KINECT Sensor Based Gesture Control Robot for Fire Fighting

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Abstract— There are many possibilities that a fire can start in industries or in any remote area. In the proposed work, a gesture controlled robot is implemented using Kinect based gesture recognition making it a humanized robot for fire-fighting. The movement of the human arm in front of the sensor is captured, processed and the according actions are followed by the robot. The human arm gestures are transmitted to the microcontroller after using Kinect sensor. Microcontroller receives the gestures and commands the robot. In testing the accuracy of control based on gestures performed by human hands was tested. This work depends on visual basic application. With this project we can extinguish the fire and save lives as there is no human intervention in actual scenario.

Key words: Gesture, Humanized robot, Kinect sensor, Visual basic

I. INTRODUCTION

In today's era, the robotic industry has been evolving many new trends to upsurge the efficiency, Approach ability and accuracy of the systems. Robot are used for jobs that may be injurious to humans , repetitive jobs that are tedious, hectic etc. Although robots can be used to replace humans but still they need to be controlled by humans. Other than controlling the robotic system through physical devices, recent techniques of controlling robotic system through gesture and speech have become very popular. The main motto of using gestures and speech is that it is a more easier way of controlling and provides an intuitive form of interface with the robotic system. Automation is an essential part of robotics today. Automated robots can perform the tasks of loading and unloading weights according to the need. The motivation behind the development of this project was to create a prototype for testing of different human machine interfaces. This project contains the field of robotics by integrating the following areas:

1) Gesture Recognition
2) Remote Monitoring

During the development of this project we followed a modular approach because modularity provides flexibility for the further expansion, research and testing etc. by hardware and software changes in the existing system. The main module used for gesture and speech recognition was Kinect Sensor.

The Kinect sensor is widely used for human motion recognition in video game playing. Here Kinect sensor is being used for commanding a mobile robot according to the movements of hands (gesture), as a pervasive human machine interface. The robot is in the form of a loader vehicle, which can be used for fire-fighting. After decision making based on gesture recognition, the corresponding command is sent wirelessly to the robot and action is performed according to the movement of the hands.

The main objective of this project was to build a prototype that would facilitate the testing of different algorithms for motion of robot. Utilization of kinect camera has been done. The softwares that have been used are Processing 2 and Microsoft Visual Studio. In the gesture control mode, the Kinect camera captures a stream of images that are forwarded to processing 2, which runs the motion algorithm. Based on the hand movements, the robot gets the commands according to the motion algorithm. There is a wireless link between the robots and the computer that gives the commands. Robot has a microcontroller that processes those commands and the robotic loader perform the particular task accordingly.

This project contributes greatly in the fields of:

1) Kinect Application Development
2) Motion Detection
3) Human Computer Interaction
4) Speech Recognition

II. PROPOSED SYSTEM

In this project we are going to implement the fire-fighting robot which will control with the help of kinect sensor.The kinect sensor is connected to the computer with the help of visual studio.

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The robot is interface with the computer with the help of wireless module. The wireless module connected with the help of USB port to the computer. The CO2 spray is placed on the top of the robot.

A. Hardware module

This section describes the block diagram of transmitter and receiver section of the proposed system.

1) Transmitter Section:

This part consist of kinect sensor, laptop, serial transmission module. The detail diagram shown below.

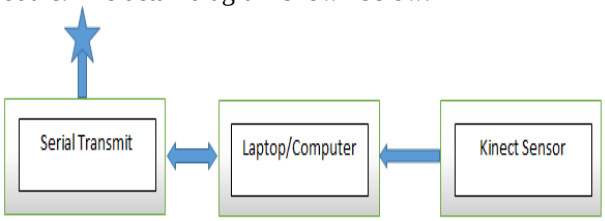

Fig. 1: Transmitter Section of Robot

2) Receiver Section:

Receiver part consists of the drivers and controllers for driving the robot. The motors of this part will moves as per the commands coming from the transmitter section.

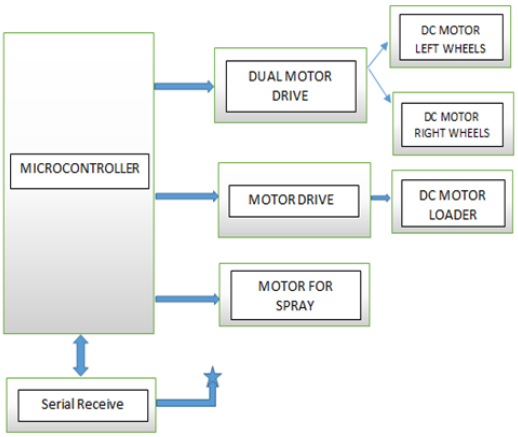

Fig. 2: Receiver Section of Robot

B. Methodology:

The below section describes working and system flow of the proposed model

1) System Flow

a) For Transmitter:

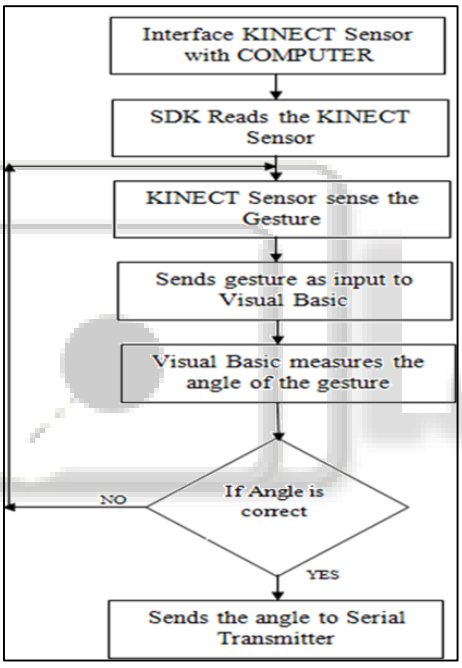

Fig. 3:

b) For Receiver:

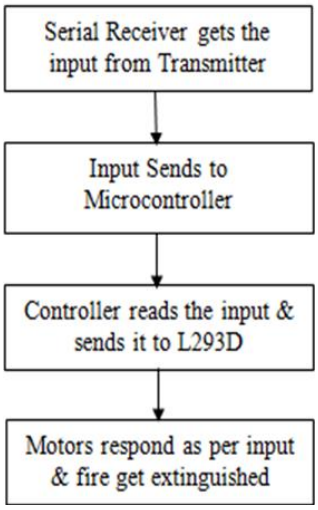

Fig. 4:

C. Hardware Specifications:

1) Kinect Sensor:

As mentioned before, Kinect is an input device used primarily for human body motion sensing. It could be used for colour and depth sensing. An inside look of the Kinect is shown in figure

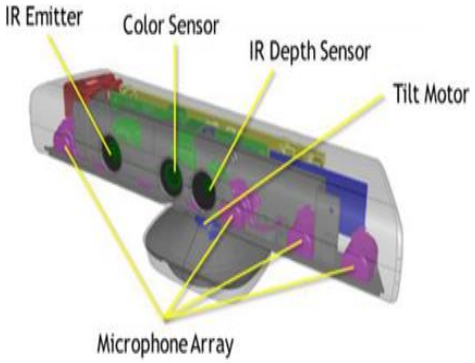

Fig. 5: Kinect Sensor Internal Hardware[10]

The Kinect comprises of the following components:

1) RGB camera for capturing color images has been used. It can capture images at 1280x960 resolutions.
2) An IR Emitter and IR Sensor for depth sensing. The emitter emits a beam of infrared light which is absorbed by the sensor on its way back. This information is then converted into a depth image.
3) A multi-array microphone, containing four microphones for both recording the audio and localizing its source.
4) A 3-axis accelerometer for determining the orientation of the Kinect. It is configured for a 2g acceleration due to gravity (g) range.

In below table 1 shows the detail specifications of the kinect sensor.

Kinect	Array Specifications
Viewing angle	43° vertical by 57° horizontal field of view
Vertical tilt range	±27°
Frame rate	30 frames per second (FPS)
Audio format	16-kHz, 24-bit mono pulse code modulation (PCM)
Audio input characteristics	A four-microphone array with 24-bit analog-to-digital converter (ADC) and Kinect-resident signal processing including acoustic echo cancellation and noise suppression
Accelerometer characteristics	A 2G/4G/8G accelerometer configured for the 2G range, with a 1° accuracy upper limit.

Table 1: Kinect Sensor Specifications

2) Bluetooth Module:

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Blue core 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm.

Fig. 6: Bluetooth Module

Following are the Specifications of Bluetooth Module:

- Typical -80dBm sensitivity.
- Up to +4dBm RF transmit power.
- Low Power 1.8V Operation, 3.3 to 5 V I/O.
- PIO control.
- UART interface with programmable baud rate.
- With integrated antenna.
- With edge connector.

3) Dc Motors:

Fig. 7: DC Motor [9]

12V DC geared motors for robotics applications. Very easy to use and available in standard size. Nut and threads on shaft to easily connect and internal threaded shaft for easily connecting it to wheel.

Features of DC motor:

- 200 RPM 12V DC motors with Gearbox
- 4mm shaft diameter with internal hole
- 125gm weight
- Same size motor available in various rpm
- 2kgcm torque
- No-load current = 60 mA(Max), Load current = 300 mA(Max)

a) Details Of Motors Used In The System:

In the Proposed system we used total 5 motors, Out of which 4 motors for robot base and remaining 1 for spraying the CO2 on fire. In below table 2 there are detail specifications of DC motor. We use the motors which has 200 rpm because for carrying the weight of robot the motor having less rpm was not sufficient.

Motors	Purpose	Voltage	RPM
1	Robot Base (Front left)	12	200
2	Robot Base (Front right)	12	200
3	Robot Base (Back left)	12	200
4	Robot Base (Back right)	12	200
5	Spraying the CO_2	12	200

Table 2: DC Motor Specifications

D. Software Specifications:

1) Visual Studio:Visual studio is used to interface the kinect sensor with the laptop. In which we use visual studio 2012. With the help of different modules of visual C++ we check that the accessories are connected to the system or not.
2) PROTEL: Protel is the software used to design the PCB of the microcontroller. There is another good software for designing namely as EAGLE.
3) KEIL 4: For the programming of microcontroller we use KEIL 4 compiler. The programming of the microcontroller we use basic C language.

E. Applications

- We can use this system in Offices, School, Smart cities, etc.
- This system is very easy to use so everyone can handle it.
- This system is most useful in chemical industry area because it extinguishes the fire.
- The place where man can't go or if he goes then he can injured due to fire.

III. Result Analysis

While analyzing the whole system we get the gestures in the quadrants having coordinates as X, Y & Z. Following table shows the location as well as action done by human arm at the specific location in all 4 quadrants.

Gestu-res	Action	Kinect Sensor Output		
		X	Y	Z
G1	Robot Turns Left	-199.84	123.68	474.44
G2	Robot Turns Right	-199.75	-137.13	786.85
G3	Robot Moves Forward	177.81	-329.18	771.11
G4	Robot Moves Backward	168.99	57.88	852.93
G5	Base Motors turns OFF	-389.15	-25.66	956.57
G6	Spraying Motor ON	-20.83	-72.22	1047.3
G7	Spraying Motor OFF	-40.65	-108.68	494.76

Table 3:Gestures and Its Co-ordinates

Real Images of Gestures and Their Co-Ordinates:

Fig. 8: Gesture 1

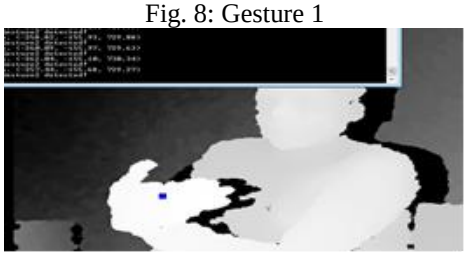

Fig. 9: Gesture 2

Fig. 11: Gesture 4

Fig. 12: Gesture 5

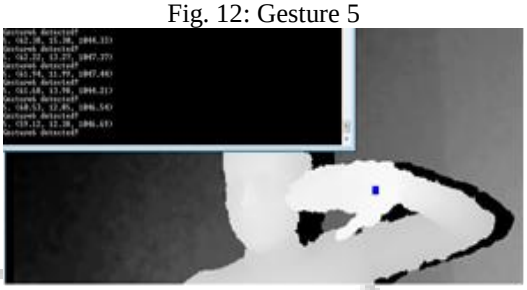

Fig. 13: Gesture 6

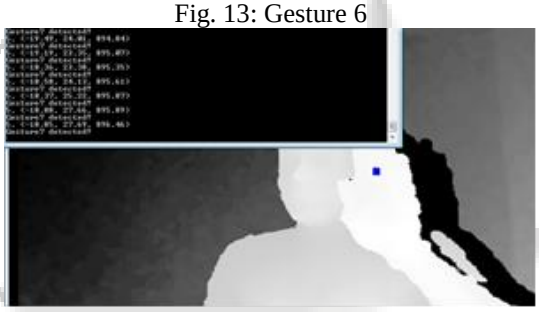

Fig. 14: Gesture 7

IV. CONCLUSION

The Gesture Controlled Robot System is much easier and interactive way of controlling robots. Gesture control being a more easier way of controlling devices makes control of robots more efficient and easy. This interactive way between human and robots helps new users to control the robot freely, making human robot interaction much easier. We can improve this system by using the web camera, where webcam is used for capturing the actual images of fire as well as shows us that where the actual fire exists. With the help of other features of kinect sensor like speech recognition, RGB recognition we have chance to control the robot on voice commands as well as finger tips respectively.

ACKNOWLEDGEMENT

We would like to acknowledge the contribution of all the people who have helped in reviewing the paper. And also like to give sincere thanks to Dr. Gayarti M. Phade for her guidance and support throughout this paper. We would also like to thank our families and friends who helped us in the course of writing this paper.

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