IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 5, Oct-Nov, 2014
ISSN: 2320 – 8791 (Impact Factor: 1.479)
www.ijreat.org

A Novelty System For Implementation Of Hand Gesture To Real Motion

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Abstract

This paper is to analyze human hand gesticulation to control robots from video. Video is recorded using camera attached to a computer and off-line analysis is carried out in Mat lab. We limited our work to slow, predefined hand gestures such as moving the hand to one side or vertically. The overall goal is to repeatedly recognize and divide various gestures in the work using Centroid based approach along with image subtraction. The preliminary steps of tracking a hand gesture by using Blob analysis and Kalman filter is designed as offline. The future work includes implementing a stand-alone application of Blob analysis and Kalman filter based hand gestures tracking for both offline and online cases to control robots.

Keywords – *Web camera, Kalman filter, Robotics tele operation, gesture recognition*

1. INTRODUCTION

1.1. Introduction to Gesture

Gesture recognition has been a research area which received much attention from many research communities such as human computer interaction and various researches. The increase in human-machine interactions in our daily lives has made user interface technology progressively more important. Human gestures as intuitive expressions will greatly ease the interaction process and enable humans to more naturally command computers etc. For example, in telerobotics, slave robots have been demonstrated to follow the master's hand motions remotely [1]. Other proposed applications of recognizing hand gestures include character-recognition in 3-D space using inertial sensors [2], [3], gesture recognition to control a television set remotely [4], enabling a hand as a 3-D mouse [5], and using hand gestures as a control mechanism in virtual reality [6]. It can also be used for the improvement of interaction between humans. In our work, a MEMS accelerometer based recognition system which can recognize eight hand gestures in 3-D space is built. The system has potential uses such it act as a vocal tract for speech impaired people.

1.2. Introduction to Human-Robot Interaction

Human manipulation is necessary in making a decision and in controlling a robot, particularly in unstructured dynamic environments. Some commonly used human–robot interfaces [1] include joysticks [2], dials [3], and robot–arm replica [4]. However, using these mechanical contact devices for teleoperation tasks always requires unnatural human hand–arm movements. This paper presents the human hand control the robotic arm. In the industry most of the robots have no vision system, they just move following predefined paths, which they have learned previously, but no decision is made by them, we can tell almost no artificial intelligence is implemented in their control software.

Nowadays, the commonly used human-robot interface is the contacting mechanical devices such as joysticks and robot replicas. Human can just simply move their hand and arm to complete the tele operation tasks with these devices. However, these motions are mechanical. The operator has to practice for a long time to manipulate the robot effectively. There is another kind of human-robot interface, which can track the position and orientation of the operator's hand in real time, such as electromagnetic tracking devices, inertial sensors and data gloves[2-3], also used in robot teleoperation area. However, because the devices are also contacting, people encounter the same problem while using them, the motion of the operator is unnatural.

Human hand control robotic arms are the vital part of almost all the industries. A robotic arm performs various different tasks such as welding, trimming, picking and placing etc in industry. Moreover the biggest advantage of these arms is that it can work in hazardous areas and also in the areas which cannot be accessed by human. Many variants of these robots/robotic are available or designed as per the requirement. Few variants are Keypad Controlled, Voice Control, Gesture Control, etc. However, most of the industrial robots are still programmed using the typical teaching process which is still a tedious and time-consuming task that requires technical expertise. Therefore, there is a need for new and easier ways for programming the robots.

2. MEASUREMENT USING LQE ALGORITHM

2.1. LQE Algorithm

LQE (Linear quadrature estimation algorithm) is used to estimate the state of IMU from a set of noisy and incomplete measurements, because both gyroscopes and magnetometer have white noise and random walk. LQE is a stochastic technique that estimates the state at time k from the state at time k – 1.It is also called Kalman filter algorithm.

There are two analyses in Kalman filter algorithm:
1. Object tracking and analysis
2. Merge split handling

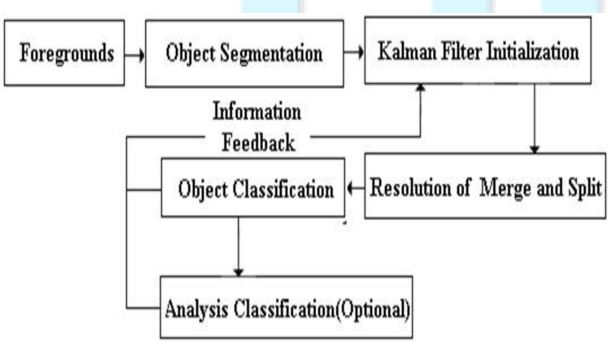


Fig.1 Object tracking and analysis

The Kalman filter was developed to solve specific problems in the areas of rocket tracking and autonomous or assisted spacecraft navigation (e.g. Apollo space program). Since the Kalman filter has found applications in hundreds of diverse areas, including all forms of navigation (aerospace, land, and marine), signal processing and communication, nuclear power plant method, demographic modeling, Etc.,

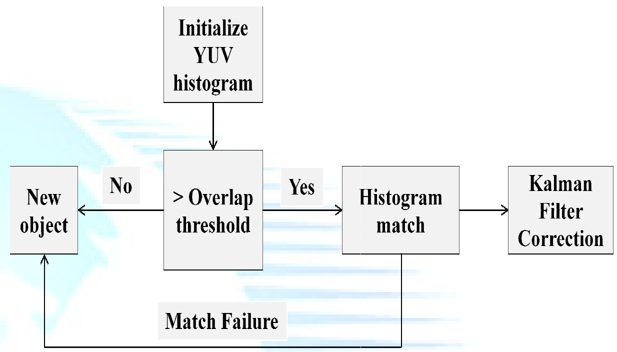


Fig.2 Merge split handling

The Kalman filter consists of two steps, the prediction and the correction. In the first step is predicted with the dynamic model and the second step is corrected with the observation model. The LQE function predicts the position of a moving object based on its past values. LQE is otherwise called kalman filter. It uses a Kalman filter estimator, a recursive filter that estimates the state of a dynamic system from a series of noisy measurements. Kalman filtering has a wide range of application in areas such as signal processing, Tracking objects, Navigation.

3. ARCHITECTURE OF PROPOSED SYSTEM

In this paper, a human hand gesture command to control the robotic arm by moving left, right, up, down etc. and also to pick the desired object and place them at the desired location. Based on functionality, the system has been categorized into the following parts:-

- Camera
- Blob analysis technique
- Robotic arm
- Hand gesture process and Personal computer

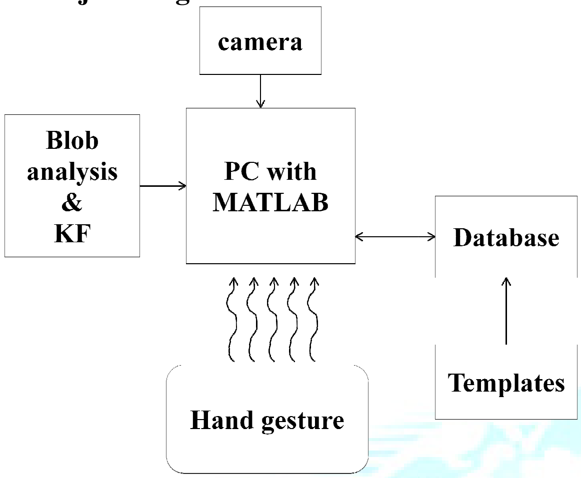


Fig. 3 Proposed System architecture

3.1. AMT (Adaptive multispace transformation)

Humans have inherent perceptive limitations (e.g., perception of distance) and motor limitations (e.g., physiological tremor), which prevent them from doing certain tasks precisely and smoothly. To improve the distance and motor performances of tele operation interfaces, the modified AMT is applied.

To improve the distance and motor performances of teleoperation interfaces, the modified AMT is applied. In this method, the teleoperation interface introduces two scaling processes is used to link the human operator working space (WS) to the robot WS. The first change scales the movement produced by the human operation. Another change of scale is applied between the virtual unit vector K of the central axis of the robot EE and the robot movements. Such changes in scale modify the robot speed, thus improving performance. The scaling vector S is used to coordinate the actions of the human hand in master space (MS) and the movement of the virtual point K in the visual space (VS). Let S = [Spos, Sori], where Spos is the scaling vector of the position, and Sori is the scaling variable of the orientation.

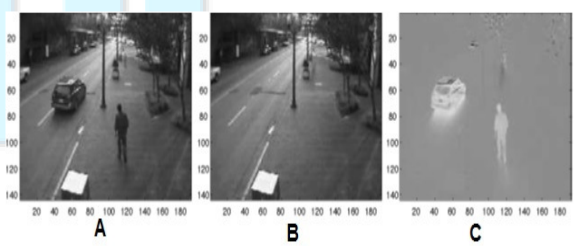
3.2. Blob analysis

In the field of computer vision, blob detection refers to gesture detection methods that are aimed at detecting regions in a digital image that differ in properties, such as color, compared to areas surrounding those regions. Informally, a blob extraction is a region of a digital image in which some properties are constant or vary within a prescribed range of values; all the points in a blob can be considered in some sense to be similar to each other.

3.3. Human body part detection using blob analysis

An application for body part detection is presented in Blob Analysis of the Head and Hands: A Method for Deception Detection by Lu et al. It is applied on 2D/3D video images and it tries to capture the location and movements of head and hands to identify behavioral states. The position, size and angle of head and hands are tracked using color analysis, Eigen space-based shape segmentation and Kalman filters. Hand and face regions are detected as blobs using 3D Look- Up-Table (LUT) of skin color samples. Regions that are incorrectly identified because their color matches to the skin color, are disregarded through fine segmentation and comparing the subspaces of the face and hand candidates. Another application for body part detection is given in Real-Time Marker less Human Body Tracking Using Colored Voxels and 3-D Blobs by Caillette and Howard. The system first reconstructs a 3D Voxels-based representation of a person from images of multiple cameras, and then matches a kinematic model in 3D space. Voxels are classified from pixel-samples taken inside the 2D projections onto the surface planes. To attain real time performance, a measure of the distance to the background model is computed for each 2D sample. Voxels are then classified from statistics on these distances across the available views, as discarded, subdivided or retained as belonging to the foreground.

Blob analysis Example



Advantage of Blog analysis

The subtraction approach is used to avoid the problem with same color objects which are not in motion and not of interest so that our tracking will be easy and reliable. As we track motion of the objects and it gives the motion part (the change from previous frame to current frame) tracking is found to be easy.

3.4. Camera

A 3-D camera has been integrated with this system for real time video streaming. The video captured by the camera and it converted into frame by frame and it to deliver a corresponding output.

3.5. Hand gesture

The hand motions performed by the platform used in this project are: UP, DOWN, RIGHT and LEFT motions. The preliminary steps of tracking a hand gesture by using Blob analysis and Kalman filter is designed as offline.

4 .WORKING

In this project one thing was clear that a system is going to be developed which can capture a hand gesture performed by the user in front of camera, this captured image is then processed to identify the valid gesture through specific algorithm & execute the corresponding operation. The overall implementation of process is described as follows:

4.1. Human Generated Gesture

In the first step of implementation user will show one gesture. The gesture should be constant for some period of time, which is necessary for dynamic processing. These gestures should be already defined as valid gesture for processing.

4.2. Camera

The purpose of camera is to capture the human generated hand gesture and store its image in memory. The package called Java Media Framework is used for storing image in memory and again calling the same program after particular interval.

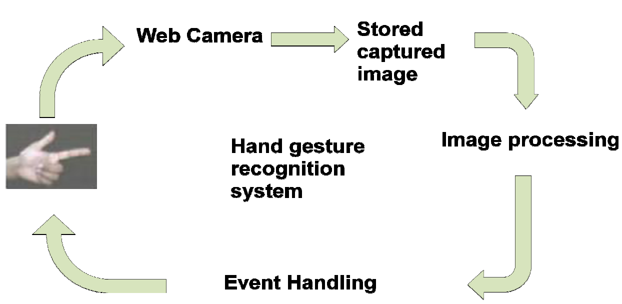


Fig. 4 Interaction among the components

4.3. Image Processing Algorithm

This carries the major portion of implementation. First the captured image is preprocessed by techniques like real-time hand tracking and kalman filter algorithm, feature extraction and gesture recognition.

4.4. Event Handling

Once the hand gesture is identified the appropriate command it will be executed.

5. IMPLEMENTATION AND SYSTEM DESCRIPTION

5.1. Hand tracking and hand shape extraction

Here, a real-time hand tracking method is developed. This method is robust and reliable in complex background. For tracking the moving hand and then for extracting the hand shape fast and accurately, the trade-off between the computation complexity and robustness need to be considered.

5.1.1 Feature extraction

To find the movement information, the input gesture is assumed to be non-stationary or moving. When objects move in the spatial-time space, an image sequence is generated, motion detector is able to track the moving objects by examining the local gray-level changes. Let Fi(x, y) be the i^{th} frame of the sequence and Di(x, y) be the image difference between the i^{th} and the $(i+1)^{th}$ frame defined as:

$$Di(x, y) = Ti\ \{|Fi(x, y)-Fi+1(x, y)|\} \quad (1)$$

Where Ti is a threshold function, Fi(x, y) and Di(x, y) are all 160 X 120 images, and Di(x, y) is binary image.

(1)Threshold- Having extracted the moving object region; the threshold on the frame difference can be applied for the extraction of the possible moving region in background. Threshold methods, such as Otsu threshold are not suitable for the case of detecting motion difference. Instead, a threshold technique is used to extract moving regions. The threshold for motion detection is determined as tM=0.2μ; where μ is the average luminous of captured image Fi(x, y).

(2)Skin color detection-Skin can be easily detected by using the color information. First, we use the constraint, i.e. R < G < B, to find the skin color regions which may include a wide range of colors, such as red, orange, and brown colors. So, we will find many regions other than the skin regions. However, those non-skin regions which satisfy our constraint will be excluded due to there is no motion information, e.g. orange color region will not be misidentified as the hand region. Second, some sample colors from the hand region may be obtained. To find the skin regions, we compare the colors in the regions with the pre stored sample colors. If it is similar, then the region must be skin region.

(3) Edge detection- Edge detection is applied to separate the arm region from the hand region. There are fewer edges on the arm region than on the palm region. A simple edge detection technique (e.g. Kirsch edge operator) to obtain different edge direction is used, and then the absolute maximum value of each pixel is chosen to form the edge image of ith frame as Ei(x, y).

(4) Combination of motion, color, and edge- The hand gestures information consists of color, movement and edge feature. We use the logic 'AND' to combine these three types of information. Di(x,y), Si(x,y) and Ei(x,y) indicate the movement, skin color and edge images.

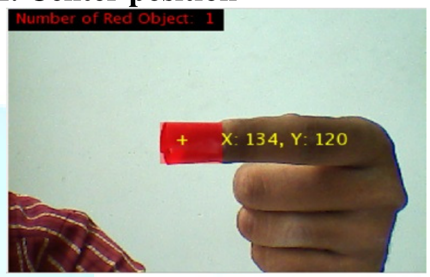
(5) Region identification-A simple method for region identification is to label each region with a unique integer number which is called the labeling process. After labeling, the largest integer label indicates the number of regions in the image.

6. RESULT AND DISCUSSION

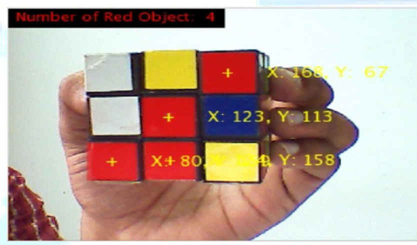
In this experiment the objective is analyze human hand gesticulation to control robots from video. We used centroid, image subtraction and window based approaches and we included the resulting images and output. We studied Kalman filter and have done preliminary study of tracking a moving ball using Kalman filter. An attempt is made to apply the same procedure for hand gesture tracking and observed the results. While our results with centroid, subtraction and window-based approaches gave reasonably good results, the Kalman filter application requires further thinking and fine-tuning. Combining blob analysis and Kalman filter the proposed project is implemented in real time to recognize the gesture coordinates in order to find the motion of hands.

In figure 5 shows the hand/finger gestures for four directions. In center position the x and y value is constant. For move up direction the y-axis value is decreased and down direction the y-axis value is increased. Based upon these values the gesture direction is displayed in the system and the gesture is transmitted by using zigbee protocol to the robot. Based upon these gestures directions the robot arm will move in corresponding movements.

1. Center position

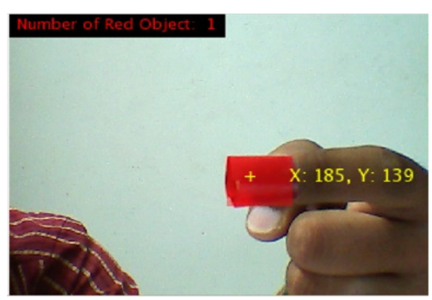


2. Detect no. of red colors



3. Finger movement (Left direction)

4. Finger movement (Right direction)



IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 5, Oct-Nov, 2014
ISSN: 2320 – 8791 (Impact Factor: 1.479)
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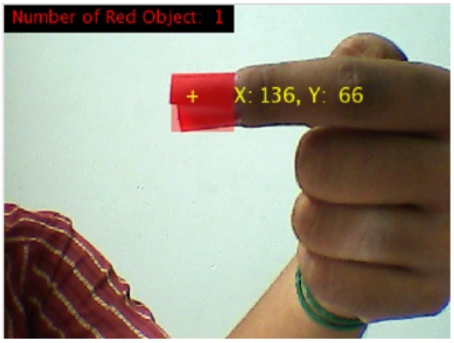
5. Finger movement (Up direction)



6. Finger movement (Down direction)

Fig.5 Shows gesture positions in center, left, right, up and down direction. 2nd figure shows the example of number of red colors detect in Rubik's cube

7. DISCUSSION

In this section we describe the accuracy of our hand tracking and gesture recognition algorithm. The video have been captured using a Logitech Messenger Web Cam with USB connection. The camera provides 640x480 images at a capture and processing rate of 30 frames per second. Each user has performed a predefined set of 6 movements and therefore we have 360 gestures to evaluate the application results. It is natural to think that the system's accuracy will be measured controlling the performance of the desired user movements for managing the calculator. This sequence included all the application possible states and transitions. The translation and the orientation of the robot manipulator are controlled by copying the movement of the human hand. Compared with electromagnetic contact devices, such as hand joystick and data gloves, the proposed method rarely hinders natural human limb movements and even enables the operator to focus on his own task instead of thinking of how to deconstruct the commands into some simple orders. Moreover, the algorithm presented in requires a bare hand to recognize the color of skin; otherwise, the algorithm cannot be used to extract the hand data. In comparison, the proposed algorithm does not require a bare hand, and the operator can wear gloves when using the system in the cold outdoor working environment. This feature therefore expands the application range of the system.

8. CONCLUSION

In this paper we have proposed and implemented a real time hand gesture recognition system. First we have applied a number of image processing algorithms to detect gesturer's bitmap images acquired from simple web cameras. Next we have trained blob analysis to recognize different gestures using the input sequences. Combining blob analysis and Kalman filter the proposed project is implemented in real time to recognize the gesture coordinates in order to find the motion of hands. All the several experimental tests conclude that the proposed system presents two benefits. The first one is implementation simplicity and execution quickness. And the second one is it can be used in all kinds of friendly interfaces such as computerized applications, Robotic applications, games, remote controls, home systems, etc.

ACKNOWLEDGEMENT

I would like to thank our guide Prof. Mr.Dineshsundar Asst. Prof., Electronics and communication engineering Department, Parisutham Institute of Technology and Science, thanjavur for his help and guidance to enable us to propose this system.

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