Hand Detection

Orin board users can directly open the terminal and input the tutorial commands to run directly. Jetson-Nano board users need to enter the docker container first, then input the tutorial commands in the docker to start the program.

1. Introduction

MediaPipe is a data stream processing machine learning application development framework developed and open-sourced by Google. It is a graph-based data processing pipeline used to build applications that use various 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 (Jetson nano, 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.

Features of MediaPipe:

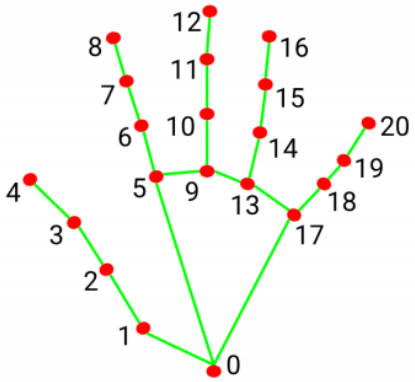
- End-to-end acceleration: Built-in fast ML inference and processing accelerates even on ordinary hardware.
- Build once, deploy anywhere: Unified solution for Android, iOS, desktop/cloud, web and IoT.
- Ready-to-use solutions: Cutting-edge ML solutions that showcase the full capabilities of the framework.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

2. MediaPipe Hands

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

After performing palm detection on the entire image, the hand landmark model performs precise keypoint localization of 21 3D hand joint coordinates within the detected hand region through regression, which is direct coordinate prediction. The model learns a consistent internal hand pose representation 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 obtained from image depth maps, if each corresponding coordinate has a Z value). To better cover possible hand poses and provide additional supervision on the nature of hand geometry, high-quality synthetic hand models in various backgrounds were also rendered and mapped to corresponding 3D coordinates.



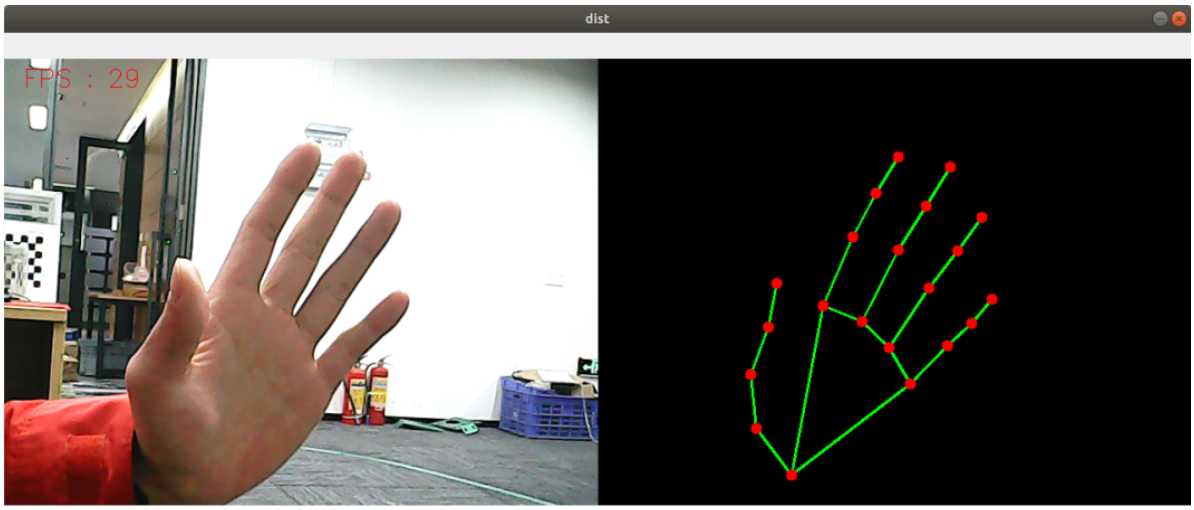
0. WRIST
1. THUMB_CMC
2. THUMB_MCP
3. THUMB_IP
4. THUMB_TIP
5. INDEX_FINGER_MCP
6. INDEX_FINGER_PIP
7. INDEX_FINGER_DIP
8. INDEX_FINGER_TIP
9. MIDDLE_FINGER_MCP
10. MIDDLE_FINGER_PIP
11. MIDDLE_FINGER_DIP
12. MIDDLE_FINGER_TIP
13. RING_FINGER_MCP
14. RING_FINGER_PIP
15. RING_FINGER_DIP
16. RING_FINGER_TIP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

3. Hand Detection

3.1. Launch

- Enter the following command to start the program

```
ros2 run dofbot_pro_mediapipe 01_HandDetector
```



3.2. Source Code

Source code location:

```
# Jetson-Nano users need to enter the docker container to view
~/dofbot_pro_ws/src/dofbot_pro_mediapipe/dofbot_pro_mediapipe/01_HandDetector.py
```

```
#!/usr/bin/env python3
# encoding: utf-8
import rclpy
import cv2 as cv
import numpy as np
import mediapipe as mp
import time
from rclpy.node import Node
from geometry_msgs.msg import Point
from dofbot_pro_msgs.msg import PointArray

class HandDetector(Node):
    def __init__(self):
        super().__init__('hand_detector')
```

```
        self.mpHand = mp.solutions.hands
        self.mpDraw = mp.solutions.drawing_utils
        self.hands = self.mpHand.Hands(
            static_image_mode=False,
            max_num_hands=2,
            min_detection_confidence=0.5,
            min_tracking_confidence=0.5
        )

        self.publisher_ = self.create_publisher(PointArray, '/mediapipe/points',
10)
        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)

        # Initialize the camera
        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)

        if not self.capture.isOpened():
            self.get_logger().error("Failed to open the camera")
            return

        self.get_logger().info(f"Camera FPS:
{self.capture.get(cv.CAP_PROP_FPS)}")
        self.pTime = time.time()

        # Create a timer to process frames approximately at 30 FPS
        self.timer = self.create_timer(0.03, self.process_frame)

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

        frame, img = self.pubHandsPoint(frame, draw=True)

        cTime = time.time()
        fps = 1 / (cTime - self.pTime)
        self.pTime = cTime
        text = "FPS : " + str(int(fps))
        cv.putText(frame, text, (20, 30), cv.FONT_HERSHEY_SIMPLEX, 0.9, (0, 0,
255), 1)

        HandDetector = self.frame_combine(frame, img)
        cv.imshow('HandDetector', HandDetector)

        if cv.waitKey(1) & 0xFF == ord('q'):
            self.get_logger().info("Exiting program")
            self.capture.release()
            cv.destroyAllWindows()
            self.destroy_node()
            rclpy.shutdown()
            exit(0)
```

```
    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 lm in 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.publisher_.publish(pointArray)
        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 main(args=None):
    rclpy.init(args=args)
    node = HandDetector()
    try:
        rclpy.spin(node)
    except KeyboardInterrupt:
        pass
    finally:
        node.capture.release()
        cv.destroyAllWindows()
        node.destroy_node()
        rclpy.shutdown()

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