1.Hand detection

1.1. 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 for building and using multiple forms of data sources, such as video, audio, sensor data, and any time series data. MediaPipe is cross-platform and can run on embedded platforms (Raspberry Pi, etc.), 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 Packet, Stream, Calculator, Graph and Subgraph.

MediaPipe Features:

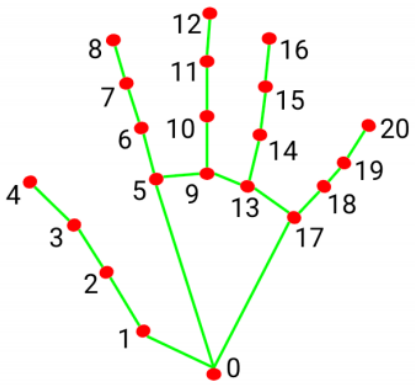
- End-to-end acceleration: Built-in fast ML inference and processing accelerates even on commodity hardware.
- Build once, deploy anywhere: Unified solution for Android, iOS, desktop/cloud, web and IoT.
- Ready-to-use solutions: cutting-edge ML solutions that showcase the full capabilities of the framework.
- Free and open source: frameworks and solutions under Apache2.0, fully extensible and customizable.

1.2. MediaPipe Hands

MediaPipe Hands is a high-fidelity hand and finger tracking solution. It uses machine learning (ML) to infer the 3D coordinates of 21 hands from a frame.

After hand detection on the entire image, the 21 3D hand joint coordinates in the detected hand area are accurately positioned through regression based on the hand mark model, that is, direct coordinate prediction. The model learns consistent internal hand pose representations and is robust even to partially visible hands and self-occlusion.

To obtain ground truth data, approximately 30K real-world images were manually annotated with 21 3D coordinates as shown below (Z values are obtained from the image depth map, if there is a Z value for each corresponding coordinate). To better cover possible hand poses and provide additional supervision on the nature of the hand geometry, high-quality synthetic hand models in various backgrounds are also drawn and mapped to corresponding 3D coordinates.



0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP
17. PINKY_MCP
18. PINKY_PIP
19. PINKY_DIP
20. PINKY_TIP

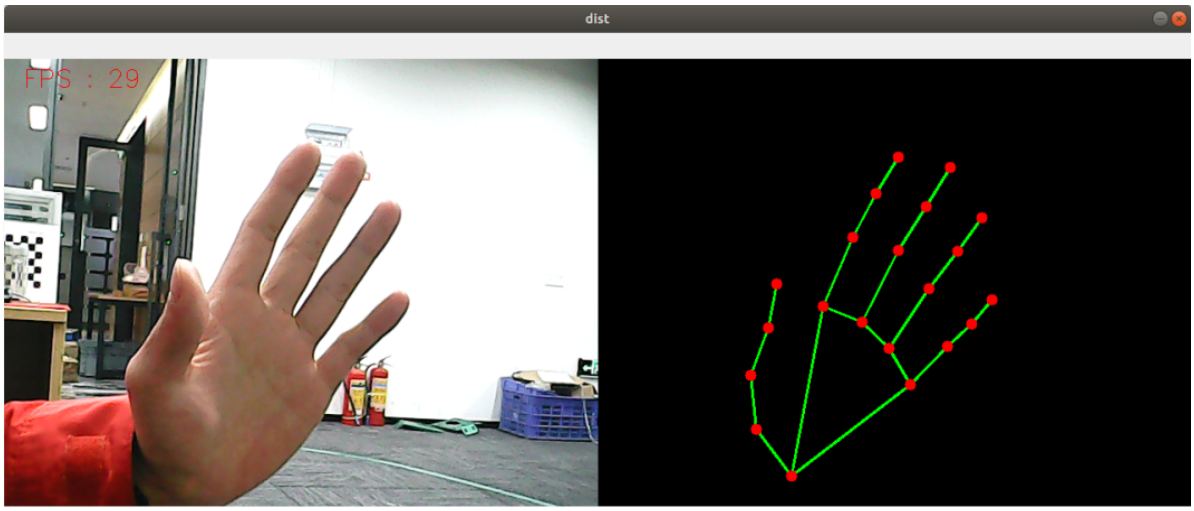
1.3. Hand detection

1.3.1.Startup

Note: Before running this case, please make sure that the [/dev/video0] device has been successfully mounted into the docker container, otherwise the camera will not be opened.

Enter the docker container and execute:

```
ros2 run yahboomcar_mediapipe 01_HandDetector
```

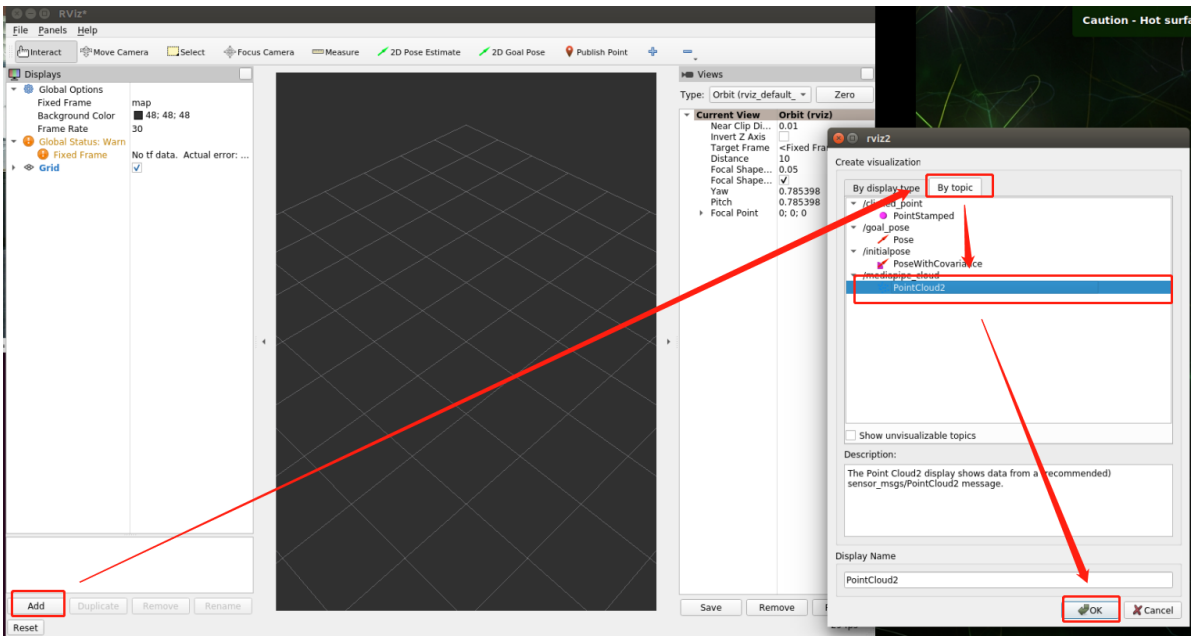


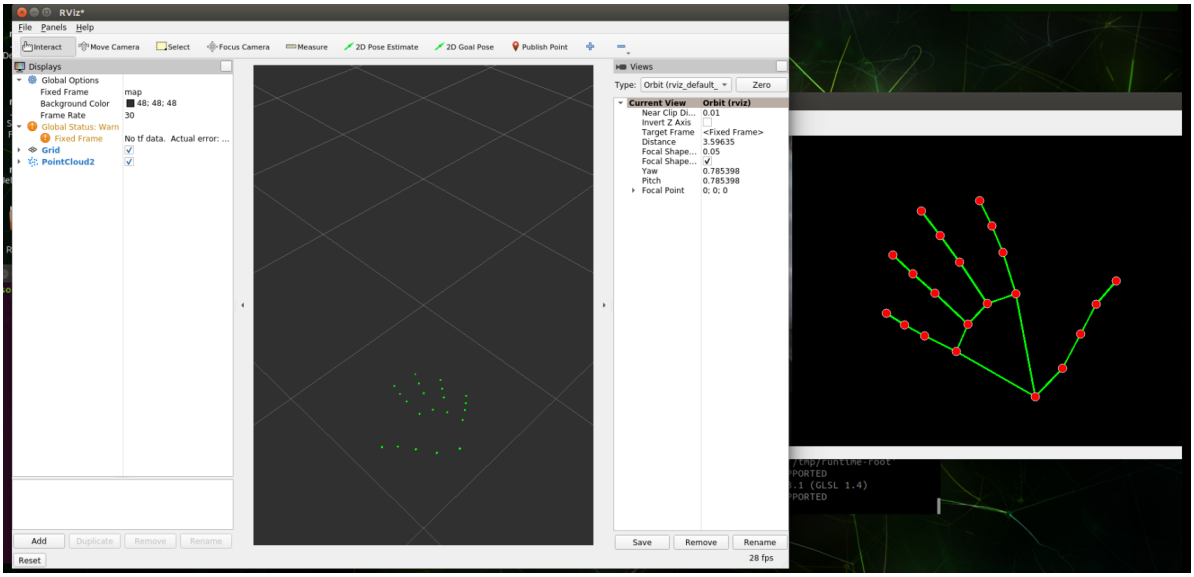
1.3.2. View point cloud data

Enter the docker container and execute:

```
#Run the point cloud publishing program
ros2 run yahboomcar_point pub_point
#Start rviz to view point cloud
rviz2
```

Follow the steps below to add a point cloud topic in rviz,

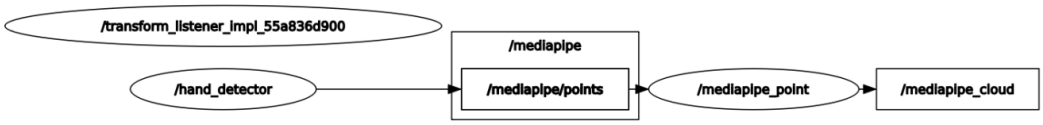




1.3.3. View node topic communication diagram

Enter the docker container and execute:

```
ros2 run  rqt_graph rqt_graph
```



1.3.4.Source code

Source code location:

```
/root/yahboomcar_ros2_ws/yahboomcar_ws/src/yahboomcar_mediapipe/yahboomcar_media
pipe/01_HandDetector.py
```

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

#import ros lib
import rclpy
from rclpy.node import Node
from geometry_msgs.msg import Point
import mediapipe as mp
#import define msg
from yahboomcar_msgs.msg import PointArray

#import commom lib
```

```
import cv2 as cv
import numpy as np
import time
print("import done")


class HandDetector(Node):
    def __init__(self,name, mode=False, maxHands=2, detectorCon=0.5,
trackCon=0.5):
        super().__init__(name)
        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.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)
        #create a publisher
        self.pub_point =
self.create_publisher(PointArray,'/mediapipe/points',1000)

    def pubHandsPoint(self, frame, draw=True):
        pointArray = PointArray()
        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):
                    point = Point()
                    point.x, point.y, point.z = lm.x, lm.y, lm.z
                    pointArray.points.append(point)

        self.pub_point.publish(pointArray)
        return frame, img

    def frame_combine(slef,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 main():
    print("start it")
    rclpy.init()
    hand_detector = HandDetector('hand_detector')
    capture = cv.VideoCapture(0)
    capture.set(6, cv.VideoWriter.fourcc('M', 'J', 'P', 'G'))
    capture.set(cv.CAP_PROP_FRAME_WIDTH, 640)
    capture.set(cv.CAP_PROP_FRAME_HEIGHT, 480)
    print("capture get FPS : ", capture.get(cv.CAP_PROP_FPS))
    pTime = cTime = 0

    while capture.isOpened():
        ret, frame = capture.read()
        # frame = cv.flip(frame, 1)
        frame, img = hand_detector.pubHandsPoint(frame, draw=False)
        if cv.waitKey(1) & 0xFF == ord('q'): break
        cTime = time.time()
        fps = 1 / (cTime - pTime)
        pTime = cTime
        text = "FPS : " + str(int(fps))
        cv.putText(frame, text, (20, 30), cv.FONT_HERSHEY_SIMPLEX, 0.9, (0, 0,
255), 1)
        dist = hand_detector.frame_combine(frame, img)
        cv.imshow('dist', dist)
        # cv.imshow('frame', frame)
        # cv.imshow('img', img)
    capture.release()
    cv.destroyAllWindows()
```