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Design of Voice and Hand Gesture Controlled Quadcopter

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ABSTRACT

Minimalistic hardware design of a Quad copter that can be controlled with gesture and voice commands using LabVIEW platform is presented in this paper. Transmission loss and time delay in manual remote control are overcome by the natural communication technique. Thus, smooth cooperative environment between human and mobile robot is obtained by coordinating voice and visual information. Arduino microcontroller effectively controls the direction of flight of the Quad copter.

Keywords: Quad copter, Lab VIEW, Arduino, Gesture Recognition, IMAQ vision, Machine Vision

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INTRODUCTION

Quad copter is a four-rotor helicopter with two pair of blades rotating in opposite direction. The drawbacks in classical joystick based control of mobile robots have lead to the concept of gesture and voice command based control (Achtelik M et al,2009).

Many military and search and rescue operations such as, fire accidents, flight crash require unmanned vehicles and it is possible that gesture based controls can create very simplistic controls for volunteers or new members of these task forces so that speedy and immediate recovery can be done(Lei Zhang et al,2012). Another opportunity would be freeing up the operator to do other things, for instance a user could verbally prompt the gesture based control system to take new orders, and then carry on doing more advanced tasks that require human interaction. Speech recognition system is used which is a speaker-independent speech recognition that identifies what is said rather than, who spoke (S.G.Pawar et al,2015).

HARDWARE DESIGN

Virtual Instrumentation based Quadcopter control

Apart from RC method, Quad copter can be controlled by interfacing with VISION CONTROL which is based on vision process technology using Lab VIEW platform of controlling the Quad copter. The Quad copter is controlled through Image processing technology by analyzing the captured images from the camera. The balancing condition is sensed using FY90 and IMU 5DOF sensors and leveling condition is sensed using GYRO sensor(Pavel Chmelar,2011).

The VI based Quadcopter control shown in Fig.1 consists of three modules namely CONTROLLER module, TRANSMITTER module and RECEIVER module. In the controller module reference image is collected by the web camera and then processed by vision assistant tool. The vision assistant tool extracts features from the captured image and identifies the control action by comparing the features with the database(Dirman Hanafi et al,2013).

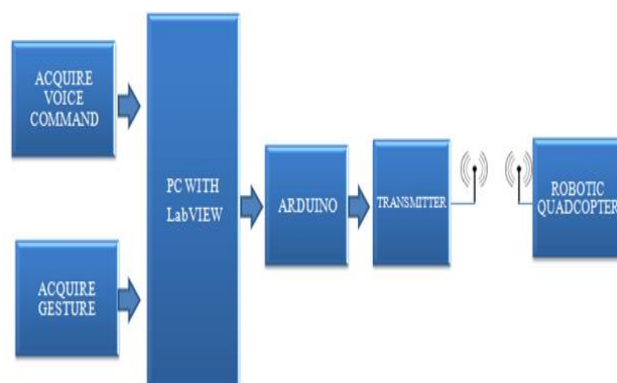


Figure 1: Block Diagram of VI Based Quad copter Control

Then the control command is communicated to the quad copter through Arduino controller and Zigbee transmitter.

Webcam Specifications

The webcam used in this work has a high quality 1/4" CMOS Image sensor. Sensor resolution is about 480k pixels and video format is 24 Bit true color with high quality lens of 5g video angles, 4x digital zoom. Power supply is through USB bus. Adjustable focus is between 5cm to infinity. Frame rate is 30 frames per second with Video resolution of 2304*1728.

Machine Vision

The machine vision application software consists of vision builder for automated inspection to configure benchmark and deploy without programming. The vision development module includes NI vision assistant and hundreds of machine vision and image processing function for complete control and functionality in an application development in Lab View (www.ni.com/pdf/manuals/371007a.pdf).

IMAQ Vision

These devices include advanced triggering and digital I/O feature that you use to trigger an acquisition from an outside signal. IMAQ devices feature up to 128 MB on board memory. Fig.2 shows the vision palette implemented in Lab View to get and save the processed image. The Image Display control contains two elements, Display area to display an image and Image information indicator that displays information about the image and the ROI that are drawn currently.

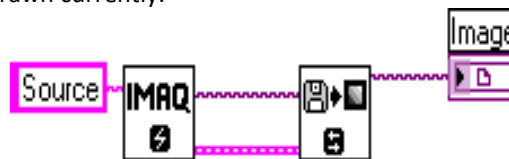


Figure 2: Vision Palette

Capturing Voice and Gesture Command:

Fig 3 shows a flow chart describing the steps involved in voice and gesture recognition by the quad copter. In this work, principal component analysis method is used for feature extraction from images and Mel cepstral coefficients are used for voice recognition (Park.D et al, 2001).

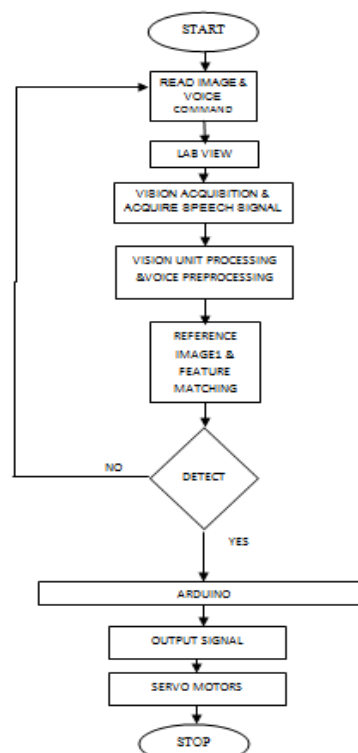


Figure 3 : Voice and Gesture control Flow Chart

Fig. 4 depicts the algorithm used in the Arduino microcontroller used to control the quad copter flight mechanism through wireless modules.

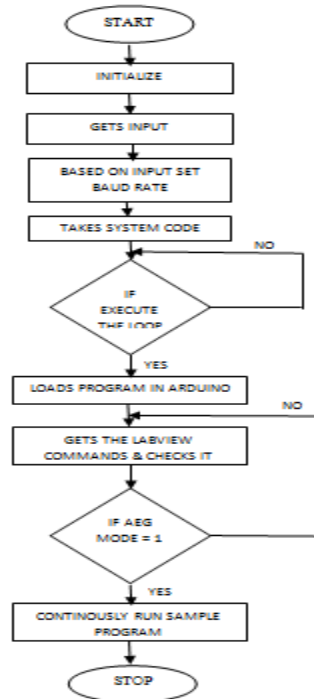


Figure 4: Flow chart of Arduino Control program

Gesture recognition system

Fig. 5 depicts the steps involved in recognizing the command from the captured image through feature extraction and pattern matching.

STEP 1: The image of user gesture is captured by a digital camera interfaced to the USB port and the image is acquired using IMAQ function palette in Lab view environment.

STEP 2: Image recognition is the process of assigning a label to an object based on the information provided by its descriptors. Interpretation is assigning meaning to an ensemble of recognized objects. Reference image which is given as input is identified by Image Reorganization. The Image is detected and it is matched by color matching pattern.

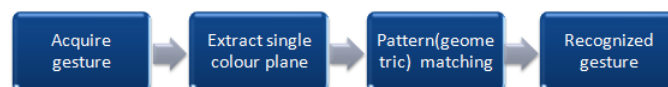


Figure 5: Block diagram for hand gesture recognition

STEP 3: Image segmentation is the process of identifying boundaries of various objects in an image. Here sober technique is used for segmentation.

STEP 4: Image enhancement process is used for highlighting certain features in an image such as changing brightness, color etc. Median and Gaussian filters are used to remove noises from the image.

STEP 5: Geometric matching gives details about the known reference value in an image using edge information as shown in Fig.6

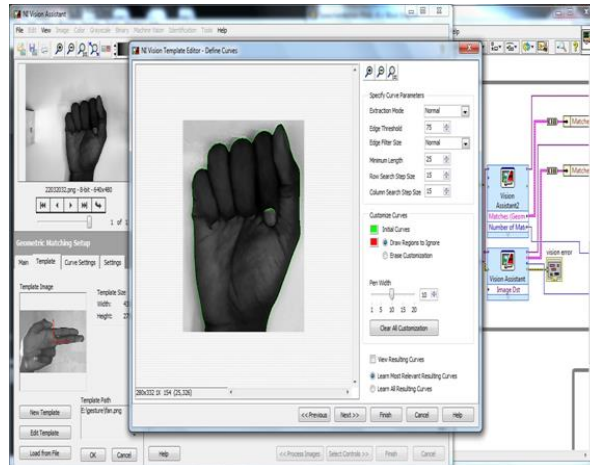


Figure 6: Geometric matching

Voice Command Recognition System

Fig 7 shows the block diagram of voice command recognition. First step is identifying the speaker what they are saying. Then Recognizing is the simplest task of translating the signal. The steps in voice recognition are as follows:

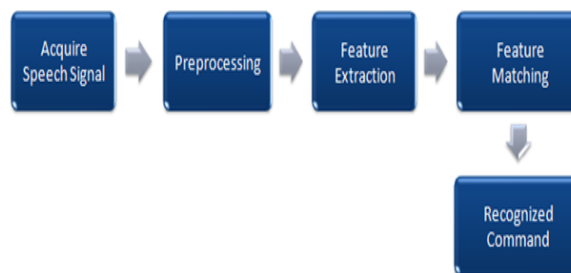


Figure 7: Voice command recognition

STEP 1: Acquire speech signal, Fig 8 shows the express VI that automatically configures an input task, acquires the data, and clears the task after the acquisition completes. This express VI acquires the sound for every three seconds with sample rate of 16228Hz from internal or external microphone.

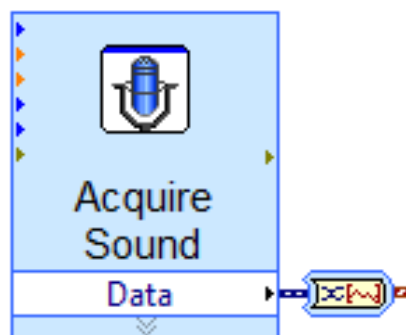


Figure 8: VI to Acquire Sound

STEP 2: Preprocessing of voice is done using LabView preprocessing block sets shown in Fig.9 to boost the amplitude level and filter noises.

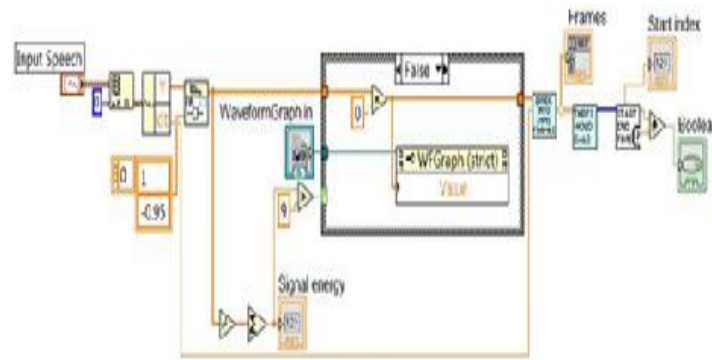


Figure 9: LabVIEW model for Preprocessing

STEP 3: The input speech signal is segmented into small frames of 20ms length with 50% overlap with the adjoining frames to create continuity.

STEP 4: Each frame is multiplied with the hamming window shown in Fig. 10 in time domain. This helps to reduce the discontinuity at the start and end of each frame.

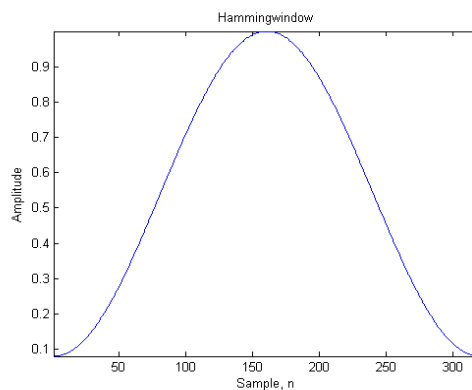


Figure 10: Windowing

STEP 5: Noise threshold detection, for detecting the starting of the utterance from the 3sec long input speech signal, energy of each frame of the input speech signal is calculated and stored into an array. Size of the energy array will be equal to the total number of frames. This energy array is arranged in the ascending order and mean of first 15 elements gives the energy of the noise. Threshold set was 10 times the noise energy.

STEP 6: Utterance detection, once the threshold has been calculated, all the elements in the energy array which are greater than the threshold are replaced by 1 and rest by 0. Thus a Boolean array form is obtained. Sometimes spikes due to the external noise crosses the threshold and contributes 1 to the Boolean array. To remove these spikes a median filter VI in Lab VIEW with left and right rank as 3 is used. The median filter replaces the 1th element of the Boolean array with the median of $\{i-3, i-2, i-1, i, i+1, i+2, i+3\}$ elements. Hence the median filter smoothen the Boolean array.

STEP 7: Peak detector VI in Lab VIEW shown in Fig.11 is used to find the index of the start and end of the utterance. Using these index extract the corresponding frames containing the utterance. In my project, all commands were of length less than 0.6sec.

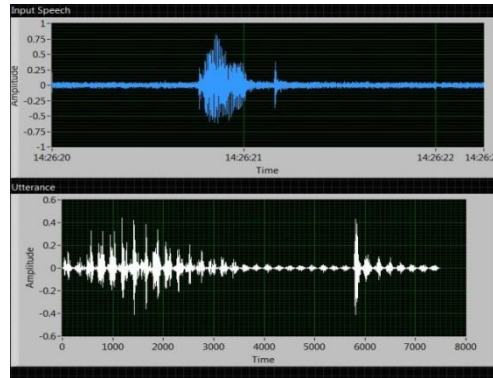


Figure 11: Input Speech Signal and Peak Detection

STEP 8: FFT is done on each frame of the utterance and half of it is taken. The spectrum of each frame is warped onto the Mel scale and thus Mel spectral coefficients are obtained. Discrete cosine transform is done on Mel spectral coefficients of each frame, hence obtaining MFCC.

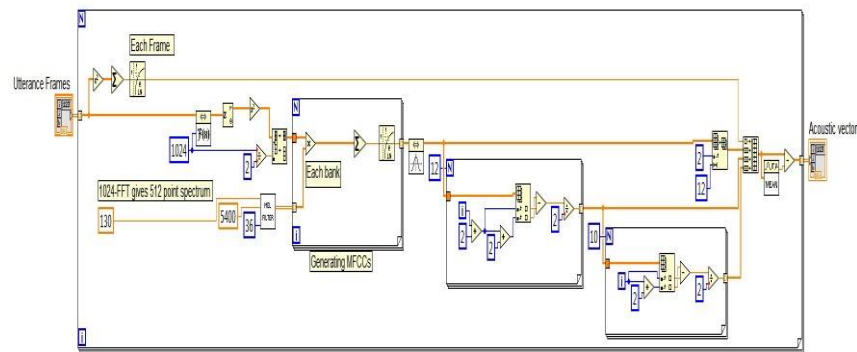


Figure 12: Feature Extraction

STEP 9: In Feature matching, Dictionary with six sets has been created as shown in Fig.12. In each set, the feature vector sequence of the words to be recognized is stored. The feature of the test sequence is compared with each word in the sets using DTW and the best match in each set is outputted. The mode of all six set is considered to be the recognized command.

STEP 10: Dynamic time warping is a method that calculates an optimal match between two given sequences (e.g. time series) with certain conditions(Fig.13). The warping in the time dimension is mainly used to determine a similarity independent of some variations.

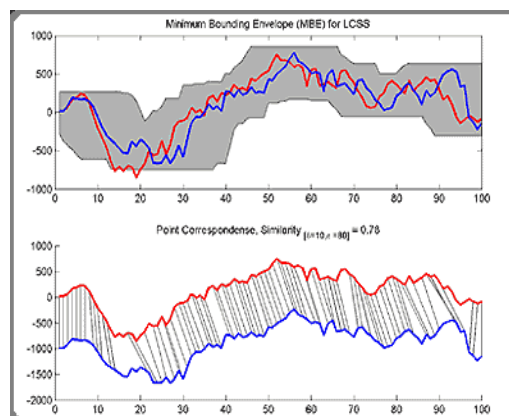


Figure 13: Distance calculating using DTW

Each utterance is divided into frames of 20ms. MFCC for each of frame is computed and represented by a vector. Hence each utterance is represented by a vector sequence.

Prototype Quadcopter:

Prototype model of Quad copter designed is shown in Fig.14 and it is controlled with the software using Virtual Instrumentation. The model which is designed using Lab VIEW is translated to into machine code for the Arduino controller board.



Figure 14: Design of quad copter

RESULTS AND DISCUSSION

Gesture Recognition:

The output images for the various gestures are displayed below which includes Start, Stop, and Right and Left directions.

Start:

Fig. 15 shows the simulation output for the start. So when the full hand gesture is observed the quad copter starts flying.

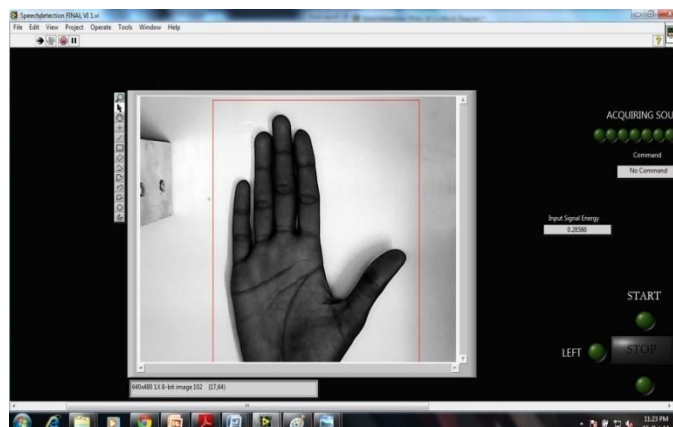


Figure 15: hand gesture for start

Right direction:

Fig.16 shows the simulation output for the right turn. So when the two fingers are observed the Quad copter moves towards its right side. On the right side of the image it is clearly understood that the copter

moves towards its right since, green light glows on right box. Here the reference images are two fingers respectively.

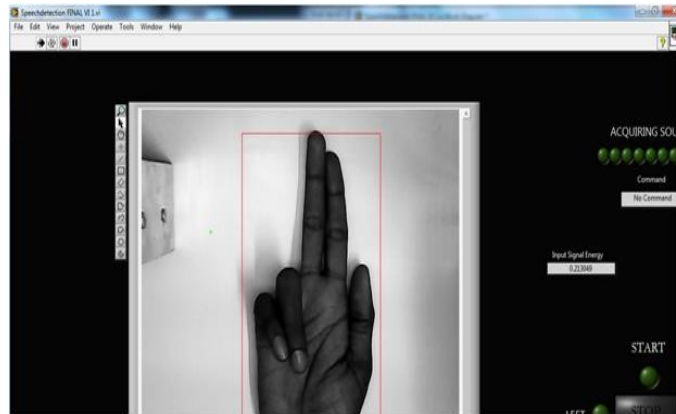


Figure 16: Gesture output for right

Left Direction:

Fig. 17 shows the simulation output for the left turn. So when the hand is turn opposite direction Quad copter also moves towards its left side. Green light glows on left box. Here the reference images are stored as shown in the fig respectively.

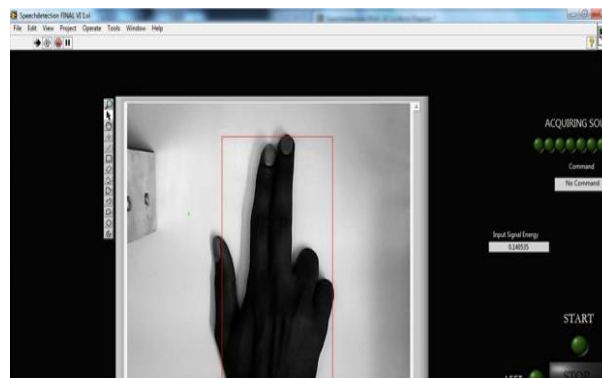


Figure 17: Gesture output for left

STOP:

Fig.18 Shows When The Hand Shows Like This That Time All Program Stopped.

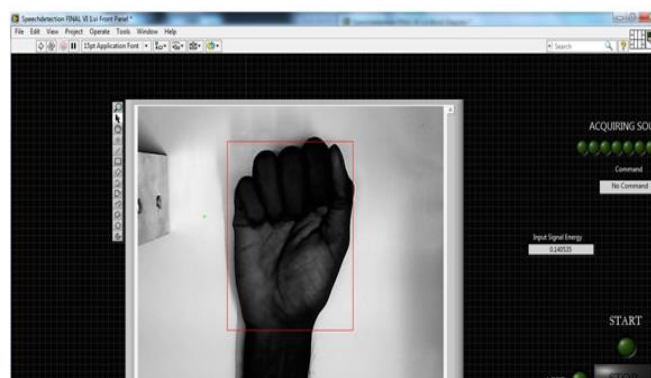


Figure 18: Gesture output for stop

Voice Command Recognition:

Images shown below (Fig.19, 20, 21, 22) show the output of all voice commands. The led shows the start command received. All commands are already stored in the dictionary.

START:

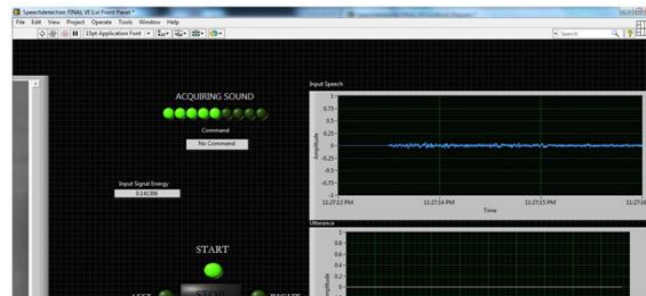


Figure 19: Start command output

Right Direction:



Figure 20: Right command output

Left Direction:

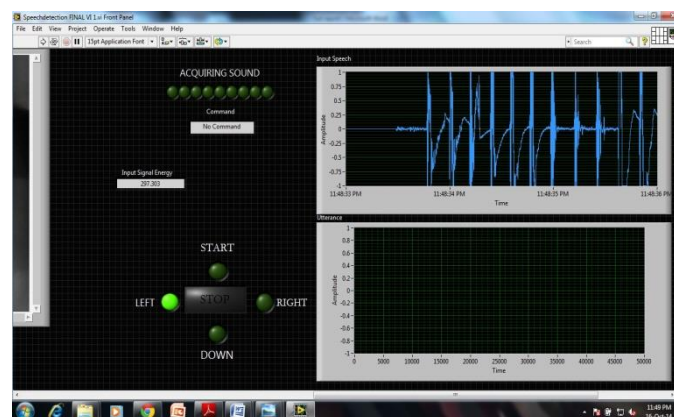


Figure 21: Left command output

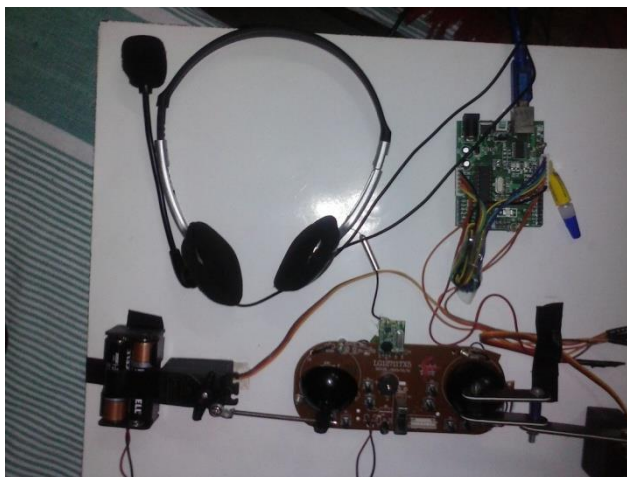


Figure 22: Transmitter design

CONCLUSION

In this project, a Quad copter has been designed and can be used in many applications such as defense and surveillance. A camera is used on the quad copter so as to capture and send images from extreme environmental conditions where human presence is not advisable such as fire accidents, flight crash etc. The Quad copter flies up to a height of 50 meters. The work can be extended by embedding GPS module within the circuit through which the copter can be controlled from very long distance, hence improving the precision. The project can also be extended to a level where in the shortest path is determined automatically by the copter, once the destination location is sent to it.

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