Robot navigation using hand gestures

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1 Abstract

This project aims to develop a system that allows a robot to navigate based on hand gestures. The system utilizes computer vision techniques to recognize specific hand gestures and translate them into navigation commands for the robot. The implementation involves the use of a camera to capture hand gestures, simple image processing algorithms to identify the gestures and a control system to direct the robot's movements accordingly.

2 Introduction

The ability for robots to understand and respond to human gestures is a significant step towards more intuitive human-robot interaction. Hand gestures are a natural form of communication for humans, and enabling robots to interpret these gestures can enhance their usability in various applications, such as assistive robotics, service robots, and interactive entertainment.

3 Methodology

The system is designed to recognize a set of predefined hand gestures, each corresponding to a specific navigation command for the robot. The following steps outline the methodology used in this project:

3.1 Gesture Recognition

A camera is used to capture real-time video of the user's hand gestures. The video feed is processed using computer vision techniques to identify and classify the gestures. The following steps are involved in gesture recognition:

- **Preprocessing:** The captured images are converted from BRG to RGB so the colors are represented correctly.
- **Contour Detection:** The contours of the hand are detected using edge detection algorithms. The largest contour is assumed to be the hand.

- **Feature Extraction:** Key features of the hand, such as the number of fingers extended, are extracted from the contour.
- **Classification:** A simple rule-based classifier is used to map the extracted features to predefined gestures.

3.2 Robot Control

Once a gesture is recognized, it is translated into a navigation command for the robot. The following commands are defined:

- **Start:** Triggered all the fingers are up, except the thumb
- **Move Forward:** Triggered when the index finger points up.
- **Move Backward:** Triggered when the index and middle finger point up.
- **Turn Left:** Triggered by a left-pointing gesture (thumb up).
- **Turn Right:** Triggered by a right-pointing gesture (pinky finger up).
- **Quit:** Triggered when thumb and index fingers are down and the rest fingers are up.
- **Stop:** There is not 'Stop' hand gesture. The robot stays still when no hand gesture is valid or when no hand is detected.

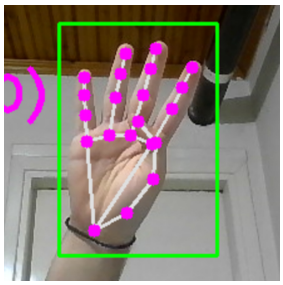
The robot's control system receives these commands and executes the corresponding movements.

The implementation of the robot came to life thanks to the "turtle" library from python. This library provides a simple way to create an interactive environment where a turtle can be controlled using commands. The turtle can move in any direction.

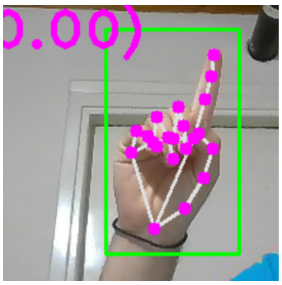
4 Results

The system was tested in a controlled environment with a set of predefined hand gestures. The robot successfully recognized and responded to the gestures, demonstrating the effectiveness of the gesture recognition and control system. The following observations were made:

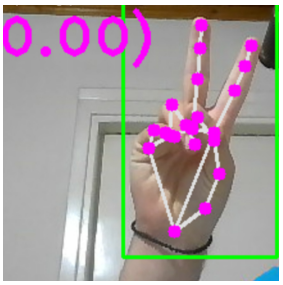
- The gesture recognition system was able to accurately identify the predefined gestures with a high success rate.
- The robot responded promptly to the navigation commands, executing the corresponding movements as intended.



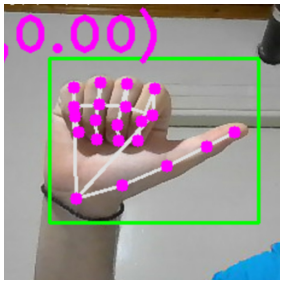
(a) ”Start” gesture



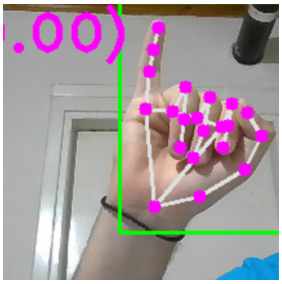
(b) ”Move forward” gesture



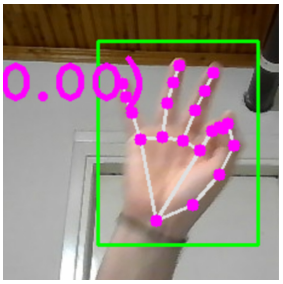
(c) ”Move backward” gesture



(d) ”Turn left” gesture

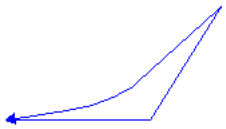


(e) ”Turn right” gesture



(f) ”Quit” gesture

Below there is an example of the robot’s route:



5 Conclusion

This project successfully demonstrated the feasibility of using hand gestures to control a robot's navigation. The combination of computer vision techniques for gesture recognition and a simple control system allowed for intuitive human-robot interaction. Future work could involve expanding the set of recognized gestures, improving the robustness of the gesture recognition system, and testing the system in more complex environments. Additionally, integrating machine learning techniques could enhance the accuracy and adaptability of the gesture recognition process. Also, the robot could be replaces with a real robot, such as a drone or a car. Another use of the system could be in virtual reality environments, where users can control virtual entities using hand gesturesn and last but not least, the system could be adapted for sign language recognition, enabling more advanced communication between humans with dissabilities and robots.

6 References

- OpenCV Documentation: `https://docs.opencv.org/`
- Python Turtle Graphics: `https://docs.python.org/3/library/turtle.html`
- Gesture Recognition Techniques: `https://en.wikipedia.org/wiki/Gesture_recognition`
- Gesture Recognition using OpenCV and Python: `https://lotalutfunnahar.medium.com/hand-recognition-with-python-guide-with-code-samples-a0b17f4cd813`