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Artificial Intelligence Based Robot Control System Using Image Processing and Embedded System

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Abstract: **- In recent years, the field of artificial computer vision and robotics progressed rapidly and the efforts have been made to apply research results in the real-world scenarios applications. These systems also focus on some issue for artificial intelligence and robotics which will be applied in real-world scenarios. This paper includes image based face authentication using web-cam for robot to human authentication while the control movement of robot is done with the help of same web-cam by using hand gesture technique.**

The gesture recognition is completed with the help of template matching schemes, instead of using the feature based approach. This embedded system is better approach of human computer interaction, as it uses the natural human face and hand for the communication with the computer. The various computer vision library is freely available, this system uses, the OpenCV library EMGU CV wrapper for the face recognition and hand gesture recognition. The interaction between robot as a receiver and computer as a transmitter is done with the help of simple Radio frequency (RF) signals.

The three wheel robot is working on 8-bit AVR micro-controller with RF receiver interfaced with the AVR micro-controller. For the control working of the robot, system used Embedded C as programming language in Win AVR Development tool..

Index Term: **-- artificial intelligence, Computer Vision, EMGU CV, RF Signals etc.**

I. INTRODUCTION

In recent years, the field of computer vision progressed rapidly and the efforts have been made to apply research results in the real-world scenarios. When implementing researcher's findings, hardware cost becomes an important issue.[1] With the development of ubiquitous computing, current user interaction approaches with keyboard, mouse and pen are not sufficient. Due to the limitation of these devices the usable command set is also limited and one of the better outcomes as human natural gesture is one great interaction approach for human and computer Human-computer interaction (HCI).HCI is the study of how people design, implement, and use interactive computer systems and how computers affect individuals, organizations, and society. HCI in the large is an interdisciplinary area. HCI is concerned with the joint performance of tasks by humans and machines, the structure of communication between human and machine.

The Artificial Intelligence (AI) is one of the best technique have been used in the field of image processing and pattern recognition. Artificial intelligence is basically the idea of a computer program or system that might equivalent or exceed the human brain in terms of processing supremacy and intellectual dimensions. Artificial intelligence is the human-alike intelligence shown by machines or software. Neural networks and artificial intelligence are frequently studied collectively, while this is not the only way or method, or may not the best method in all occasions, but turn into increasingly popular approach. Neural networks and artificial intelligence are work well in composed manner ever since both systems naturally use the human brain as the standard for processing capability. Artificial neural networks (ANN) were used mainly in the current years in the arenas of image processing (compression, recognition and encryption) and pattern recognition. Several studies in this area used various ANN architecture and prototypes for face detection and recognition to attain improved performance and efficiency gain of recognition.

The field of computer vision also gives the option of interaction of computer with face and hand gesture as input, Gesture recognition is an area in computer science and language technology with the objective of understanding human gestures via accurate algorithms. Gestures can initiate from any bodily gesture or state

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however usually initiate from the face or hand. A principal objective of gesture recognition exploration is to build a system which know how to recognize unambiguous human gestures and use them to carry facts or for device control and work promptly. In latest some years, face recognition has fascinated much responsiveness, since it has many prospective applications in computer communication and programmed or automatic access control system. Particularly, face detection is an essential part of face recognition as the first stage of involuntary face recognition. Face recognition is used for two principal works:

1. Verification (one-to-one matching): When offered through a face image of an indefinite individual along with a right of identity, determining whether the indefinite individual is who he/she privileges to be as he/she claimed.

2. Identification (one-to-many matching): Given an image of an unidentified individual, decisive that person's uniqueness by matching (possibly after encoding) that image with a data bank or database of images of (possibly encoded) images of identified individuals[10].

The Hand gesture recognition system can be used for interacting between computer and human using hand gesture. The methodologies for hand gesture recognition can be generally divided into Data-Glove Based and Vision Based approaches. The Data-Glove based methods uses sensor devices for digitizing hand and finger gestures into multi-parametric data. The additional sensors make it casual to gather hand configuration and movement [11]. In contrast, the Vision Based methods needs only a camera, thus comprehending a normal interaction between humans and computers without the use of any additional device.

The most scholars explored the hand gestures with four processes as-perceiving the hand in bi-manual movements, excruciating of a meaningful gesture area from an image stream, removing the required features and recognizing the gesture.

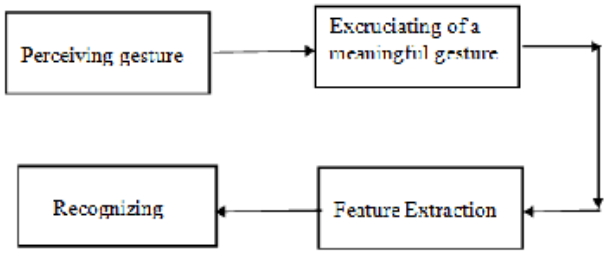

Fig 1.1: step of hand gesture recognition

Controlling the robot via gestures considered as one of the fascinating applications in the field of computer vision for example the proposed system that uses the numbering to count the hands fingers for controlling a robot using hand pose signs. Also the condition where the human operator cannot work only because of extreme conditions, in such environment the robot will be most eminent device to be operated. Controlling the robot via gestures considered as one of the fascinating applications in the field of computer vision for example the proposed system that uses the numbering to count the hands fingers for controlling a robot using hand pose signs. Also the condition where the human operator cannot work only because of extreme conditions, in such environment the robot will be most eminent device to be operated.

II. COMPARATIVE LITERATURE REVIEW

1. Human Computer Interaction Using Face and Gesture Recognition [1]

Different from the conventional communication methods between users and machines, authors combine head pose and hand gesture to control the equipment. Author's identified the position of the eyes and mouth, and use the facial center to estimate the pose of the head. Two new methods are presented in this paper: automatic gesture area segmentation and orientation normalization of the hand gesture. It is not mandatory for the user to keep gestures in upright position, the system segments and normalizes the gestures automatically

2. Rotation Invariant Neural Network-Based Face Detection [9]

In focus of face detection, head position estimation and hand gesture recognition, most of authors works which are limited to detecting upright, frontal faces, many researches only allow one degree of freedom, which is not suitable for

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the estimation of head tilt positions.This system employs multiple networks; the first is a "router"network, which processes each input window to determine its orientation. This information is then used to prepare the window for one or more "detector" networks.

3. A Survey of Face Recognition Techniques [2]

This presents two different schemes of face recognition is used for two primary tasks-

a) Verification (one-to-one matching): When presented with a face image of an unknown individual along with a claim of identity, ascertaining whether the individual is who he/she claims to be.

b) Identification (one-to-many matching): Given an image of an unknown individual, determining that person's identity by comparing (possibly after encoding) that image with a database of (possibly encoded) images of known individuals.

4. 3D Head Pose Estimation without Feature Tracking [10]

In the head angle estimation related research, researcher's presented a robust approach to estimate the 3D pose of human heads using a single image. Their method only makes use of the information about the skin and hair region of the heads. Authors uses an efficient algorithm based on a perceptually uniform color system and fuzzy theory to extract the skin region and hair region, which are then used to detect faces in images. After that, the areas, the centers, and the axis of the least inertia both of the skin region and the hair region are calculated.

5. Novel Pose-Variant Face Detection Method for Human-Robot Interaction Application [5]

The authors proposed a new facial feature detection approach based on the local image region and direct pixel-intensity distributions. For this, authors propose two novel concepts, the directional template for evaluating intensity distributions and the edge-like blob map image with multiple strength intensity. Using this blob map image, show that the locations of major facial features two eyes and a mouth. Can be reliably estimated. Without boundary information of facial area, final candidate face region is determined by both obtained locations of facial features and weighted correlations with stored facial templates.

6. Head Pose Estimation using Adaptively Scaled Template Matching [6]

Proposed a real-time head pose estimation system using a new image matching technique. The system consists of a training stage, in which the subspace dictionaries for classifying the head poses are computed using template matching and the factorization method, followed by a recognition stage, in which the head poses are estimated using the subspace method.

In Hand gesture recognition system can be used for interfacing between computer and human using hand gesture, in the hand gesture recognition related research the various scholars suggested the various approaches-,

7. Human Computer Interaction Using Face and Gesture Recognition [1]

For hand gesture recognition, we apply a particular type of neural network model, which is known as a "feed-forward back-propagation neural network".This neural network is applied for hand gesture recognition in our system. This neural model is easy to understand, and can be easily implemented in image processing tasks. With a neural network, it is possible to apply some inputs irrelevant to the solution.During the training process, the network will learn to ignore any inputs that do not contribute to the output. If some critical inputs are left out in the training process, the network will fail to result in a correct solution.

8. Cluster Labeling and Parameter Estimation for the Automated Setup of a Hand-Gesture Recognition System [7]

Authors suggested a methodology using a neighborhood-search algorithm for tuning the system parameters. They addressed the problem of simultaneous calibration of the parameters of the processing/fuzzy C-means (FCM) components of a hand gesture recognition system. This system is limited if it is implemented as a part of HCI systems because it is not capable of detecting the hand gesture locations in the image automatically. The user must restrict the hand gestures in a certain area.

9. Hand gesture recognition using a real-time tracking method and hidden Markov models [9]

The system consists of four modules: a real time hand tracking and extraction, feature extraction, hidden Markov model (HMM) training, and gesture recognition. First, we apply a real-time hand tracking and extraction algorithm to trace the moving hand and extract the hand region, then we use the Fourier descriptor (FD) to characterize spatial features and the motion analysis to

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characterize the temporal features. We combine the spatial and temporal features of the input image sequence as our feature vector. After having extracted the feature vectors, we apply HMMs to recognize the input gesture. The gesture to be recognized is separately scored against different HMMs.

10. Hand Gesture Recognition Using Haar-Like Features and a Stochastic Context-Free Grammar [4]

An author proposes a new approach to solve the problem of real-time vision-based hand gesture recognition with the combination of statistical and syntactic analyses. The fundamental idea is to divide the recognition problem into two levels according to the hierarchical property of hand gestures. The lower level of the approach implements the posture detection with a statistical method based on Haar-like features and the AdaBoost learning algorithm. With this method, a group of hand postures can be detected in real time with high recognition accuracy.

The higher level of the approach implements the hand gesture recognition using the syntactic analysis based on a stochastic context-free grammar. The postures that are detected by the lower level are converted into a sequence of terminal strings according to the grammar. Based on the probability that is associated with each production rule, given an input string, the corresponding gesture can be identified by looking for the production rule that has the highest probability of generating the input string.

III. IMPLEMENTED SYSTEM

In this system we developed a hand gesture based robot control using artificial intelligence technique which can be used in variety places. The robot is working on Micro-controller, which receives a RF signal from RF transmitter which is connected computer and performs a predefined task. The authentication process of user to a robot is completed with the help of face reorganization, in image plane using artificial Intelligence technique. The complete system is divided into two broad parts-

I) Software System II) Hardware System

Software System

In this section we are only focusing on the software implementation of system, while focusing on the software we have visited to various scholar's research work as discuss in literature survey. The implemented software system can be describe with the help of figure 3.1.

The figure 3.1 shows the system diagram for computer architecture of software system, that enabled with the single camera on computer to accept the input as a image for authentication process, the system store the image and perform the operation of segmentation and labeling while detection of face from the input image, In recognition ,if recognition is comes as false the system will again wait for the face input for the authentication until the success, and if recognition of face is done successfully, the user on computer use is authenticated to the robot for the controlled operation.

The next phase of operation is to control robot with hand gesture movement, this is again done with the single camera for the receiving of input images and artificial intelligence technique is used to detect the suitable hand gesture. After matching of hand gesture with learned process, this same hand gesture meaning bits are transmitted using wireless RF transmitter to controller to perform the movement control operation. For the design of this simple system using haar cascade feature of Emgu OpenCV library of image processing and C# as language of coding in .NET framework environment with Visual studio 12 and MySQL as simple data base

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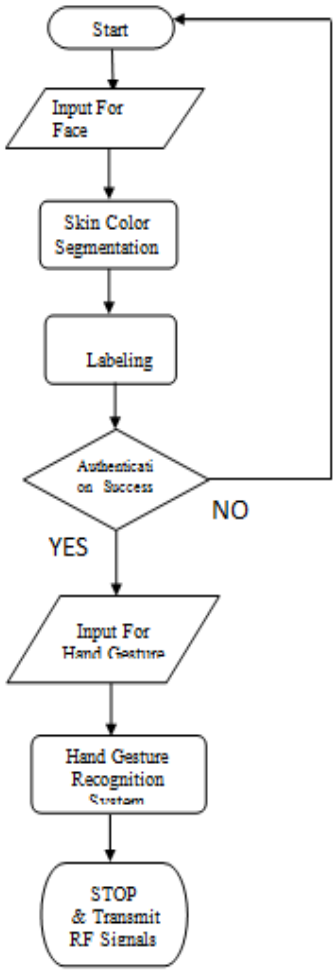

Fig: 3.1 System diagram for computer architecture of software system

Hardware System

In recent years, the field of computer vision developed rapidly and the efforts have been made to apply research results in the real-world developments. When implementing researcher's finding, hardware cost becomes an important issue. In this system, we use only a video camera and a PC to develop a face and gesture based human-computer interaction (HCI) system.

We target this system implementation towards robot; to control the movement of robot such we can change the scope of this system with accordance with the application with minimum hardware utilization's. The figure shows the system diagram for Controller, that controller enable it to receive the information from the computer to perform the required pre-defined control movement operation.

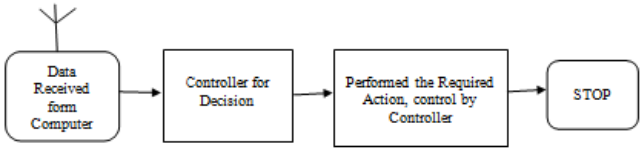

Fig 3.7: Hardware side control system diagram

The signal bit send by the computer after Hand gesture recognition using RF transmitter is received by RF receiver at Robot Side using RF receiver and send this signals at to Controller to perform the operation. The controller has proper control action associated with the each received signals and perform this action.

IV. RESULT AND DISCUSSION

The designed embedded system has been tested successfully with the model on computer as transmitter and three wheel robots as a receiver.

Software System Results

The software system includes basically two main modules of face and hand gesture recognition. The face recognition is start with the simple training module of face for the system training of face recognition; the training is done with registration process of simple passing of Username and Passwords to the system.

Fig 4.1: Registration Process for training

After the completion of registration phase of training face ,system display the message box with completion message and OK button as shown in fig 4.1 above. Now the system is ready for the face recognition, the button showing "Start Face Registration" is now changes to the "Start Face Recognition" as shown in fig 4.2 below.

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Fig 4.2: Face recognition process

When user click on the start face recognition button, the process of recognition is start and system recognize the face with the face as save at the time of face training procedure, after the success full recognition of face system will show the message box with OK button as show in fig 4.3 below

Fig 4.3: Face Recognition success message

After the click of OK button of the message of username with welcome message as shown in fig 4.4 below is displayed

Fig 4.4: Welcome message for Hand Gesture Recognition

After the click on the Start Gesture Recognition Button user will start interacting the hand gesture module of the system, and user will click of the button for obtain the count of finger in the hand gesture for performing the task of control movement of the Robot. The following table shows different count of finger and their pre-define gesture control movement.

Sr. No	Count of Finger	Gesture Control Movement
1	1 finger	Up control movement of Robot
2	2 finger	Down control movement of Robot
3	3 finger	Right control movement of Robot
4	4 finger	Left control movement of Robot
5	5 finger	Stop control movement of Robot

Table 4.1: finger count and control movement

The hand gesture module is available with the button "Get Count" to obtain the count of finger and perform the control option according to pre-define gesture control movement operation as shown in table 4.2 below

Sr.No.	No. Of Fingers	Picture
1	One	
2	Two	

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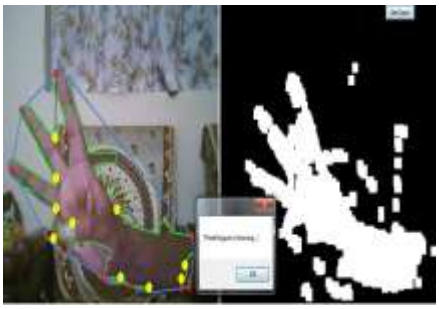
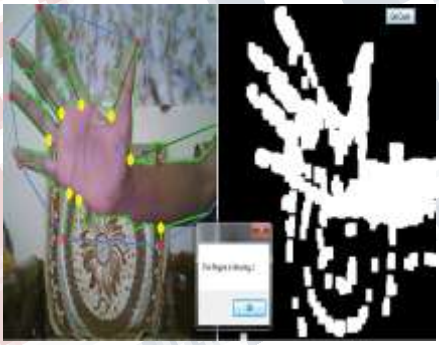
3	Three	
4	Four	
5	Five	

IV HARDWARE SYSTEM RESULTS

In hardware system the robot installed with RF receiver is working accordance to the signal bit send using software system from hand gesture module. The figure for transmitter as shown in fig 4.5 and Receiver as shown in fig 4.6 are as shown below; the transmitter is attached to the USB port of the computer while receiver is installed on Robot. The complete robot structure can be seen in fig 4.7.

Fig 4.5: Transmitter attached to the USB port

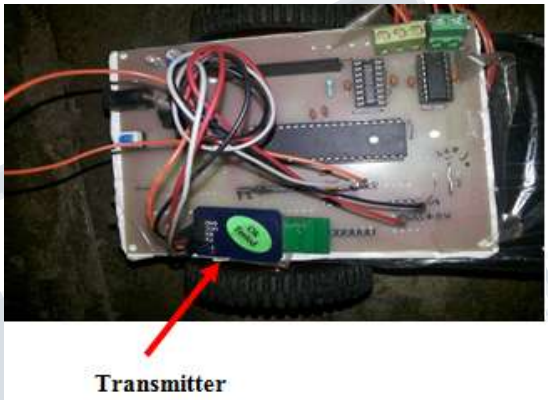


Fig 4.5: Transmitter attached to the USB port

Fig 4.5: Transmitter attached to the USB port

V. CONCLUSION

During the monitoring of system behavior under the various conditions, system gives good acceptance result. The system provide the better face recognition result under the various condition as we are using the template matching system for face recognition using Emgu CV open source .NET wrapper with Haar cascade features of detection. The selection of hand gesture is the most

important accept of any hand gesture recognition system because of dynamic nature of the gesture of hands.

This proposed system work here is an authoring method capable of creating and operation controlling motions of surveillance and industrial robots based on hand robot interaction. The proposed robot motion controlling method is expected to provide effective and implementable solutions for not only just industrial robots, but also for higher intelligence embedding robots like humanoids.
This is better embedded system in terms cost and efficiency as it uses, 8 bit AVR micro-Controller and with minimum hardware requirement for the communication of software system and hardware system with the minimum cost and single web-cam.

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