

10. Gesture recognition

1、 synopsis

MediaPipe is a data stream processing machine learning application development framework developed and open-source by Google. It is a graph based data processing pipeline that enables the construction of various forms of data sources, such as video, frequency, sensor data, and any time series data. MediaPipe is cross platform and can run on embedded platforms (such as Raspberry Pi), mobile devices (iOS and Android), workstations, and servers, while supporting mobile GPU acceleration. MediaPipe provides cross platform, customizable ML solutions for real-time and streaming media. The core framework of MediaPipe is implemented in C++ and provides support for languages such as Java and Objective C. The main concepts of MediaPipe include Packets, Streams, Calculators, Graphs, and Subgraphs.

The characteristics of MediaPipe :

- End to end acceleration: Built in fast ML inference and processing that can accelerate even on regular hardware.
- Build once, deploy anytime, anywhere: Unified solution suitable for Android, iOS, desktop/cloud, web, and IoT.
- Instant solution: A cutting-edge ML solution that showcases all features of the framework.
- Free and open source: Framework and solution under Apache 2.0, fully scalable and customizable.

2、 Gesture recognition

Gesture recognition based on the right hand design can be accurately recognized when certain conditions are met. Recognisable gestures: [Zero、 One、 Two、 Three、 Four、 Five、 Six、 Seven、 Eight、 Ok、 Rock、 Thumb_up、 Thumb_down、 Heart_single].

2.1、 activate

1. First set the proxy IP for the ROS-wifi image transfer module. For specific steps, please refer to the basic use **1. The use of ROS-wifi image transfer module in microcar** tutorial
2. The Linux system connects to the ROS-wifi image transfer module, starts docket, and enters the following command to connect the ROS-wifi image transfer module

```
#Use the provided system for direct input
sh start_Camera_computer.sh
```

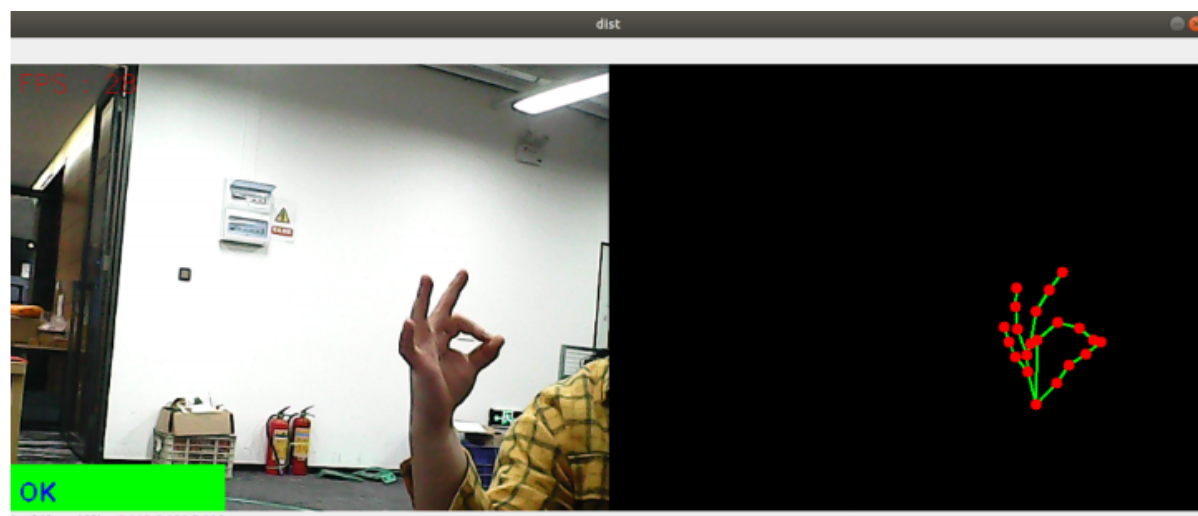
```
#Systems that are not data:
docker run -it --rm -v /dev:/dev -v /dev/shm:/dev/shm --privileged --net=host
microros/micro-ros-agent:humble udp4 --port 9999 -v4
```

```
yahboom@yahboom-VM: ~  
yahboom@yahboom-VM: ~ 80x24  
yahboom@yahboom-VM:~$ docker run -it --rm -v /dev:/dev -v /dev/shm:/dev/shm --privileged --net=host microros/micro-ros-agent:humble udp4 --port 9999 -v4  
[1711695468.874360] info | UDPv4AgentLinux.cpp | init |  
running... | port: 9999 |  
[1711695468.874663] info | Root.cpp | set_verbose_level | 1 |  
logger setup | verbose_level: 4 |  
[1711695469.608224] info | Root.cpp | create_client | c |  
create | client_key: 0x63824D0E, session_id: 0x81 |  
[1711695469.608287] info | SessionManager.hpp | establish_session | s |  
session established | client_key: 0x63824D0E, address: 192.168.2.114:27599 |  
[1711695469.626174] info | ProxyClient.cpp | create_participant | p |  
participant created | client_key: 0x63824D0E, participant_id: 0x000(1) |  
[1711695469.631263] info | ProxyClient.cpp | create_topic | t |  
topic created | client_key: 0x63824D0E, topic_id: 0x000(2), participant_id: 0x000(1) |  
[1711695469.646135] info | ProxyClient.cpp | create_publisher | p |  
publisher created | client_key: 0x63824D0E, publisher_id: 0x000(3), participant_id: 0x000(1) |  
[1711695469.652213] info | ProxyClient.cpp | create_datawriter | d |  
datawriter created | client_key: 0x63824D0E, datawriter_id: 0x000(5), publisher_id: 0x000(3) |
```

If the preceding information is displayed, the proxy connection is successful

3. Open a new terminal and execute the following command

```
ros2 run yahboom_esp32_mediapipe 11_GestureRecognition
```



4. Notes

- "If the camera angle is not centered, the Linux system needs to connect to the car agent. Please refer to the specific steps for development preparation before proceeding with tutorial **0. which provides essential information for a quick start (must-read)**. This tutorial will not provide further elaboration."
- After connecting the car's agent, enter the following command

```
ros2 run yahboom_esp32_mediapipe control_servo
```

After the steering engine is in the center, press "ctrl+C" to end the program.

5. If the camera picture is upside down, see **3. Camera picture correction (must-read)** tutorial, this tutorial is no longer explained

2.2. Code parsing

```
~/yahboomcar_ws/src/yahboom_esp32_mediapipe/yahboom_esp32_mediapipe/11_GestureRecognition.py
```

```
class handDetector:
    def __init__(self, mode=False, maxHands=2, detectorCon=0.5, trackCon=0.5):
        self.tipIds = [4, 8, 12, 16, 20]
        self.mpHand = mp.solutions.hands
        self.mpDraw = mp.solutions.drawing_utils
        self.hands = self.mpHand.Hands(
            static_image_mode=mode,
            max_num_hands=maxHands,
            min_detection_confidence=detectorCon,
            min_tracking_confidence=trackCon
        )
        self.lmList = []
        self.lmDrawSpec = mp.solutions.drawing_utils.DrawingSpec(color=(0, 0, 255), thickness=-1, circle_radius=6)
        self.drawSpec = mp.solutions.drawing_utils.DrawingSpec(color=(0, 255, 0), thickness=2, circle_radius=2)

    def get_dist(self, point1, point2):
        x1, y1 = point1
        x2, y2 = point2
        return abs(math.sqrt(math.pow(abs(y1 - y2), 2) + math.pow(abs(x1 - x2), 2)))

    def calc_angle(self, pt1, pt2, pt3):
        point1 = self.lmList[pt1][1], self.lmList[pt1][2]
        point2 = self.lmList[pt2][1], self.lmList[pt2][2]
        point3 = self.lmList[pt3][1], self.lmList[pt3][2]
        a = self.get_dist(point1, point2)
        b = self.get_dist(point2, point3)
        c = self.get_dist(point1, point3)
        try:
            radian = math.acos((math.pow(a, 2) + math.pow(b, 2) - math.pow(c, 2)) / (2 * a * b))
            angle = radian / math.pi * 180
        except:
            angle = 0
        return abs(angle)

    def findHands(self, frame, draw=True):
        self.lmList = []
        img = np.zeros(frame.shape, np.uint8)
        img_RGB = cv.cvtColor(frame, cv.COLOR_BGR2RGB)
        self.results = self.hands.process(img_RGB)
        if self.results.multi_hand_landmarks:
            for i in range(len(self.results.multi_hand_landmarks)):
```

```

        if draw: self.mpDraw.draw_landmarks(frame,
self.results.multi_hand_landmarks[i], self.mpHand.HAND_CONNECTIONS,
self.lmDrawSpec, self.drawSpec)
        self.mpDraw.draw_landmarks(img,
self.results.multi_hand_landmarks[i], self.mpHand.HAND_CONNECTIONS,
self.lmDrawSpec, self.drawSpec)
        for id, lm in
enumerate(self.results.multi_hand_landmarks[i].landmark):
            h, w, c = frame.shape
            cx, cy = int(lm.x * w), int(lm.y * h)
            self.lmList.append([id, cx, cy])
    return frame, img

def frame_combine(self, frame, src):
    if len(frame.shape) == 3:
        frameH, frameW = frame.shape[:2]
        srcH, srcW = src.shape[:2]
        dst = np.zeros((max(frameH, srcH), frameW + srcW, 3), np.uint8)
        dst[:, :frameW] = frame[:, :]
        dst[:, frameW:] = src[:, :]
    else:
        src = cv.cvtColor(src, cv.COLOR_BGR2GRAY)
        frameH, frameW = frame.shape[:2]
        imgH, imgW = src.shape[:2]
        dst = np.zeros((frameH, frameW + imgW), np.uint8)
        dst[:, :frameW] = frame[:, :]
        dst[:, frameW:] = src[:, :]
    return dst

def fingersUp(self):
    fingers=[]
    # Thumb
    if (self.calc_angle(self.tipIds[0],
                        self.tipIds[0] - 1,
                        self.tipIds[0] - 2) > 150.0) and (
        self.calc_angle(
            self.tipIds[0] - 1,
            self.tipIds[0] - 2,
            self.tipIds[0] - 3) > 150.0): fingers.append(1)
    else:
        fingers.append(0)
    # 4 finger
    for id in range(1, 5):
        if self.lmList[self.tipIds[id]][2] < self.lmList[self.tipIds[id] - 2]
[2]:
            fingers.append(1)
        else:
            fingers.append(0)
    return fingers

def get_gesture(self):
    gesture = ""
    fingers = self.fingersUp()
    if self.lmList[self.tipIds[0]][2] > self.lmList[self.tipIds[1]][2] and \
        self.lmList[self.tipIds[0]][2] > self.lmList[self.tipIds[2]][2]
and \

```

```

        self.lmList[self.tipIds[0]][2] > self.lmList[self.tipIds[3]][2]
and \
        self.lmList[self.tipIds[0]][2] > self.lmList[self.tipIds[4]][2] :
gesture = "Thumb_down"

    elif self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[1]][2] and \
\
        self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[2]][2]
and \
        self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[3]][2]
and \
        self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[4]][2]
and \
        self.calc_angle(self.tipIds[1] - 1, self.tipIds[1] - 2,
self.tipIds[1] - 3) < 150.0 : gesture = "Thumb_up"
        if fingers.count(1) == 3 or fingers.count(1) == 4:
            if fingers[0] == 1 and (
                self.get_dist(self.lmList[4][1:], self.lmList[8][1:])
<self.get_dist(self.lmList[4][1:], self.lmList[5][1:])
            ): gesture = "OK"
            elif fingers[2] == fingers[3] == 0: gesture = "Rock"
            elif fingers.count(1) == 3: gesture = "Three"
            else: gesture = "Four"
        elif fingers.count(1) == 0: gesture = "Zero"
        elif fingers.count(1) == 1: gesture = "One"
        elif fingers.count(1) == 2:
            if fingers[0] == 1 and fingers[4] == 1: gesture = "Six"
            elif fingers[0] == 1 and self.calc_angle(4, 5, 8) > 90: gesture =
"Eight"
            elif fingers[0] == fingers[1] == 1 and self.get_dist(self.lmList[4]
[1:], self.lmList[8][1:]) < 50: gesture = "Heart_single"
            else: gesture = "Two"
        elif fingers.count(1)==5:gesture = "Five"
        if self.get_dist(self.lmList[4][1:], self.lmList[8][1:]) < 60 and \
            self.get_dist(self.lmList[4][1:], self.lmList[12][1:]) < 60 and \
            self.get_dist(self.lmList[4][1:], self.lmList[16][1:]) < 60 and \
            self.get_dist(self.lmList[4][1:], self.lmList[20][1:]) < 60 :
gesture = "Seven"
            if self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[1]][2] and \
                self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[2]][2]
and \
                self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[3]][2]
and \
                self.lmList[self.tipIds[0]][2] < self.lmList[self.tipIds[4]][2]
and \
                self.calc_angle(self.tipIds[1] - 1, self.tipIds[1] - 2,
self.tipIds[1] - 3) > 150.0 : gesture = "Eight"
            return gesture

class MY_Picture(Node):
    def __init__(self, name):
        super().__init__(name)
        self.bridge = CvBridge()
        self.sub_img = self.create_subscription(

```

```

        CompressedImage, '/espRos/esp32camera', self.handleTopic, 1)

    self.hand_detector = handDetector(detectorCon=0.75)

    def handleTopic(self, msg):
        start = time.time()
        frame = self.bridge.compressed_imgmsg_to_cv2(msg)
        frame = cv.resize(frame, (640, 480))

        cv.waitKey(1)
        frame, img = self.hand_detector.findHands(frame, draw=False)

        if len(self.hand_detector.lmList) != 0:
            totalFingers = self.hand_detector.get_gesture()
            cv.rectangle(frame, (0, 430), (230, 480), (0, 255, 0), cv.FILLED)
            cv.putText(frame, str(totalFingers), (10, 470),
            cv.FONT_HERSHEY_PLAIN, 2, (255, 0, 0), 2)

            end = time.time()
            fps = 1 / (end - start)
            text = "FPS : " + str(int(fps))
            cv.putText(frame, text, (20, 30), cv.FONT_HERSHEY_SIMPLEX, 0.9, (0, 0,
            255), 1)
            dist = self.hand_detector.frame_combine(frame, img)
            cv.imshow('dist', dist)

        ...

Zero One Two Three Four Five Six Seven Eight
Ok: OK
Rock: rock
Thumb_up : Thumb up
Thumb_down: Thumb down
Heart_single: Compare hearts with one hand
...

def main():
    print("start it")
    rclpy.init()
    esp_img = MY_Picture("My_Picture")
    try:
        rclpy.spin(esp_img)
    except KeyboardInterrupt:
        pass
    finally:
        esp_img.destroy_node()
        rclpy.shutdown()

```

The main process of the program: subscribe to the image from esp32, through MediaPipe to do the relevant recognition, and then through opencv to display the processed image.

