Gesture Recognition

1. Introduction

MediaPipe is an open-source data stream processing machine learning application development framework developed by Google. It is a graph-based data processing pipeline used to build data sources in various forms, such as video, audio, sensor data, and any time series data.

MediaPipe is cross-platform and can run on embedded platforms (such as Jetson nano), mobile devices (iOS and Android), workstations and servers, and supports 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.

Features of MediaPipe:

- End-to-end acceleration: built-in fast ML inference and processing can be accelerated even on ordinary hardware.
- Build once, deploy anywhere: unified solution for Android, iOS, desktop/cloud, web and IoT.
- Ready-to-use solution: cutting-edge ML solution that demonstrates the full functionality of the framework.
- Free and open source: framework and solution under Apache2.0, fully extensible and customizable.

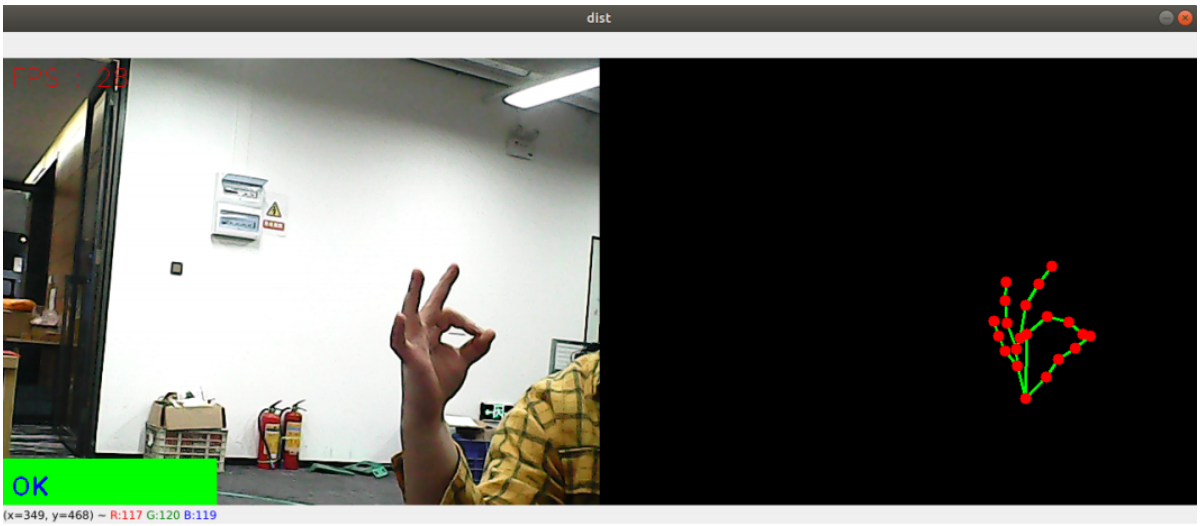
2. Gesture recognition

Gesture recognition designed based on the right hand can be accurately recognized when specific conditions are met. The recognizable gestures are: [Zero, One, Two, Three, Four, Five, Six, Seven, Eight, Ok, Rock, Thumb_up (like), Thumb_down (thumbs down), Heart_single (single-hand heart)], a total of 14 categories.

2.1. Start

- Enter the following command to start the program

```
ros2 run dofbot_pro_mediapipe 10_GestureRecognition
```



2. Source code

Source code location:
~/dofbot_pro_ws/src/dofbot_pro_mediapipe/dofbot_pro_mediapipe/10_GestureRecognition.py

```
#!/usr/bin/env python3
# encoding: utf-8

import math
import time
import cv2 as cv
import numpy as np
import mediapipe as mp
import rclpy
from rclpy.node import Node
from sensor_msgs.msg import Image
from cv_bridge import CvBridge

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 (
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                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 fingers
        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:
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                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 HandGestureNode(Node):
    def __init__(self):
        super().__init__('hand_gesture_node')
        self.publisher_ = self.create_publisher(Image, 'hand_gesture_image', 10)
        self.timer = self.create_timer(0.1, self.timer_callback)
        self.bridge = CvBridge()
        self.hand_detector = HandDetector(detectorCon=0.75)
        self.capture = cv.VideoCapture(0, cv.CAP_V4L2)
        self.capture.set(cv.CAP_PROP_FRAME_WIDTH, 640)
        self.capture.set(cv.CAP_PROP_FRAME_HEIGHT, 480)
        self.pTime = 0

    def timer_callback(self):
        ret, frame = self.capture.read()
        if not ret:
            self.get_logger().error('Failed to capture frame')
            return

        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)

        if cv.waitKey(1) & 0xFF == ord('q'):
            self.capture.release()
            cv.destroyAllWindows()
            rclpy.shutdown()
            return
```

```
        cTime = time.time()
        fps = 1 / (cTime - self.pTime)
        self.pTime = cTime
        text = "FPS : " + str(int(fps))
        cv.putText(frame, text, (10, 30), cv.FONT_HERSHEY_SIMPLEX, 0.9, (0, 0,
255), 1)
        dist = self.hand_detector.frame_combine(frame, img)
        cv.imshow('dist', dist)

        msg = self.bridge.cv2_to_imgmsg(frame, "bgr8")
        self.publisher_.publish(msg)

def main(args=None):
    rclpy.init(args=args)
    hand_gesture_node = HandGestureNode()
    rclpy.spin(hand_gesture_node)
    hand_gesture_node.destroy_node()
    rclpy.shutdown()

if __name__ == '__main__':
    main()
```