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HAND GESTURE CONTROLLED REAL TIME APPLICATION FOR AUTOMATION

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Abstract: A considerable effort has been put toward the development of intelligent and natural interfaces between users and computer systems. Gestures are now an important part of communication. Hand gesture recognition is widely used in many applications, such as in computer games, machinery control (e.g., crane), and mouse replacement. Hand Gesture provides a natural and intuitive source of interaction between a machine and a human being. Hand gestures can be classified into two categories: static and dynamic. This paper focuses on different application domains such as heavy duty lift instruments or vehicles like cranes, dumpers, etc. that can be controlled by hand gestures and can be effectively used for efficient interaction. In the existing method the Cranes are controlled by either wired livers or joysticks for selecting or controlling the Crane tasks by holding the joysticks and levers in hands. It is very difficult and risky to handle heavy loads using these methods. The crane operator has to risk his life and operate the crane. Hence a system is designed to operate or control the Cranes from a distant end by using hand gesture and wireless communication technology. Here a desktop PC or an ARM controller can be used at remote end to control the crane. Communication between the controller and the actuators is through the ZigBee module.

Keywords: Real time system, Gesture Crane control, ZigBee, heavy lifting control, bare hand gesture

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INTRODUCTION

Gestures are in several types such as hand, body and face. Gesture gives a spontaneous response between human and a machine. It is intuitive way of conveying information. There are two types of gestural interactions developed for the Human Computer Interface (HCI), they are static gestures and dynamic gestures. Many systems have been developed which uses gloves, or color markers to recognize gestures [1]. Another system which used the recognition of gesture by using color glove was developed which used feature extraction and learning vector quantization [2]. Using color markers and gloves reduces the convenience of the user as they have to be worn every time before accessing the system. This system is developed such that a vision based approach is used on bare hand gesture and excluding any gloves or color markers.

MEMS sensors which use 3-axes accelerometer are used as a gestural interface to control several applications [3] [4]. The sensor is a 3-axes accelerometer which detects the change in trajectory and accordingly tracks a gesture.

Now a day's Computers are also controlled by hand gesture [5]. Gestural interaction in robotics is an interesting field of research. Many systems have been developed in robotic applications which work on gesture inputs. A robotic hand was developed in which the arm of the robot is manipulated by using gestures [7]. Here pattern matching technique is used for gesture recognition purpose and upon right gesture detection the robotic hand functions accordingly. A car robot was designed which worked on the gestures that used 3-axes accelerometer for tracking hand trajectory [8]. The car robot was used to navigate car by sending control commands using RF module. A robotic system was developed which had a vision based wireless control and used HSV color space for gesture recognition [9]. This system had predefined gesture commands that controlled the robot.

The use of gesture in field of vehicles is increasing rapidly. Many vehicles are using gestural approach to control applications such as music system, power window control, etc [10].

A system was developed for gaming applications which worked on real time gesture detection [13]. This system proposed the method for detecting bare hand gestures in changing backgrounds and cluttered backgrounds. It used training method which used extraction of points from training images. It used a method in which if face is present in image then face extraction was applied. In household automation a gesture based system is developed in which we can control applications in the house with the help of gestures [14]. This system is called as 'handmote'. It is useful for physically challenged people to access the household applications without moving to the actual location.

The purpose behind development of this system is to control the heavy lifting equipment's from a distance through which the operator can observe the loads. The control takes place through hand gestures. The controller person needs to input the gesture commands to which the crane responds through actuators. There is risk of life for operating cranes and other instruments at some places. Many people have lost their lives due to failure of the cranes. Due to such reasons remote controlling is necessary. Remote controlling is possible through wireless communication.

- **THE CONTROL SYSTEM**

  - *The heavy lifting equipment's.*

The heavy lifting equipment's mainly include a crane which is used in construction sites as well as dockyards, these are called tower cranes. A heavily loaded dumper is also considered as heavy lifting equipment. The crane is shown in following diagram has many degree of freedom for its operation (Fig 2a.)

Fig. 2 a: A truck mounted crane.[16]

As shown in Fig.2 the truck mounted crane has five degree of freedom. The crane has five types of motion to be controlled.

They are:

A. the horizontal motion of truck

B. circular motion

C. diagonal movement of arm

D. extending and compressing arm

E. hook vertical movement.

The truck mounted crane is shown as follows (fig.2b)

Fig.2b: A truck mounted crane.[16]

Another type of crane is the tower cranes which are used in construction and dockyards for loading and unloading cargo vessels. The tower crane is shown as follows (fig2.c).

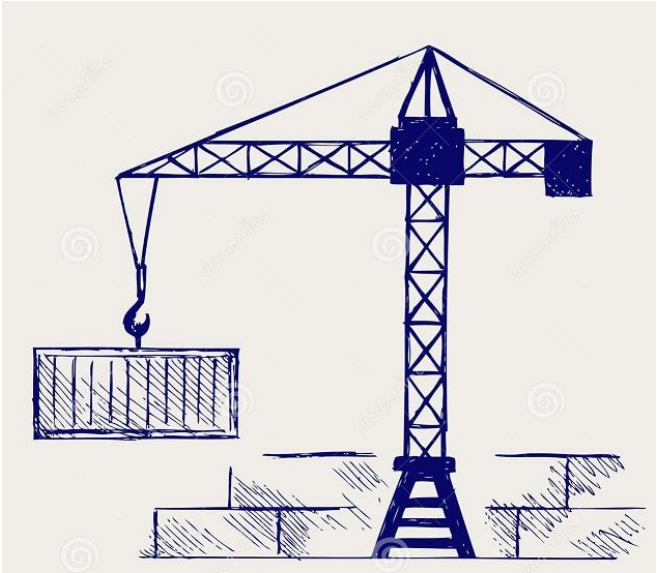

Fig.2c: A tower crane.[17]

The degree of freedom of tower cranes can be shown in following diagram (fig.2d)

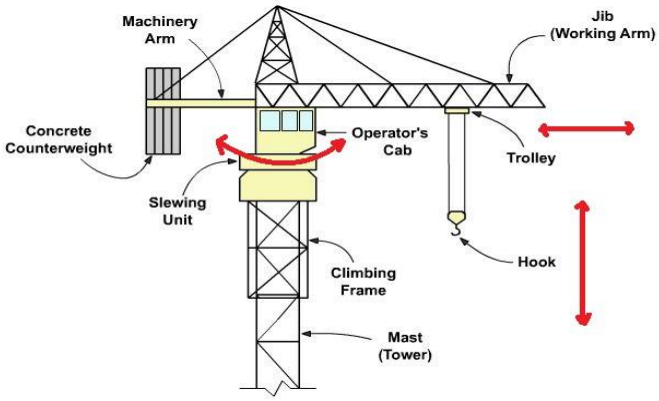

Fig.2d: A tower crane's degree of freedom.[17]

As we can see there is three degree of freedom for a tower operated crane:

a. The vertical motion of hook

b. The rotational motion of Arm

c. The horizontal motion of arm.

- *The Gesture controlled system.*

The designed system is one which performs the operation of getting gesture from user, compares it with the gesture commands and accordingly send a signal to the actuators through wireless module to perform the desired operation. Each operation of the crane is previously associated with a gesture. So whenever we put a gesture in front of the camera the corresponding operation takes place. The system is divided into two parts, one is the control end and other is the remote end. Here we are using a camera for capturing gestures from the controller. Then the system compares the gesture with the command to which it is associated in the algorithm. Then accordingly it sends a signal to the remote end. At the remote end after receiving the signal the controller reacts accordingly and controls the crane. The control end or the user end of the system is shown in following block diagram (fig 2e).

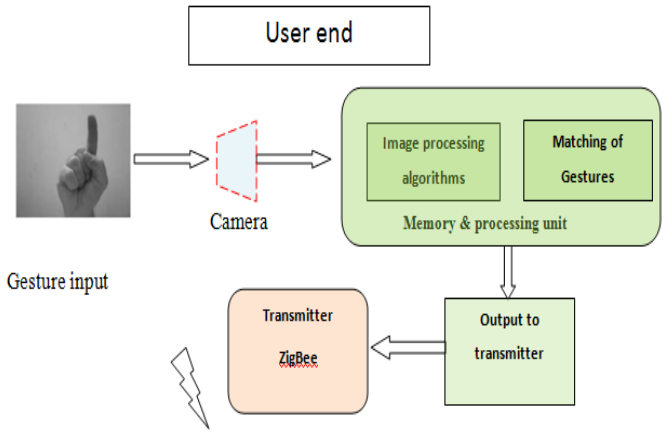

Fig. 2e: Configuration of the system (Control end).

The remote end of the system is shown in the following figure (Fig.2f).

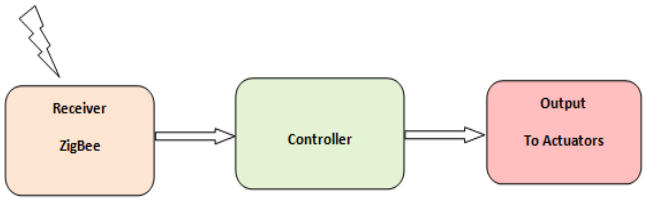

Fig. 2f: Configuration of the system (Remote end).

Here we are developing a prototype of the system. We can use our desktop pc to control the prototype crane. We can also use raspberry pi as a controller if we don't want to use our desktop pc. A camera is interfaced to the pi board to capture the gesture from the user. The pi board compares the gestures from the user and sends a signal to the ZigBee module (IEEE 802.15.4). Here for wireless communication a ZigBee module is used. The raspberry pi is a fast minicomputer which has a speed of 700MHz. After porting of the operating system the algorithm can be ported in to it. Here the operating system is Rasbian® which is a linux operating system supported by ARM 11. It has various interfaces for keypad, display and mouse and also an HDMI interface. The camera used here is a normal webcam and the frame rate is 30fps which is standard. An Xbee Pro S2 is the device which has zigbee protocol is used for wireless communication. It has a good range for communication. It supports 1500 m line of sight communication. We can get a minimum of 200 m for non-line of sight communication which is also an optimum range. A controller is interfaced at the remote end to the ZigBee receiver to perform the desired action through actuators. Preliminarily we had used AT mega

16 for this purpose. Then we used a driver to actuate a stepper motor. We can also use dc or high torque motors for actuation purpose. In real time operation we have to use hydraulics and pneumatics for actuation purpose.

- **IMPLEMENTATION**

The implementation process starts with gesture recognition. It can be shown by the flowchart of the algorithm (Fig.2a and Fig.3a).

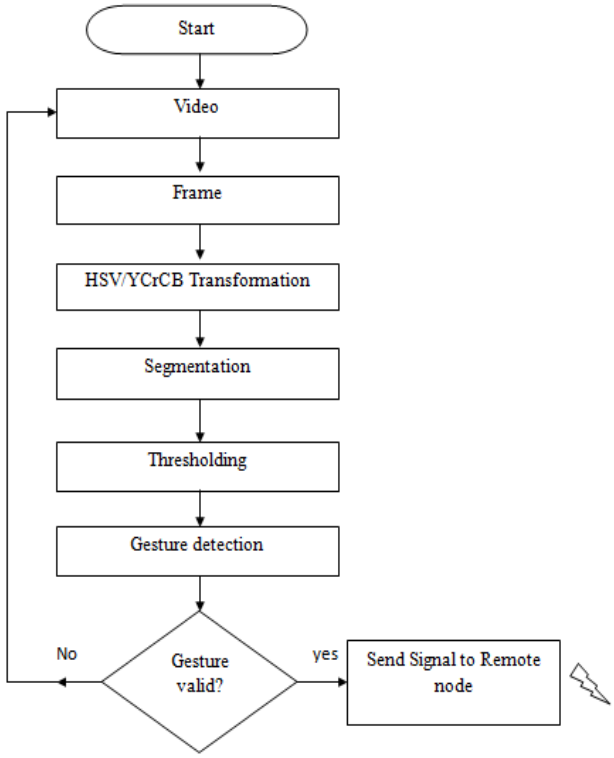

Fig.3a: Flowchart of the system (User control end).

The camera takes input at 30fps. The frames captured are in RGB color space. We change the color space into HSV or YCrCb space. Work is being performed on accuracy of both transformations, such as which transform to be used precisely. Once the frame is converted into HSV space a range of skin tone is entered and the image is segmented according to the range. The range extracts skin like pixels from the image. The image is transformed to a threshold one and the noise is removed by morphological operations like dilation, erosion and opening operations. After that contour is applied to that image and the feature points from the frame are extracted. These points are hulls and defects. According to the points the gesture is

detected. By using certain code for each function to be performed, then this code is transmitted by the ZigBee transmitter. The flow of the remote end is shown as follows (Fig.3b)

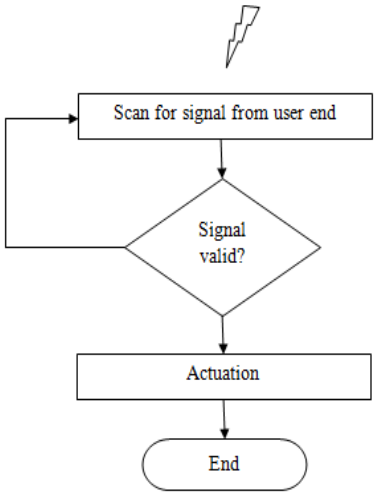

Fig.3b: Flowchart of the system (Remote end)

Here the receiver at the remote end scans for the signal and checks what is present in the signal. The code that is present in the signal is decoded by the controller present there and according to the code, the actuation signal is given to the actuator to perform predefined task. Actuation is performed here by stepper motors, we can also use simple dc motors and high torque motors. In real time hydraulics, pneumatics and high power motors are used.

- **RESULT**

The system is still being worked upon for different gestures and different functions. Here the system is still being developed on raspberry pi board. We have tested the software code on desktop and it works very well. Here for gesture recognition we have used HSV color space as well as YCrCb and then contour was applied and hulls and defects were calculated and depending on that gestures are detected. We have also compared both color space's gesture recognition. Upon matching the gesture a code which defines a function at remote end is transmitted. The results produced for gesture detection are greater than 95% in a plain background as well as cluttered background and also changing backgrounds. The remaining 5% is because of false gesture detection. The Gesture detection for HSV and YCrCb color spaces are compared in following table.

TABLE I: Gesture recognition rate with HSV and YCrCb spaces.

Color space	Total applied gestures	False Gestures	Efficiency
HSV	50	3	94%
YCrCb	50	2	96%

The ZigBee frame format for transmission of the data from user end to remote end is shown in following diagram (Fig.4a).

Start of Frame	Length		Data		Checksum
S	MSB	LSB	ID	Data	C- 1byte

The result of gesture recognition is shown in the following snapshots (Fig 4b and Fig 4c).

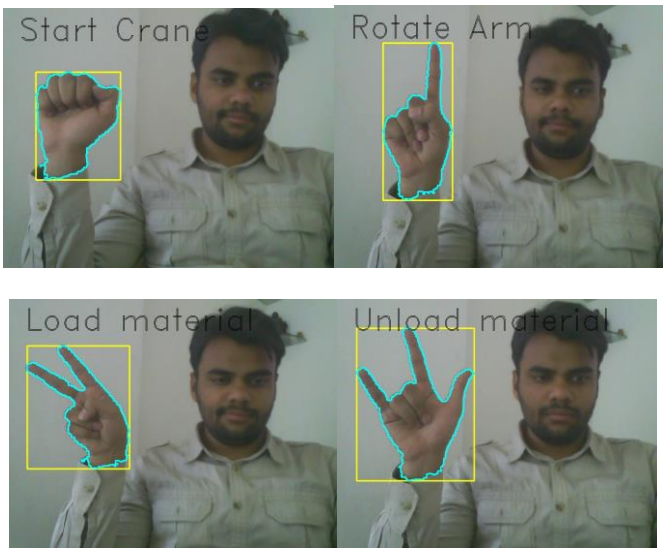

Fig.4a: Communication frame from transmitter to receiver.

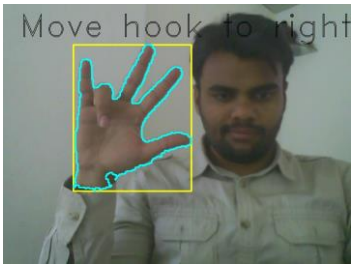

Fig. 4b: Gesture recognition with predefined commands.

Fig.4c: Gesture recognition with predefined commands.

- **CONCLUSION**

We have worked with the software part and it works well. We are currently developing a hardware module to develop a prototype of the system using stepper motors. In real time the system must have hydraulics and pneumatics as the actuators. The fully developed system will control the crane by using gestures that too from a remote end. The manual controller need not sit in the crane and control it. As the controller conventionally needs to climb the height of the crane which is risky and control it with wired joysticks. Hence we can eliminate the conventional thing of climbing the crane and control it and also one can control the crane from a remote distance by using ZigBee module.

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