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Vehicle Control Using Hand Gestures

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Abstract: Accurate gesture recognition in real time is a very challenging problem. If an architecture that has the capacity of correctly recognizing gestures based on context, can adaptively learn new gestures taking into account variations of the same gesture is built, it can be used to solve a multitude of problems from sign language translation, detection of body language and micro expressions to providing an intuitive method for control of automobiles. The problem can be solved with coloured gloves and markers; however, these models do not generalize well. Boundary based gesture recognition has also been carried out, however these models consume a lot of time during prediction and are complicated to build. This project tries to solve both these problems by the construction of a simple machine learning architecture for real time gesture recognition that also generalizes well.

Keywords: Image processing, sequence learning, adaptive learning, machine learning, hand gesture detection, hand motion detection.

I. INTRODUCTION

Intuitive gesture recognition has developed in human beings after millions of years of evolution. It represents information in a more abstract format enabling quicker transfer of knowledge from one organism to another. If a machine is able to understand these abstractions and recover the information in them, interaction with them not only gets easier but also feels more human like. Understanding these abstractions also allows us to better comprehend these gestures their meaning and origin.

Improvements in computing power and techniques for image processing and machine learning have enabled us to build such systems unlocking the potential of these abstractions that have been used for information transfer from centuries.

A. Motivation

Automobiles these days are seen everywhere. Right from easy to use environment friendly bicycles to Unarmed automated vehicles (UAV). But most of these vehicles currently have a control unit affixed to its system. Which restricts control of the vehicle only to a certain distance.

In some cases, there exists a remote control that controls the vehicles.
Reason why we chose to improvise the existing technology using gesture control is

i. The lag between man and the machine is reduced. Machine doesn't respond to the human stimuli via and mediating machine such as the remote control.
ii. It would be easier to train the gestures to the people and harder to train the people on using a control device.
iii. Even while incorporating hand gestures, the product would not require accessories such as gloves to control the device. A person shall be able to control with a freehand.
iv.

B. Objective

i. From a camera onboard a vehicle/on a ground control station, create an image stream for real time data analysis.
ii. Actively analyze image stream for hand gestures taking into account the vibration and movement of the vehicle if camera is onboard.
iii. Provide control commands to a vehicle based on recognized gestures, using machine learning for adaptive error control so that the algorithm gets "intuition" regarding when to do which control command.
iv.

C. Scope

This system provides solutions to a wide range of problems. Some of them are listed below

i. Real time translation of sign language.
ii. Body language analysis.
iii. Recognition of micro expressions for criminal investigation.
iv. Control of remote vehicles.

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II. Literature Survey

Md Hasanuzzaman et al[1] have built an adaptive visual gesture recognition system for human robot interaction using a knowledge based software platform. Once hand and face poses are classified, gestures are recognized using a frame based approach. It is capable of learning new users and poses using multi clustering based incremental learning where a new pose it registered when an unrecognized frame is seen for a specific time slot determined by a judge function. The user must then define pose name is knowledge base and associate with corresponding cluster.

Gaurav Chauhan and Prasad Chaudhari [2] have implemented a gesture based control for robots using histogram analysis, i.e. separating the RGB values of each pixel and counting the number of pixels with same having skin color. There exists a pre-defined mapping between the number of detected pixels and the gesture using which the appropriate control commands is sent to the robot using Zigbee wireless modules.

A real time vision based hand gesture recognition system was developed by Qing Chen et al[3] using Haar like features for posture recognition and propose a context free grammar for gesture recognition.

Alexandru Pasarica et al [4] have implemented a remote control of a robotic platform based on hand gesture recognition. They have used two VGA camera positioned to form a 3D space from two perpendicular planes. A white wrist band was used to distinguish the hand from the black background created using a backdrop. The 3D space was divided into 9 quadrants and presence of the hand in each quadrant indicated movement in a particular direction, and hand gesture determined by the number of fingers held out indicated the motor speed.

R Vivek et al [5], Gaurav Chauhan et al[6] have proposed a control system based on both voice and gesture control. Pattern matching is done based on edge information. This limits recognition to only previously fed images. The vibration of the quadcopter affecting the camera input is also not accounted for.

Pawel Plawiak et al [7], Daling Lu et al[8] have proposed a hand gesture recognition system based on a special glove, with each finger indicating a different flight parameter. Machine learning was used to enable adaptive error control. This mapping of hand motion to control signals is not very intuitive for users.

Existing systems that implement real time gesture control are based on either:

i. Accelerometer, Gyroscope and Compass
   a. These systems use special gloves that are fitted with one or more of the above sensor and gesture classification is done based on the spatial data of the hand that these sensors are giving.
   b. Though accuracy is very high when such systems are used and time lag between input and output is minimal the setup time is very large and requires continuous communication between gloves and vehicle used.

ii. Image processing based
   a. Colored glove based – The hand is identified based on the color of the glove the user is wearing and classification is made based on contour maps
   b. Boundary recognition – Boundary recognition is carried out in multiple ways. One method is based on edge and corner detectors that identify position of edges and corners by observing color boundaries in a moving window.
   c. Image processing based models though easier to setup do not generalize very well to larger varieties of classes and classification is time consuming

All the above systems use samplers for sampling data of fixed time intervals from sensors, perform feature extraction and then classify them. However, this has the following drawbacks

- Event can be lost in between two samples.
- Event can be split between two samples.
- Can create noisy data samples and further decrease classification accuracy.

III. Design

A. *High Level Design*

The project is divided into three main modules.

1. Image Capture – Interfacing with camera, create image stream and recognition of hand among other objects is done by this module.
2. Gesture Recognition – This module tracks the hand over time, recognizes appropriate events and classifies movements as a particular gesture.

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3. Vehicle Control – This module takes care of control the vehicles based on the control command provided by the gesture recognition module.

1) System Architecture

The system architecture is divided into separate components to make it easy in case of any changes in any component of the system. In the first component the interfacing of the hand gesture with the camera module takes place. The continuous motion of hand creates a stream for real time data analysis. This gesture is recognized and analysis is done in the next component taking into account the vibration and movement of the camera and the hand. Later, the control commands are provided to a vehicle based on recognized gestures, using machine learning for adaptive error control so that the algorithm gets "intuition" regarding when to obey what control command.

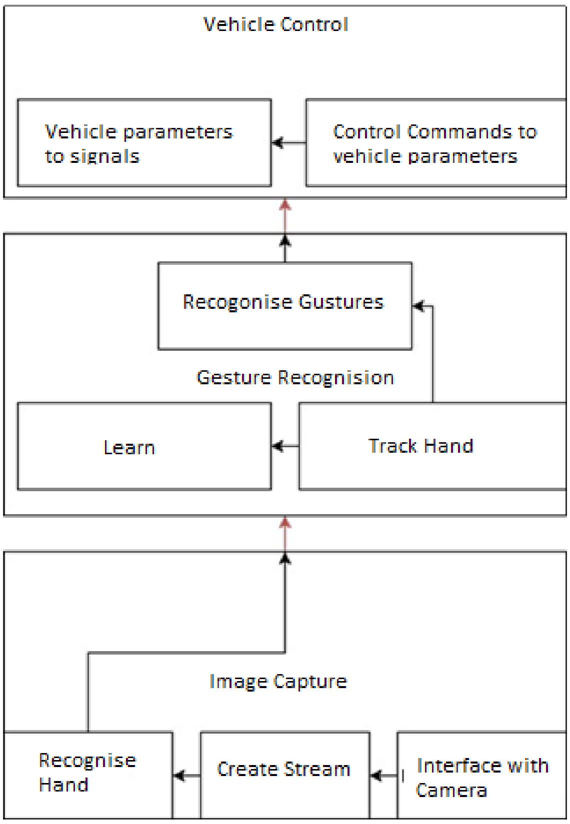

Fig 1 : System Architecture for the proposed design

2) Sub System Design

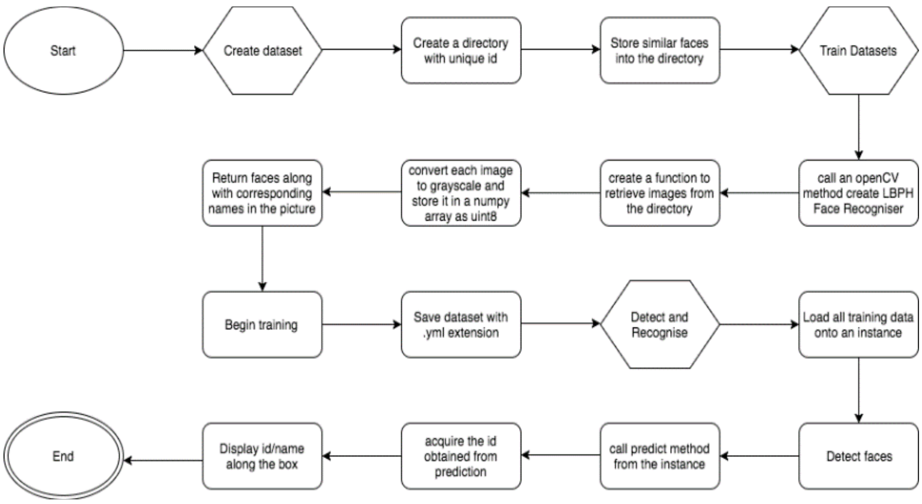

Fig 2 : Steps for facial recognition

The figure 3 shows the process of facial recogntion that is carried out to establish the id of the person performing gesture control. The explanation of the entire figure is This is done to enable adaptive learning based on user, so that it can adapt to user specific gestures and variations.

IV. METHODOLOGY

Creation of data stream for image processing is taken care of by the PiCamera modules inbuilt video function.
Features of hand boundaries are detected using inbuilt OpenCV functions such as ORBS() and FastFeatureDetector().

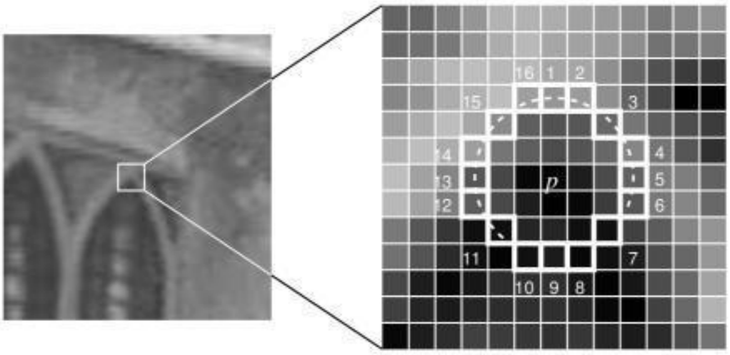

Fig 3 : Example for boundary detection

Boundary detection is done to recognize the hand. Each image which is received from the video stream is blurred and based on the contrast difference in the shade, boundary of the hand is recognized.
The proposed system solves all the drawbacks of the existing system by Fast feature detector and template matching for hand recognition in real time.

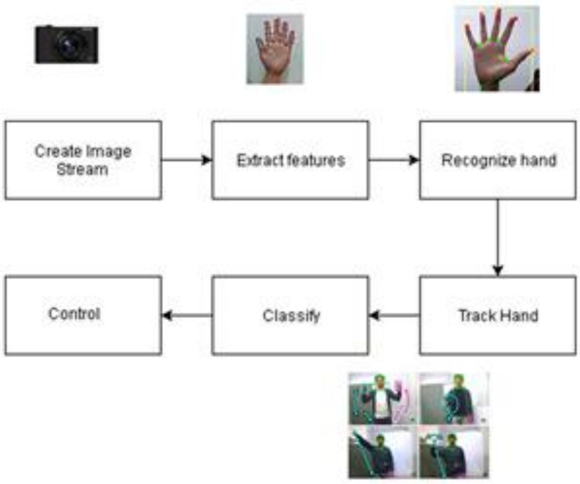

Fig 4 : Steps to generate hand signals for the vehicles

Explains how hand would be potentially used for generating signals for the vehicles. The steps for controlling the any vehicle would be :

1. Create Image Stream
   We will be using a raspberry pi camera (connected to a raspberry pi) to stream live videos of the user. The user will then gesture the camera
2. Extract Features in the video stream raspberry pi needs to recognize what part of it is a hand, in order to generate signals. This is done using a method called template matching which was explained previously.
3. Recognize hand once feature extraction is done, it is necessary to identify which of those features makes up a hand. Once a hand is recognized then it's motion needs to be tracked.
4. Track Hand the motion of hand will further describe the signal and hence it is important for raspberry pi to determine hand movement and generate signals.
5. Classify these signals that are needed to be generated should determine the directions for each vehicle and hence whatever directions are observed by the vehicle, needs to be classified based on the gestures displayed by hand.
6. Control the vehicle once the signals are transmitted and received by the vehicle learns in what direction it needs to move to.

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Our other objective in this paper is to make the control personalized. For which we need to identify what user is trying to control the vehicle. For which we have employed facial recognition techniques.
Facial recognition generates a unique ID parameter for adaptive learning. The steps to complete facial recognition would be:

1. Dataset creator

   a. An identifier is created. In order to store the face along id.
   b. Capture faces and store it inside the folder. Make sure there are enough picture to train the dataset for best accuracy.

2. Trainer

   a. Get all samples to recognize what id corresponds to what face.
   b. Use libraries: os cv2 numpy and pilow..
   c. Create a recogniser using cv2.createLBPHFaceRecogniser()
   d. Create a function in order to retrieve images with id in sample directory
   e. Convert each image to grayscale and store it in a numpy array as uint8
   f. Return back faces along with corresponding name of the picture
   g. Begin training the recognizer by taking faces as the numpy array and an ID as the name
   h. Use the recognizer instance created initially and train the images.
   i. Save the recognizer as a .yml file
   j. Run the python script

3. Detector

   a. Create a recognizer using cv2.createLBPHFaceRecogniser()
   b. Load all the training data onto an instance say recognizer
   c. Run a script to detect face.
   d. Consider the face detection
   e. Use recogniser.predict() to figure out the face being displayed.
   f. Add id along with the box at the detector of the image.

Based on correctness of output and user variability, learning takes place and weights and parameters of the model are updated.

V. FUTURE ENHANCEMENT

This architecture can be implement for a variety of other applications such as sign language translation and body language analysis. Modification can be easily made to suit these applications.

VI. CONCLUSION

Therefore, gesture recognition shows promise of being a good model for real time-sequence analysis of hand gestures for generation of control signals. The addition of adaptive learning should make this model user friendly for gesture recognition. Integration with most vehicles requires stabilization of the vehicle to required thresholds.

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