Finger Control Robot Arm

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

The finger-controlled robot arm function is based on finger control, adding the capability to control the robot arm's up and down movement.

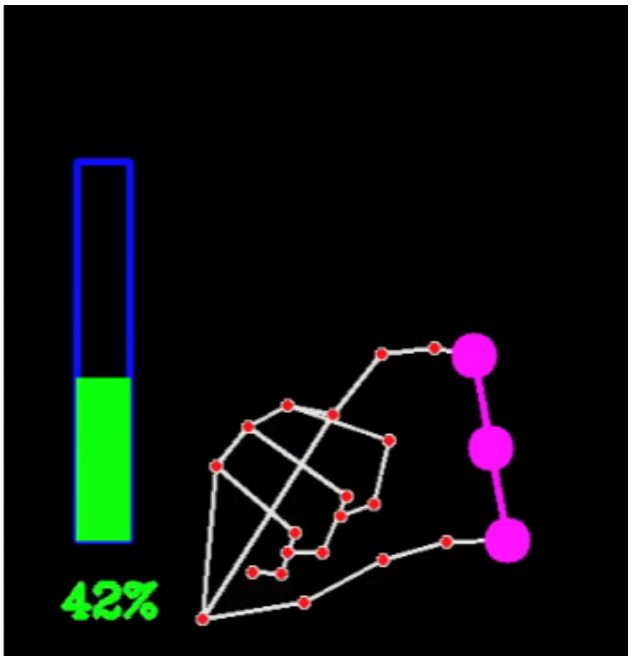
2. Finger Control

Press the [f key] to switch recognition effects. Through the distance between thumb and index finger (open/close), you can control the image effects.

2.1. Launch

- Enter the following command to start the program

```
ros2 run dofbot_pro_mediapipe 18_HandCtrlArm
```



At this time, place your fingers in the camera frame, and it will display the current finger opening percentage. When the percentage is less than 40, it controls the robot arm to move downward. When the percentage is greater than 50, it controls the robot arm to move upward.

Press the q key in the image or press Ctrl+c in the terminal to exit the program.

2.2. 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/18_HandCtrlArm.py
```

```python
#!/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 Arm_Lib import Arm_Device
from threading import Thread

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.lmDrawSpec = mp.solutions.drawing_utils.DrawingSpec(color=(0, 0,
255), thickness=-1, circle_radius=15)
        self.drawSpec = mp.solutions.drawing_utils.DrawingSpec(color=(0, 255,
0), thickness=10, circle_radius=10)

    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):
        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 handLms in self.results.multi_hand_landmarks:
```

```
                if draw: self.mpDraw.draw_landmarks(img, handLms,
self.mpHand.HAND_CONNECTIONS)
        return img

    def findPosition(self, frame, draw=True):
        self.lmList = []
        if self.results.multi_hand_landmarks:
            for id, lm in
enumerate(self.results.multi_hand_landmarks[0].landmark):
                h, w, c = frame.shape
                cx, cy = int(lm.x * w), int(lm.y * h)
                self.lmList.append([id, cx, cy])
                if draw: cv.circle(frame, (cx, cy), 15, (0, 0, 255), cv.FILLED)
        return self.lmList

    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


class GestureArmControlNode(Node):
    def __init__(self):
        super().__init__('gesture_arm_control')
        self.hand_detector = HandDetector(detectorCon=0.75)
        self.pTime = 0

        self.effect = ["color", "thresh", "blur", "hue", "enhance"]
        self.index = 0
        self.volBar = 400
        self.volPer = 0
        self.value = 0
        self.state = 0

        self.arm = Arm_Device()
        self.arm.Arm_serial_servo_write6_array([90, 180, 0, 0, 90, 30], 1000)

        # Initialize video capture device
        self.cap = cv.VideoCapture(0, cv.CAP_V4L2)
        self.cap.set(cv.CAP_PROP_FRAME_WIDTH, 640)
        self.cap.set(cv.CAP_PROP_FRAME_HEIGHT, 480)
        if not self.cap.isOpened():
            self.get_logger().error("Error: Could not open video device.")
            rclpy.shutdown()

    def process_frame(self, frame):
        img = self.hand_detector.findHands(frame)
```

```
        lmList = self.hand_detector.findPosition(frame, draw=False)
        if len(lmList) != 0:
            angle = self.hand_detector.calc_angle(4, 0, 8)
            x1, y1 = lmList[4][1], lmList[4][2]
            x2, y2 = lmList[8][1], lmList[8][2]
            cx, cy = (x1 + x2) // 2, (y1 + y2) // 2
            cv.circle(img, (x1, y1), 15, (255, 0, 255), cv.FILLED)
            cv.circle(img, (x2, y2), 15, (255, 0, 255), cv.FILLED)
            cv.line(img, (x1, y1), (x2, y2), (255, 0, 255), 3)
            cv.circle(img, (cx, cy), 15, (255, 0, 255), cv.FILLED)
            if angle <= 10: cv.circle(img, (cx, cy), 15, (0, 255, 0), cv.FILLED)
            self.volBar = np.interp(angle, [0, 70], [400, 150])
            self.volPer = np.interp(angle, [0, 70], [0, 100])
            self.value = np.interp(angle, [0, 70], [0, 255])

        if self.effect[self.index] == "thresh":
            gray = cv.cvtColor(frame, cv.COLOR_BGR2GRAY)
            frame = cv.threshold(gray, self.value, 255, cv.THRESH_BINARY)[1]
        elif self.effect[self.index] == "blur":
            frame = cv.GaussianBlur(frame, (21, 21), np.interp(self.value, [0,
255], [0, 11]))
        elif self.effect[self.index] == "hue":
            frame = cv.cvtColor(frame, cv.COLOR_BGR2HSV)
            frame[:, :, 0] += int(self.value)
            frame = cv.cvtColor(frame, cv.COLOR_HSV2BGR)
        elif self.effect[self.index] == "enhance":
            enh_val = self.value / 40
            clahe = cv.createCLAHE(clipLimit=enh_val, tileGridSize=(8, 8))
            lab = cv.cvtColor(frame, cv.COLOR_BGR2LAB)
            lab[:, :, 0] = clahe.apply(lab[:, :, 0])
            frame = cv.cvtColor(lab, cv.COLOR_LAB2BGR)

        if int(self.volPer) < 40 and self.state != 1:
            self.state = 1
            abc = [90, 180, 0, 0, 90, 30]
            self.arm.Arm_serial_servo_write6_array(abc, 1000)
        if int(self.volPer) > 50 and self.state != 2:
            self.state = 2
            abc = [90, 127, 46, 9, 90, 30]
            self.arm.Arm_serial_servo_write6_array(abc, 1000)

        cTime = time.time()
        fps = 1 / (cTime - self.pTime)
        self.pTime = cTime
        text = "FPS : " + str(int(fps))
        cv.rectangle(img, (50, 150), (85, 400), (255, 0, 0), 3)
        cv.rectangle(img, (50, int(self.volBar)), (85, 400), (0, 255, 0),
cv.FILLED)
        cv.putText(img, f'{int(self.volPer)}%', (40, 450),
cv.FONT_HERSHEY_COMPLEX, 1, (0, 255, 0), 3)
        cv.putText(frame, text, (20, 30), cv.FONT_HERSHEY_SIMPLEX, 0.9, (0, 0,
255), 1)
        dst = self.hand_detector.frame_combine(frame, img)
        return dst

    def run(self):
        while rclpy.ok():
            ret, frame = self.cap.read()
```

```
            if not ret:
                self.get_logger().error("Error: Could not read frame from video
device.")
                break

            action = cv.waitKey(1) & 0xFF
            frame = self.process_frame(frame)
            if action == ord('q'):
                break
            if action == ord('f'):
                self.index = (self.index + 1) % len(self.effect)
            cv.imshow('dst', frame)

        self.cap.release()
        cv.destroyAllWindows()


def main(args=None):
    rclpy.init(args=args)
    gesture_arm_control_node = GestureArmControlNode()
    try:
        gesture_arm_control_node.run()
    except KeyboardInterrupt:
        pass
    finally:
        gesture_arm_control_node.cap.release()
        cv.destroyAllWindows()
        rclpy.shutdown()


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