



**TAIWAN
TECH**
National Taiwan University of
Science and Technology

Gesture Recognition Based on Coral USB Accelerator

Shanq-Jang Ruan, Ph. D.

Distinguished Professor

Dept. Electronic and Computer Engineering

National Taiwan University of Science and Technology



Outline

- Gesture Recognition

- ▣ Hand Tracker

- ▣ Gesture Classification

- Raspberry Pi

- Google Coral

- Conclusion

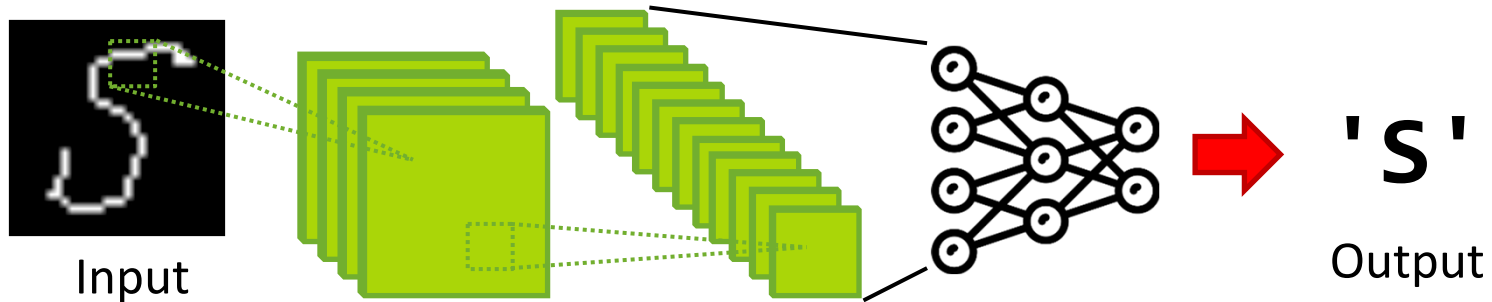


Gesture Recognition

□ Hand Tracker



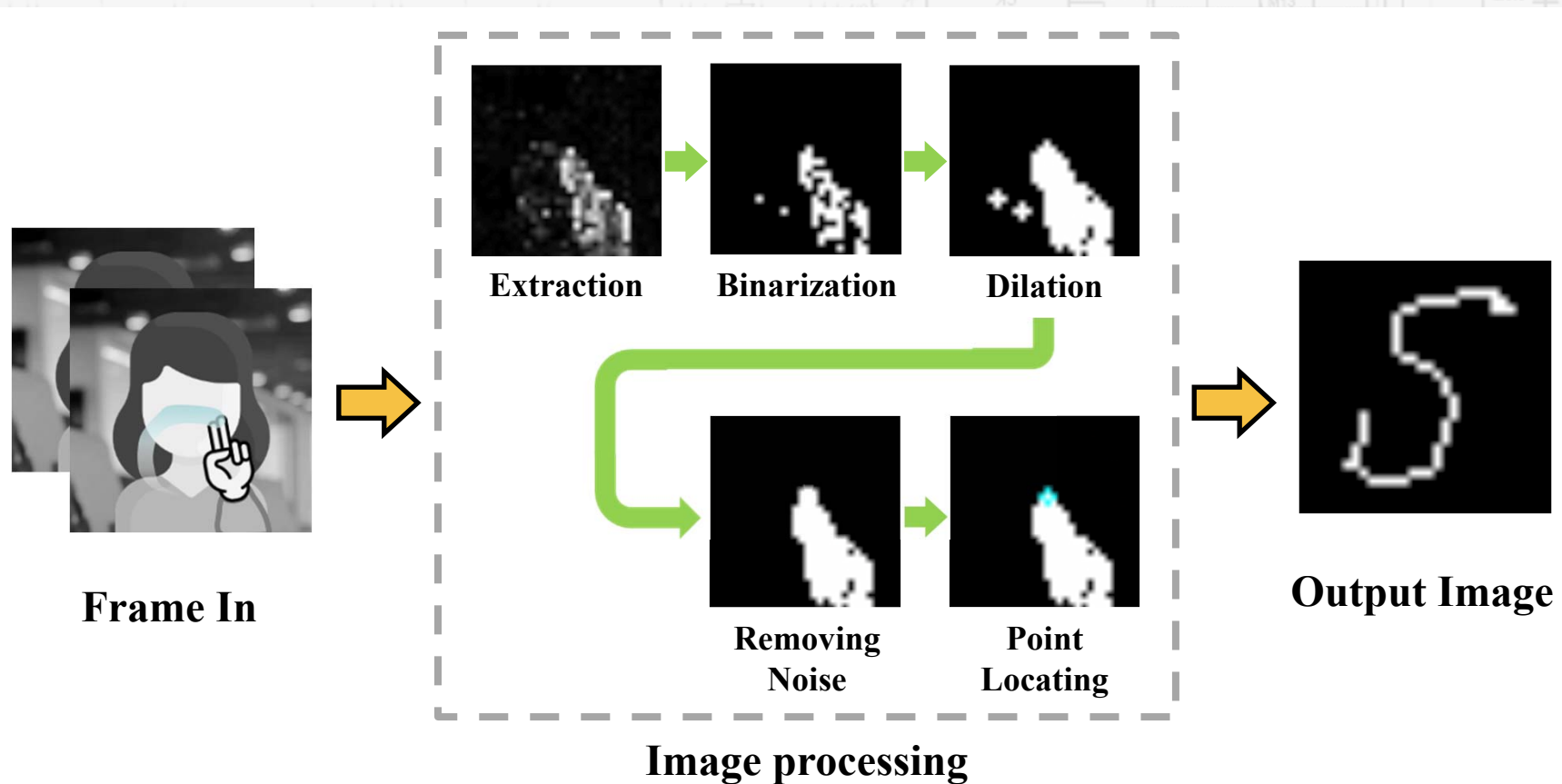
□ Gesture Classification





Hand Tracker

- Output an image every 30 frame.





Hand Tracker

□ Extraction

- Extract differences between continuous frames to capture the movement of the hand.

```
1 import cv2
2
3 cap = cv2.VideoCapture(0)
4 ret, frame_RGB = cap.read()
5
6 frame_gray = cv2.cvtColor(frame_RGB, cv2.COLOR_BGR2GRAY)
7
8 frame_absdiff = cv2.absdiff(frame_gray, frame_gray_old)
9 frame_gray_old = frame_gray
```





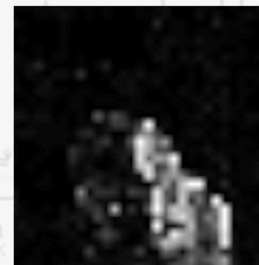
Hand Tracker

□ Binarization

□ Convert a grayscale image to a binary image.

- Global fixed threshold binarization
- Local adaptive threshold binarization
- **Otsu binarization**

```
1  # Global fixed threshold
2  ret1, th1 = cv2.threshold(img, 127, 255, cv2.THRESH_BINARY)
4  # Local adaptive threshold
5  th2 = cv2.adaptiveThreshold(img, 255, cv2.ADAPTIVE_THRESH_MEAN_C,
6                               cv2.THRESH_BINARY, 11, 2)
8  # Otsu threshold
9  ret2, th3 = cv2.threshold(img, 0, 255, cv2.THRESH_BINARY+ cv2.THRESH_OTSU)
```





Hand Tracker

□ Dilation

□ Dilation adds pixels to the boundaries of objects in an image.

```
1 kernel = cv2.getStructuringElement(cv2.MORPH_CROSS, (3,3))  
2 dilation = cv2.dilate(img, kernel, iterations = 1)
```



0	1	0
1	1	1
0	1	0

Structuring element



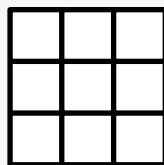
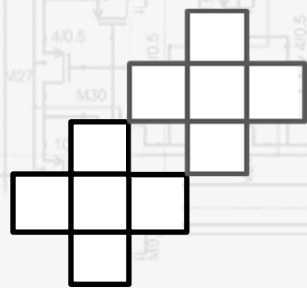


Hand Tracker

□ Removing Noise

- Find max connected-component to remove noise.
- Connected-component Labeling (CCL)
 - 4-connected
 - 8-connected

```
1 num, labels, stats, centroids = cv2.connectedComponentsWithStats(img,  
2 connectivity=4)
```



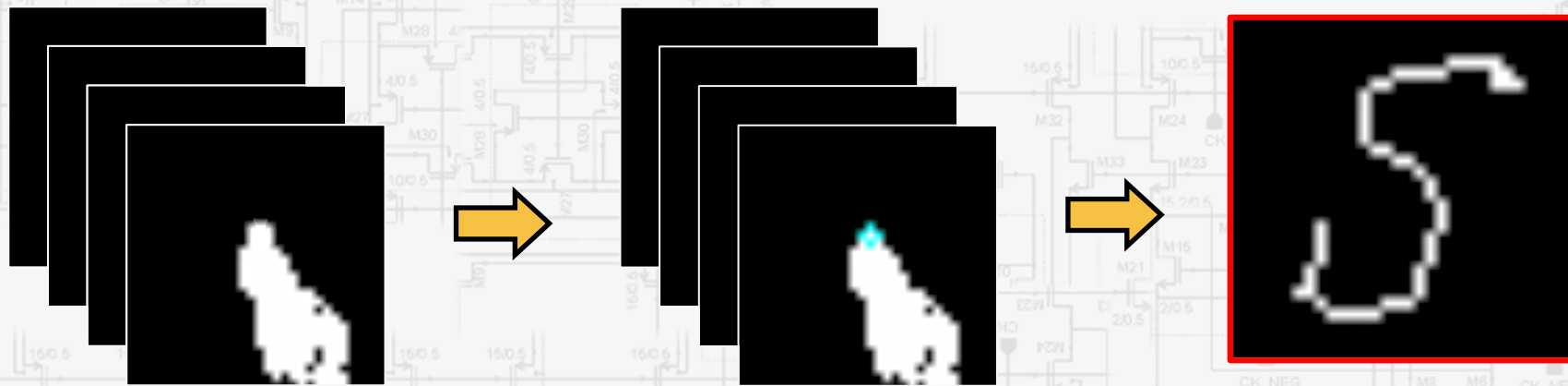


Hand Tracker

□ Hand Localization

- Find the top-right point of the object in each frame and draw lines between these points.

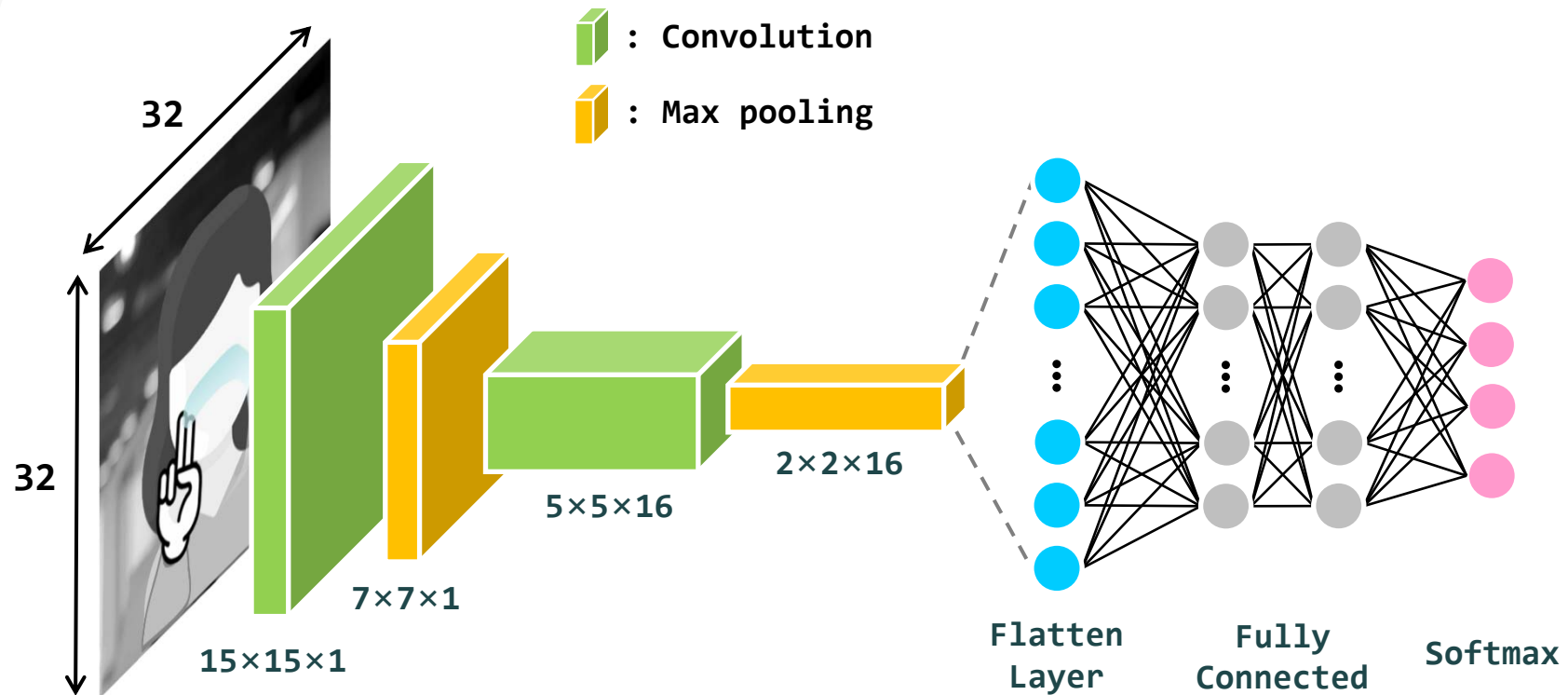
```
1 x = stats[sorted(range(len(sizes)), key=sizes.__getitem__)[-2]][0]
2 y = stats[sorted(range(len(sizes)), key=sizes.__getitem__)[-2]][1]
3
4 line = cv2.line(canvas, (pre_x, pre_y), (x, y), (0, 255, 255), 1)
5 pre_x, pre_y = x, y
```





Gesture Classification

□ Architecture





Gesture Classification

□ Architecture

□ Convolution layer

□ Max pooling

□ Fully connected layer

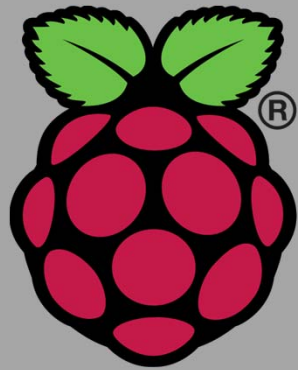
□ Activation function

■ ReLU

□ Output layer

■ Softmax

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 15, 15, 1)	10
max_pooling2d (MaxPooling2D)	(None, 7, 7, 1)	0
conv2d_1 (Conv2D)	(None, 5, 5, 16)	160
max_pooling2d_1 (MaxPooling2D)	(None, 2, 2, 16)	0
flatten (Flatten)	(None, 64)	0
dense (Dense)	(None, 16)	1040
activation (Activation)	(None, 16)	0
dense_1 (Dense)	(None, 16)	272
activation_1 (Activation)	(None, 16)	0
dense_2 (Dense)	(None, 16)	272
activation_2 (Activation)	(None, 16)	0
dense_3 (Dense)	(None, 4)	68
activation_3 (Activation)	(None, 4)	0
Total params: 1,822		
Trainable params: 1,822		
Non-trainable params: 0		

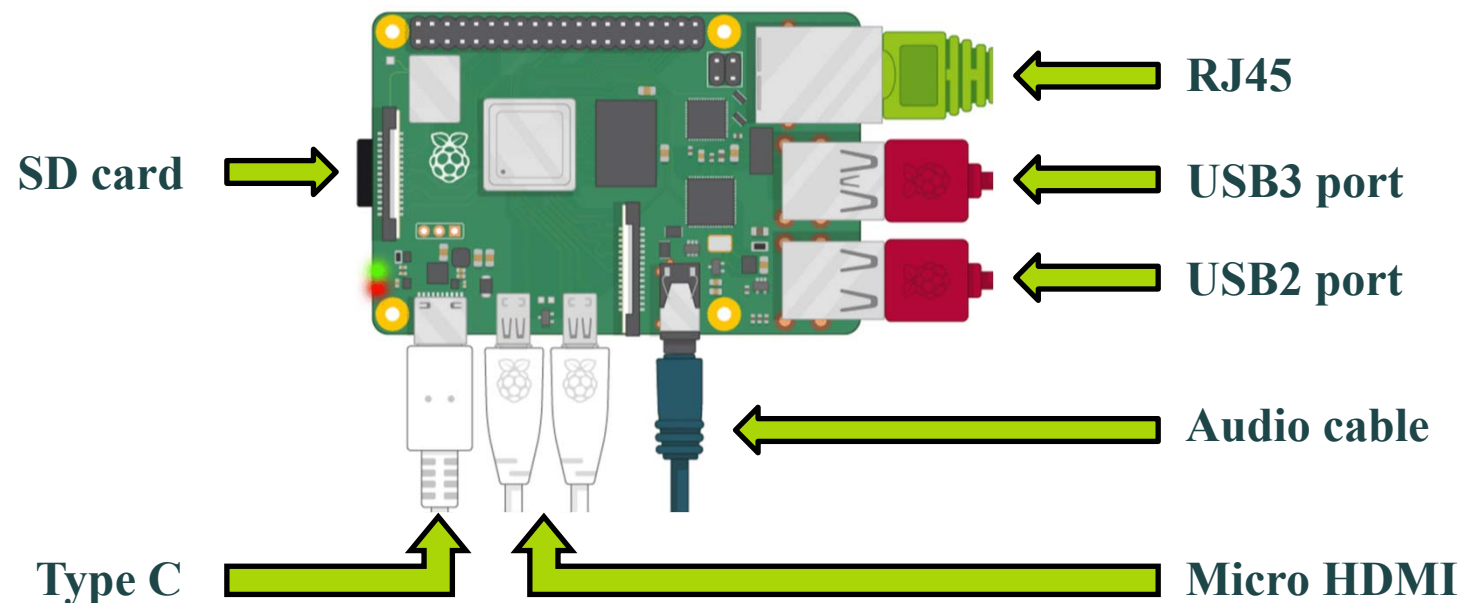


Raspberry Pi



Raspberry Pi

- The Raspberry Pi is a tiny computer that runs Linux.
- It employs SoCs, which combine the CPU and GPU onto a single integrated circuit, with the RAM, USB ports, and other components soldered to the board.





Raspberry Pi

- ❑ Raspberry Pi set up:
 - ❑ Install OS: [Raspberry Pi downloads page](#)

Install Raspberry Pi OS using Raspberry Pi Imager

Raspberry Pi Imager is the quick and easy way to install Raspberry Pi OS and other operating systems to a microSD card, ready to use with your Raspberry Pi. [Watch our 45-second video](#) to learn how to install an operating system using Raspberry Pi Imager.

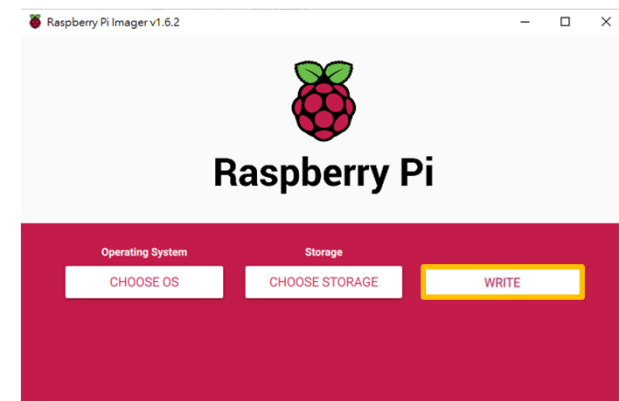
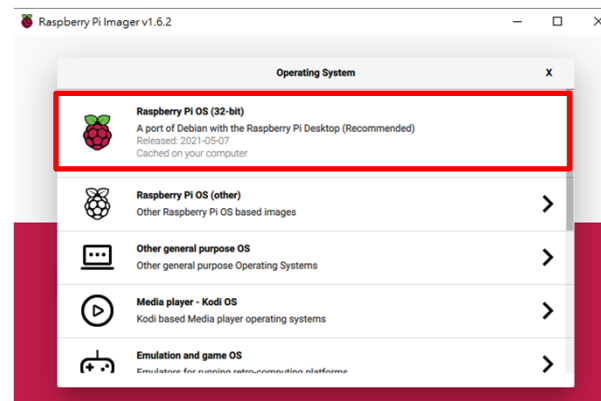
Download and install Raspberry Pi Imager to a computer with an SD card reader. Put the SD card you'll use with your Raspberry Pi into the reader and run Raspberry Pi Imager.

[Download for Windows](#)

[Download for macOS](#)

[Download for Ubuntu for x86](#)

To install on Raspberry Pi OS, type `sudo apt install rpi-imager` in a Terminal window.



Step 1: Select the Raspberry Pi Imager which matches your OS



Step 2: Launch Raspberry Pi Imager and choose your settings



Step 3: Press “**WRITE**” to write image to the SD cards



Raspberry Pi

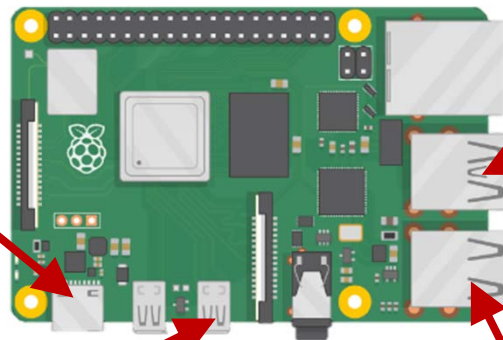
□ Raspberry Pi set up:



Power



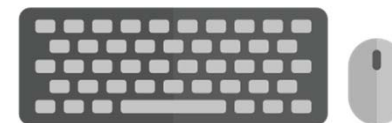
Monitor



Raspberry Pi



Webcam



Keyboard & Mouse



Raspberry Pi

□ Install Packages:

```
# upgrade the tools
```

```
$> pip3 install --upgrade pip
```

```
$> sudo apt-get -y update
```

```
$> pip3 install --upgrade setuptools
```

```
# install TensorFlow
```

```
$> pip3 install tensorflow-2.8.0-cp39-cp39-linux_aarch64.whl wrapt --upgrade  
--ignore-installed
```

```
# keras
```

```
$> pip3 install keras==2.8.0
```

```
# opencv
```

```
$> pip3 install opencv-contrib-python
```

```
$> pip install protobuf==3.20.*
```



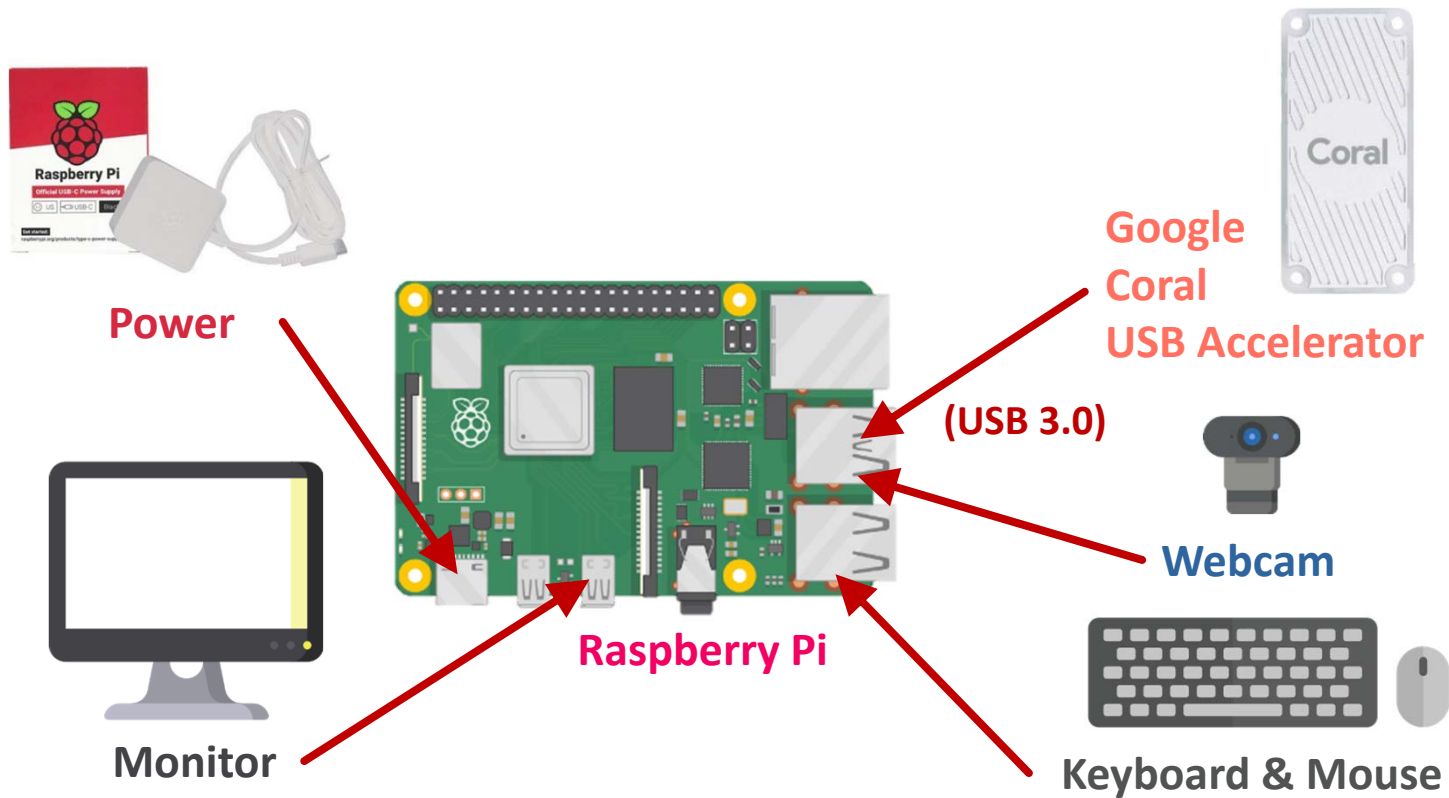
ശൃ Coral





Google Coral

□ Coral set up:





Google Coral

- Install the Edge TPU runtime
 - Add Debian package repository to your system

```
echo "deb https://packages.cloud.google.com/apt coral-edgetpu-stable main" | sudo tee /etc/apt/sources.list.d/coral-edgetpu.list
```

```
curl https://packages.cloud.google.com/apt/doc/apt-key.gpg | sudo apt-key add -  
sudo apt-get update
```

- Install the Edge TPU runtime

```
sudo apt-get install libedgetpu1-std
```

- Connect the Coral USB Accelerator to the computer using the provided USB 3.0 cable.



Google Coral

□ Edge TPU Compiler

□ Download the compiler on your Linux system

```
curl https://packages.cloud.google.com/apt/doc/apt-key.gpg | sudo apt-key add -  
  
echo "deb https://packages.cloud.google.com/apt coral-edgetpu-stable main" | sudo tee  
/etc/apt/sources.list.d/coral-edgetpu.list  
  
sudo apt-get update  
  
sudo apt-get install edgetpu-compiler
```

□ Compile the TensorFlow Lite model (.tflite file) into a file that's compatible with the Edge TPU.

```
edgetpu_compiler model/yolov4-tiny-relu-int8.tflite
```



Kneron USB Accelerator

□ Link: https://youtu.be/4aPVb8fm_o4





Gesture Recognition Based on Coral USB Accelerator

The background of the slide is a teal-colored circuit board pattern. It features a grid of lines with various electronic components and labels such as M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13, M14, M15, M16, M17, M18, M19, M20, M21, M22, M23, M24, M25, M26, M27, M28, M29, M30, M31, M32, M33, M34, M35, M36, M37, M38, M39, M40, M41, M42, M43, M44, M45, M46, M47, M48, M49, M50, M51, M52, M53, M54, M55, M56, M57, M58, M59, M60, M61, M62, M63, M64, M65, M66, M67, M68, M69, M70, M71, M72, M73, M74, M75, M76, M77, M78, M79, M80, M81, M82, M83, M84, M85, M86, M87, M88, M89, M90, M91, M92, M93, M94, M95, M96, M97, M98, M99, M100, M101, M102, M103, M104, M105, M106, M107, M108, M109, M110, M111, M112, M113, M114, M115, M116, M117, M118, M119, M120, M121, M122, M123, M124, M125, M126, M127, M128, M129, M130, M131, M132, M133, M134, M135, M136, M137, M138, M139, M140, M141, M142, M143, M144, M145, M146, M147, M148, M149, M150, M151, M152, M153, M154, M155, M156, M157, M158, M159, M160, M161, M162, M163, M164, M165, M166, M167, M168, M169, M170, M171, M172, M173, M174, M175, M176, M177, M178, M179, M180, M181, M182, M183, M184, M185, M186, M187, M188, M189, M190, M191, M192, M193, M194, M195, M196, M197, M198, M199, M200, M201, M202, M203, M204, M205, M206, M207, M208, M209, M210, M211, M212, M213, M214, M215, M216, M217, M218, M219, M220, M221, M222, M223, M224, M225, M226, M227, M228, M229, M230, M231, M232, M233, M234, M235, M236, M237, M238, M239, M240, M241, M242, M243, M244, M245, M246, M247, M248, M249, M250, M251, M252, M253, M254, M255, M256, M257, M258, M259, M260, M261, M262, M263, M264, M265, M266, M267, M268, M269, M270, M271, M272, M273, M274, M275, M276, M277, M278, M279, M280, M281, M282, M283, M284, M285, M286, M287, M288, M289, M290, M291, M292, M293, M294, M295, M296, M297, M298, M299, M300, M301, M302, M303, M304, M305, M306, M307, M308, M309, M310, M311, M312, M313, M314, M315, M316, M317, M318, M319, M320, M321, M322, M323, M324, M325, M326, M327, M328, M329, M330, M331, M332, M333, M334, M335, M336, M337, M338, M339, M340, M341, M342, M343, M344, M345, M346, M347, M348, M349, M350, M351, M352, M353, M354, M355, M356, M357, M358, M359, M360, M361, M362, M363, M364, M365, M366, M367, M368, M369, M370, M371, M372, M373, M374, M375, M376, M377, M378, M379, M380, M381, M382, M383, M384, M385, M386, M387, M388, M389, M390, M391, M392, M393, M394, M395, M396, M397, M398, M399, M400, M401, M402, M403, M404, M405, M406, M407, M408, M409, M410, M411, M412, M413, M414, M415, M416, M417, M418, M419, M420, M421, M422, M423, M424, M425, M426, M427, M428, M429, M430, M431, M432, M433, M434, M435, M436, M437, M438, M439, M440, M441, M442, M443, M444, M445, M446, M447, M448, M449, M450, M451, M452, M453, M454, M455, M456, M457, M458, M459, M460, M461, M462, M463, M464, M465, M466, M467, M468, M469, M470, M471, M472, M473, M474, M475, M476, M477, M478, M479, M480, M481, M482, M483, M484, M485, M486, M487, M488, M489, M490, M491, M492, M493, M494, M495, M496, M497, M498, M499, M500, M501, M502, M503, M504, M505, M506, M507, M508, M509, M510, M511, M512, M513, M514, M515, M516, M517, M518, M519, M520, M521, M522, M523, M524, M525, M526, M527, M528, M529, M530, M531, M532, M533, M534, M535, M536, M537, M538, M539, M540, M541, M542, M543, M544, M545, M546, M547, M548, M549, M550, M551, M552, M553, M554, M555, M556, M557, M558, M559, M560, M561, M562, M563, M564, M565, M566, M567, M568, M569, M570, M571, M572, M573, M574, M575, M576, M577, M578, M579, M580, M581, M582, M583, M584, M585, M586, M587, M588, M589, M590, M591, M592, M593, M594, M595, M596, M597, M598, M599, M600, M601, M602, M603, M604, M605, M606, M607, M608, M609, M610, M611, M612, M613, M614, M615, M616, M617, M618, M619, M620, M621, M622, M623, M624, M625, M626, M627, M628, M629, M630, M631, M632, M633, M634, M635, M636, M637, M638, M639, M640, M641, M642, M643, M644, M645, M646, M647, M648, M649, M650, M651, M652, M653, M654, M655, M656, M657, M658, M659, M660, M661, M662, M663, M664, M665, M666, M667, M668, M669, M670, M671, M672, M673, M674, M675, M676, M677, M678, M679, M680, M681, M682, M683, M684, M685, M686, M687, M688, M689, M690, M691, M692, M693, M694, M695, M696, M697, M698, M699, M700, M701, M702, M703, M704, M705, M706, M707, M708, M709, M710, M711, M712, M713, M714, M715, M716, M717, M718, M719, M720, M721, M722, M723, M724, M725, M726, M727, M728, M729, M730, M731, M732, M733, M734, M735, M736, M737, M738, M739, M740, M741, M742, M743, M744, M745, M746, M747, M748, M749, M750, M751, M752, M753, M754, M755, M756, M757, M758, M759, M760, M761, M762, M763, M764, M765, M766, M767, M768, M769, M770, M771, M772, M773, M774, M775, M776, M777, M778, M779, M780, M781, M782, M783, M784, M785, M786, M787, M788, M789, M790, M791, M792, M793, M794, M795, M796, M797, M798, M799, M800, M801, M802, M803, M804, M805, M806, M807, M808, M809, M810, M811, M812, M813, M814, M815, M816, M817, M818, M819, M820, M821, M822, M823, M824, M825, M826, M827, M828, M829, M830, M831, M832, M833, M834, M835, M836, M837, M838, M839, M840, M841, M842, M843, M844, M845, M846, M847, M848, M849, M850, M851, M852, M853, M854, M855, M856, M857, M858, M859, M860, M861, M862, M863, M864, M865, M866, M867, M868, M869, M870, M871, M872, M873, M874, M875, M876, M877, M878, M879, M880, M881, M882, M883, M884, M885, M886, M887, M888, M889, M890, M891, M892, M893, M894, M895, M896, M897, M898, M899, M900, M901, M902, M903, M904, M905, M906, M907, M908, M909, M910, M911, M912, M913, M914, M915, M916, M917, M918, M919, M920, M921, M922, M923, M924, M925, M926, M927, M928, M929, M930, M931, M932, M933, M934, M935, M936, M937, M938, M939, M940, M941, M942, M943, M944, M945, M946, M947, M948, M949, M950, M951, M952, M953, M954, M955, M956, M957, M958, M959, M960, M961, M962, M963, M964, M965, M966, M967, M968, M969, M970, M971, M972, M973, M974, M975, M976, M977, M978, M979, M980, M981, M982, M983, M984, M985, M986, M987, M988, M989, M990, M991, M992, M993, M994, M995, M996, M997, M998, M999, M1000. The text "Implementation" is centered on the slide, with a white horizontal line underneath it.

Implementation



Gesture Recognition

□ Load TensorFlow Lite model

```
1 import tensorflow as tf
2
3 model_path = "model_quant_NIST_model_edgetpu.tflite"
4 interpreter = tf.lite.Interpreter(model_path,
5 experimental_delegates=[tf.lite.experimental.load_delegate('libedgetpu.so.1')])
6
7 interpreter.allocate_tensors()
8
9 input_details = interpreter.get_input_details()
10 output_details = interpreter.get_output_details()
11
12 input_shape = input_details[0]["shape"]
13 input_data = img.reshape(input_shape).astype("float32")
14 interpreter.set_tensor(input_details[0]["index"], input_data)
15 interpreter.invoke()
16 output_data = interpreter.get_tensor(output_details[0]["index"])
```



Conclusion

□ Gesture Recognition

- We developed a hand gesture tracking and recognition method using image processing algorithms and deep learning.

□ Raspberry Pi

- Low cost, credit-card sized computer.