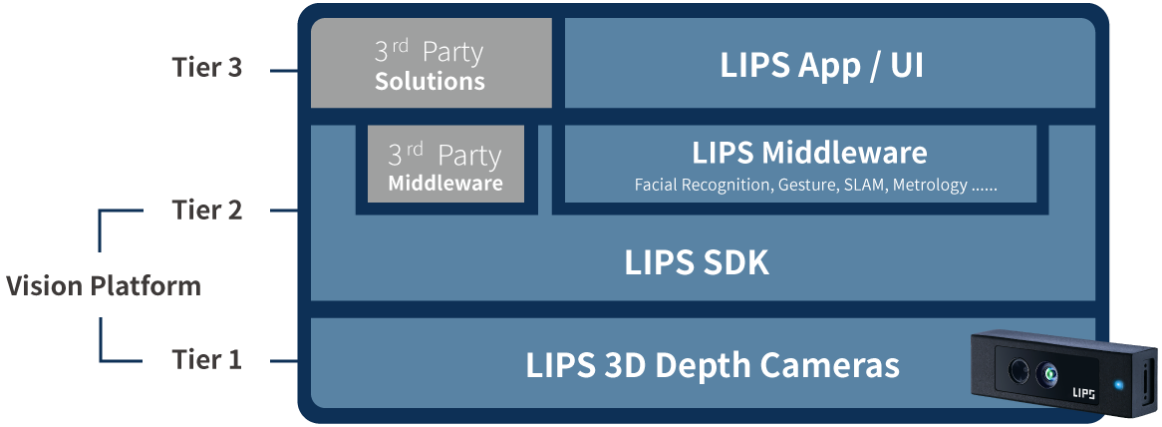
Luke Liu, Founder and CEO, LIPS

Agenda

- Company Overview
- What's 3D/Depth Information
- The Benefit of Depth for CV and ML
- Case Study, Motion Gesture Recognition
- Some Tips for XM4 & 3D ML
- *Overall Market on 3D Sensing*

Company Overview

LIPS Corp. is a 3D Sensing Solution Provider



ToF AT

(Cyclone V based)

- Built in PoE

ToF DL

ToF M3

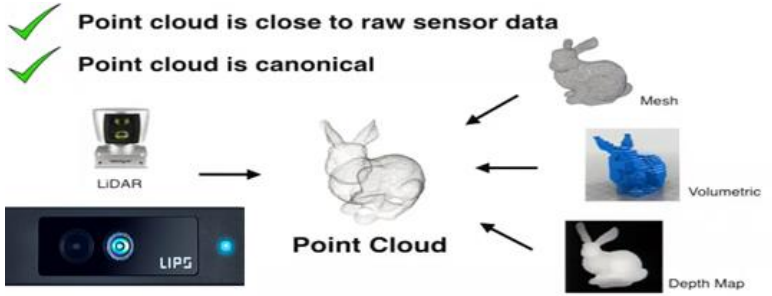
Stereo M5

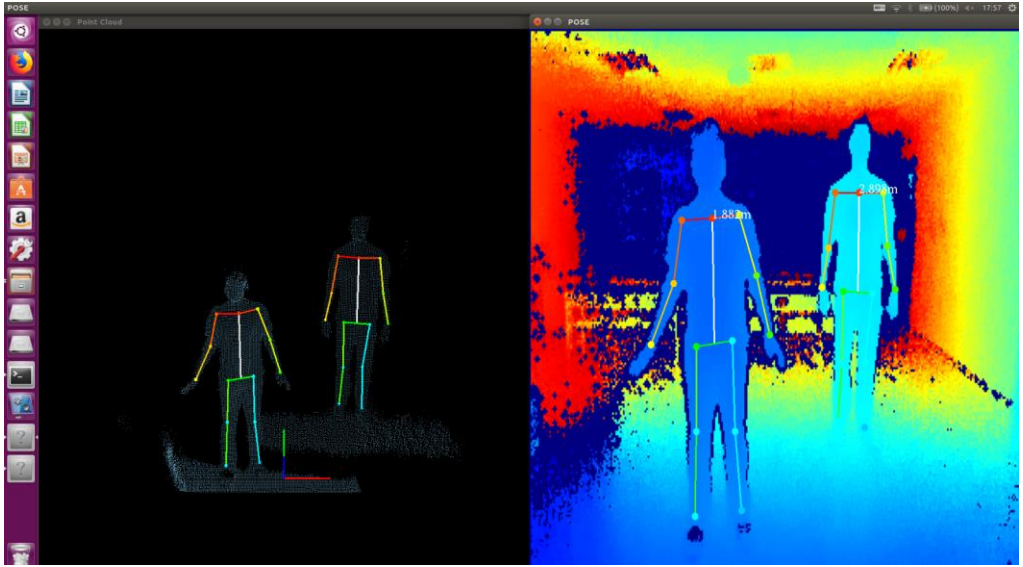
Core Competency

- HW: State-of-art 3D depth camera
  - 3D depth cameras includes ToF, Stereo and Structured Light
  - Edge Computing for IoT
- MW, AL & SW
  - Parallel processing(DSP, OpenCL, CUDA and FPGA)
  - Machine vision recognition algorithms base on depth and RGB information for ML & traditional programming
- Customization

What's 3D Information

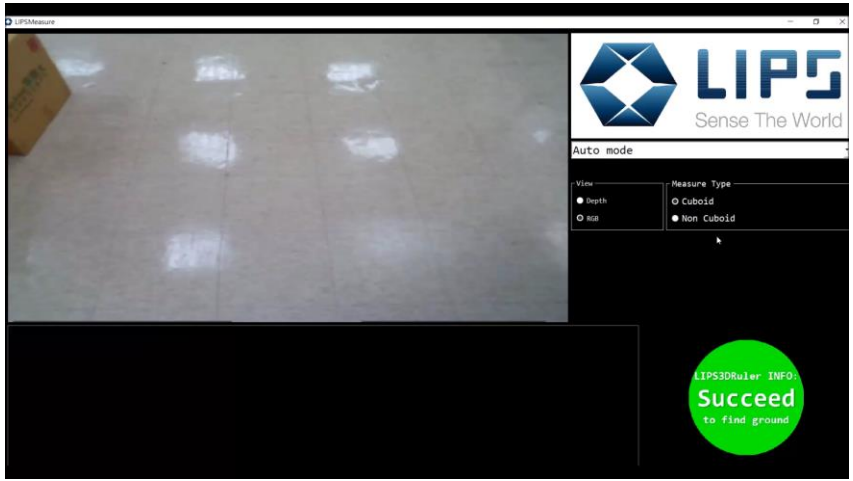
Point Cloud, Depth and RGB

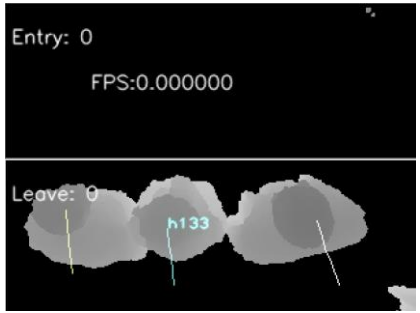




The Benefit of Depth for Traditional program

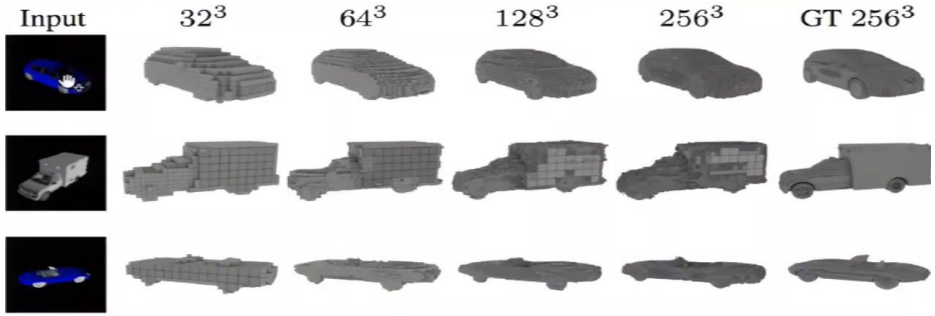
- Easy to segmentation, compare with RGB information
- Get the real dimension of the object
- Get the relative distance and angle
- Not a projected image plane, but multi view object
- And the most important, not effective by light or others

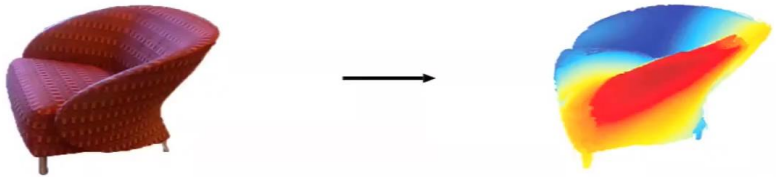




The Benefit of Depth for Machine Learning

- Easy to segmentation, and feature extraction
- Get the real dimension of the object, shape with different view
- Get the relative distance and angle
- Not a projected image plane, but multi view object
- And the most important, not effective by light or others



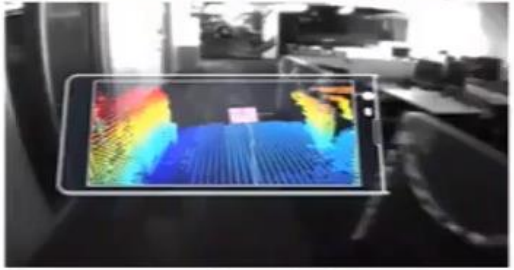


Big Data + Deep Representation Learning

Robot Perception

source: Scott J Grunewald

Augmented Reality



source: Google Tango

Shape Design

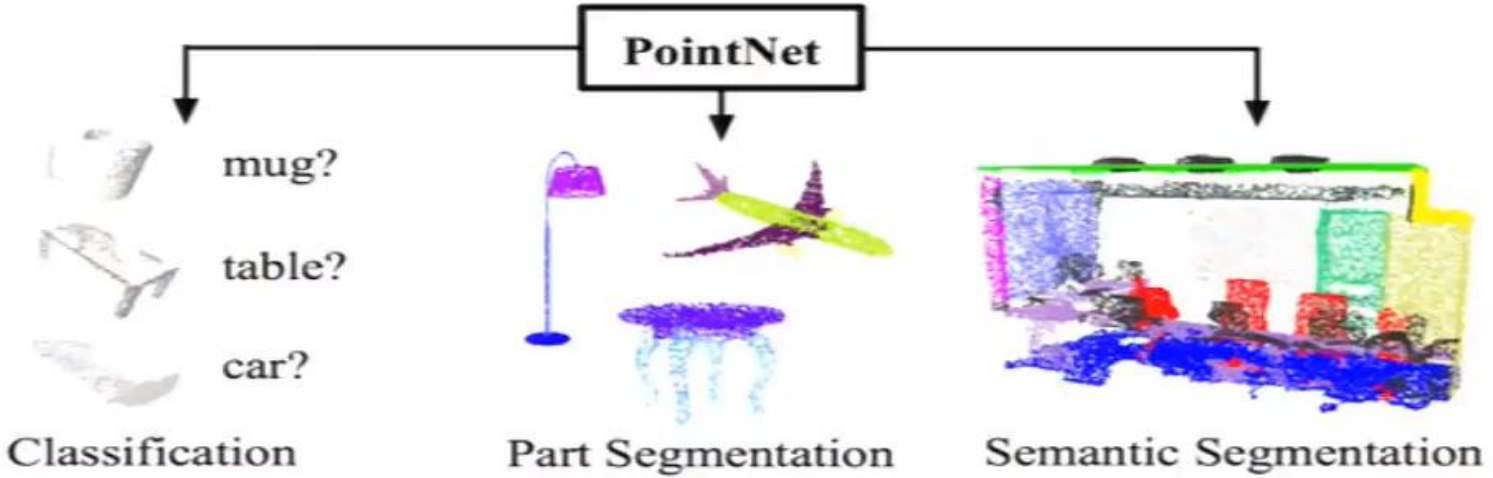
source: solidsolutions

Need for 3D Deep Learning!

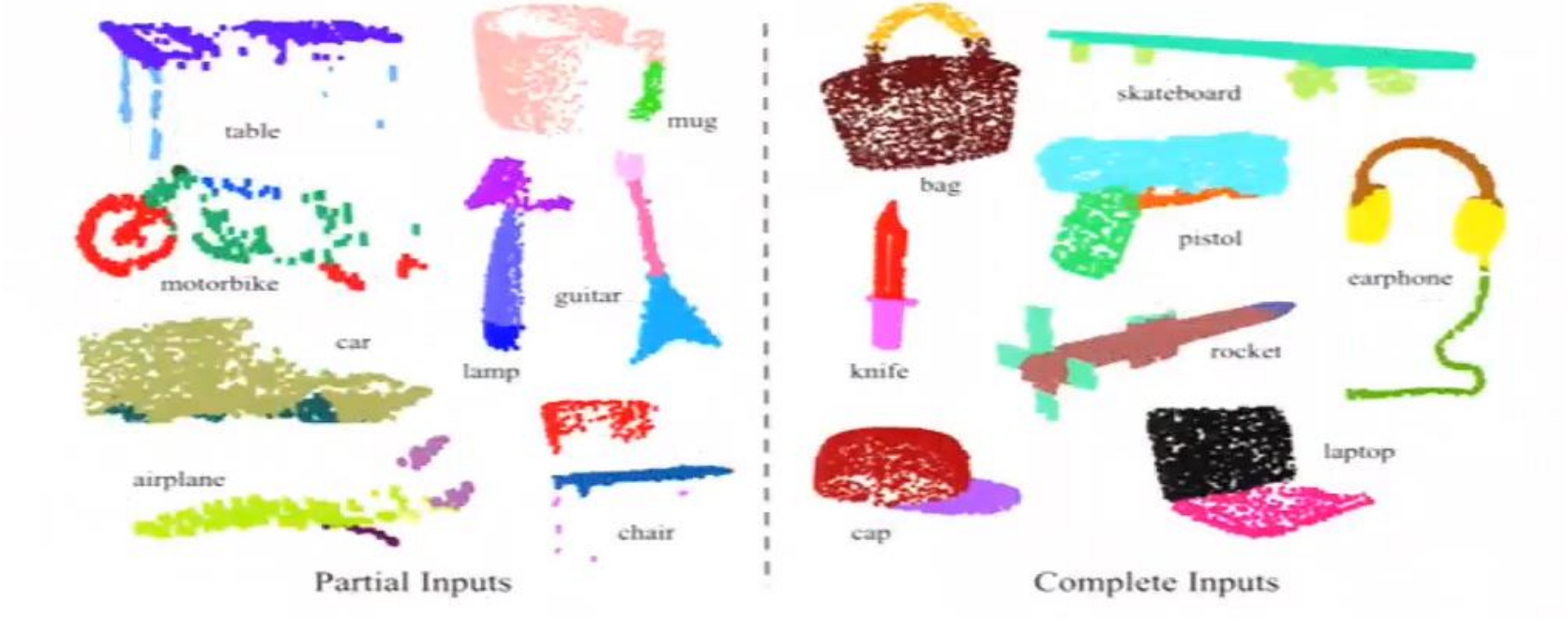
Neuro Network

End-to-end learning for **scattered, unordered** point data

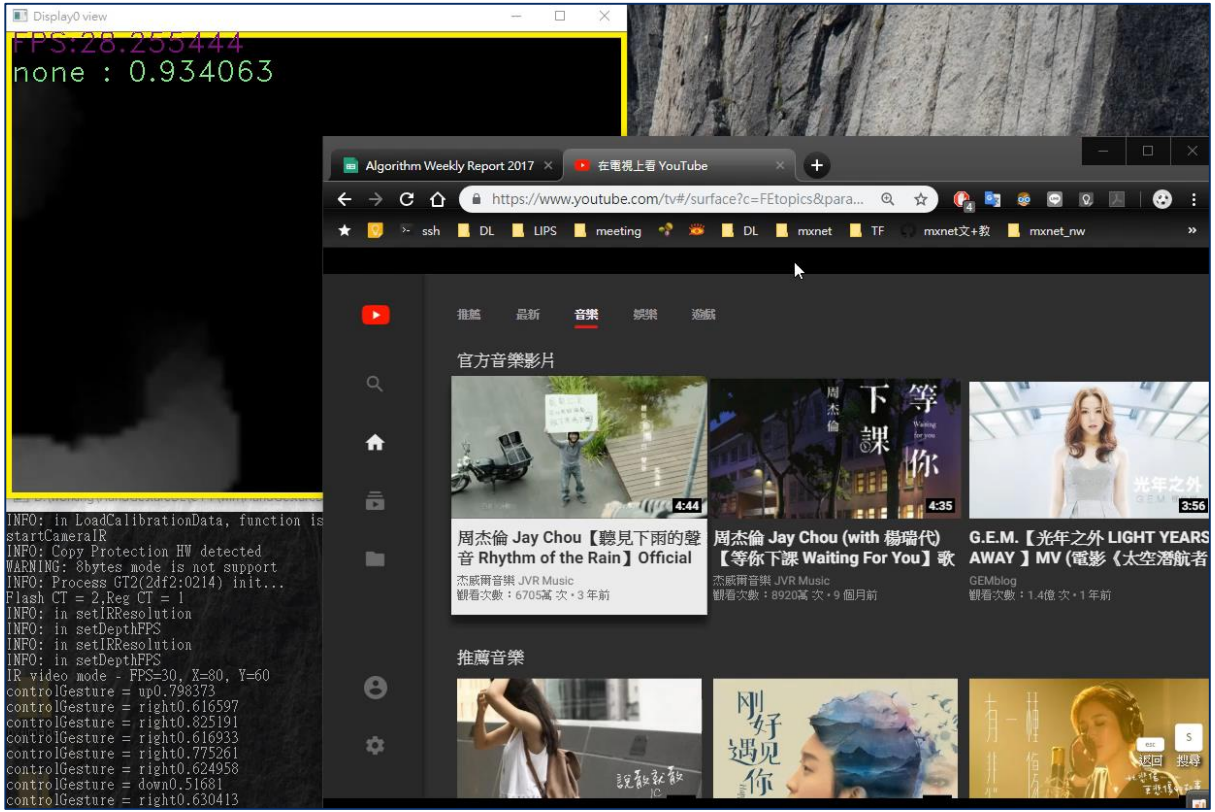
Unified framework for various tasks



Results on Object Part Segmentation

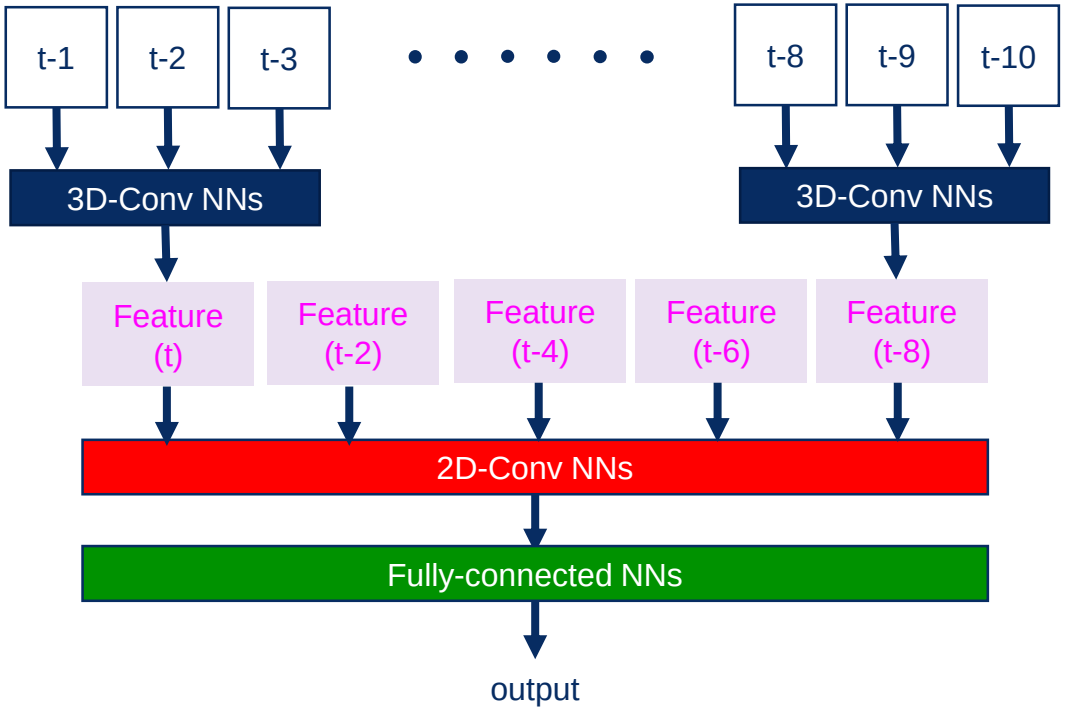


Motion Gesture Recognition Demo



Motion Gesture Recognition base on 2D

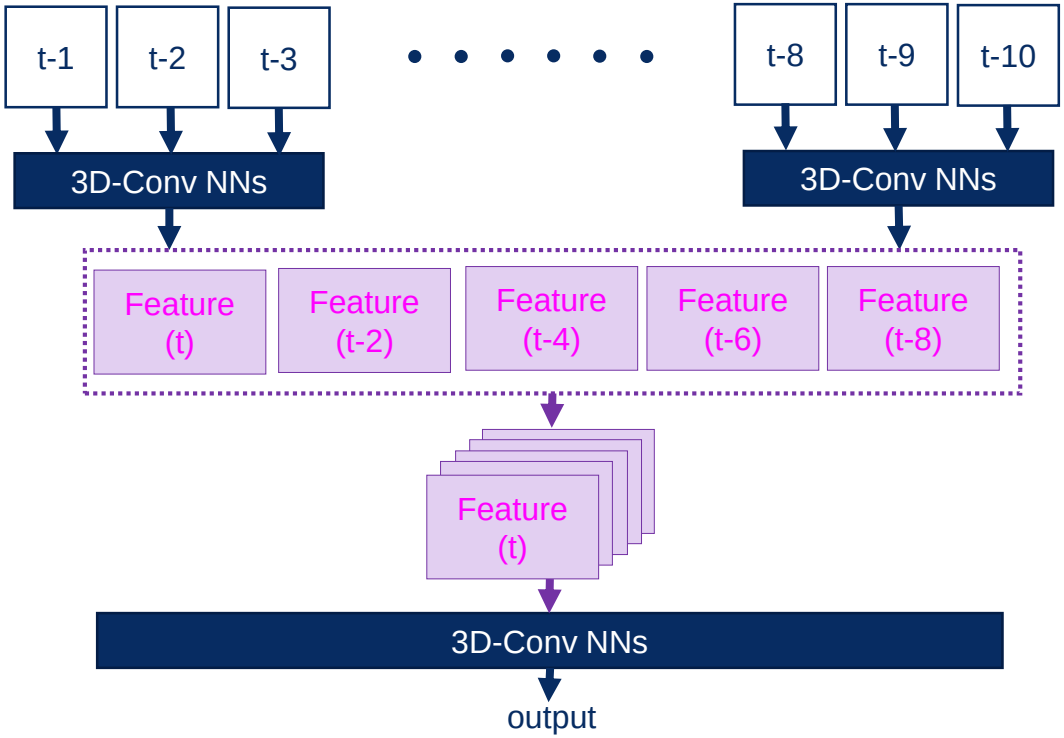
LocalNet(3D-Conv) + GlobalNet(2D-Conv)




```
Accuracy: 0.906
AveragePrecision: 0.907681888775
AverageRecall: 0.911635380279
Precision:--------------
up       :0.911
down     :0.897
+        :0.919
-        :0.925
right    :0.925
left     :0.944
click    :0.863
open     :0.878
none     :0.906
Recall:----------------
up       :0.891
down     :0.972
+        :0.971
-        :0.925
right    :0.925
left     :0.850
click    :0.917
open     :0.857
none     :0.896
```

Motion Gesture Recognition base on 3D

LocalNet(3D-Conv) + GlobalNet(3D-Conv)




```
Accuracy: 0.98
AveragePrecision: 0.985719261753
AverageRecall: 0.97697826508
Precision:--------------
up      :1.000
down    :1.000
+       :0.971
-       :1.000
right   :1.000
left    :1.000
click   :0.958
open    :0.976
none    :0.966
Recall:----------------
up      :1.000
down    :0.972
+       :0.971
-       :0.950
right   :1.000
left    :1.000
click   :0.958
open    :0.952
none    :0.988
```

Some Tips for CEVA-XM4 & 3D ML

- Suggest float type input
  - CEVA-XM4 enabled
- Suggest float accuracy inference at least FP16, better FP32
  - CEVA-XM4 enabled
- Besides ML, what you need?
  - Good performance on DSP for pre-processing or post-processing
- If you only need traditional programming, instead of ML
  - Built-in OpenCV functions shorten development time

Overall Market on 3D Sensing

Grow at CAGR 48% over the next decade to reach approximately $64.5 billion by 2025

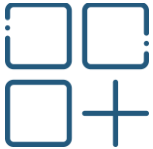
Technology

active

- Stereo
- Structured Light
- Time of Flight
- Active Stereo

Host

- Standalone Professional
- Laptop/Computer
- Smartphone
- Tablet



Verticals

- Automotive
- Robotics
- 3D Metrology
- Retail
- Security
- Healthcare
- 3D Scanning/Printing
- Gaming
- AR/VR
- Smart Home

Thank You

Luke Liu

lukeliu@lips-hci.com

www.ceva-dsp.com

www.lips-hci.com