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HAND GESTURE CONTROLLED ROBOT WITH ARM

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Abstract : This project offers the design as well as implementation of dual hand gesture-controlled robot that has a robotic arm. The system is comprised of two MPU6050 gyro-accelerator sensors, two Arduino Uno microcontrollers, SG90 servo motors, 4V DC gear motors, L298D motor driver and LM2596 buck converter. The robotic arm works under the control of the left-hand sensor whereas the robotic arm is under the control of the right-hand sensor. An ethernet-based serial connection will guarantee both low-latency and consistent data transfers. The system reflects better human-robot interaction, ability of the system to run cheaply and control on real time. The Gesture instrument interacts with the robot via the radio waves. The wireless communication allows the user to work with the robot more amicably. With the help of accelerator sensors built on a hand glove, we can also control the car. The sensors will be used to substitute the remote control that is commonly used to operate the car. It will enable user to control forward, backward, left side and right-side movements and use the same accelerator sensor to control throttle of the car. The differential mechanism controls movement of car. The working of this is the rotation of both forward and rear wheels on the left or right side to move in the anti-clockwise direction and the other two to move in the clockwise direction that causes the car to rotate around its axis making it not move forward or backward. The primary benefit of this mechanism is that the car with such mechanism can make sharp turns without any hardships. A proposal to design and construct a gesture control robotic arm based on flex sensor is presented. The robotic arm is so designed that it comprises of four movable fingers with three linkages each, an opposing thumb, a rotating wrist and an elbow. A hand glove is used to make the robotic arm replicate the human hand movements

Keywords- **Dual-hand gesture control, Robotic arm, MPU6050 sensor, Wireless communication, Differential drive mechanism**

I. INTRODUCTION

Robotics is an electronics engineering, mechanical engineering and control engineering discipline, which deals with automated functions. The switches, remote control or joysticks used to control the traditional robots are limiting to natural control as the control systems are designed. Gesture control makes it possible to communicate with natural human machines. According to Bhuiyan and Picking [1], the gesture interfaces provide interactive features, which are user friendly and inclusive. This project introduces a two-hand wired gesture control system to enable one hand to be used in controlling the motion of the robot and the other to be used in controlling the robotic arm. There can be autonomous and semi-autonomous robots. An autonomous robot is not controlled by a human being and acts based on its decision based on its senses to the environment. Majority of the industrial robots are autonomous as they are required to operate at a high rate and high precision. Nonetheless, semi-autonomous and human manipulated robots are required in certain uses. Some of the most popular control systems are the voice recognition, the tactile or touch controlled and motion controlled.

A Gesture Controlled robot refers to the kind of robot that it is possible to control using your hand signs, as opposed to the archaic buttons. All you need is to carry around a handheld transmitting device of limited size which was accompanied by an acceleration meter. This will send a correct command to the robot in the sense that it is able to perform anything that we desire. The Arduino nano, the Accelerator (MPU6050), RF Transmitter, and HT-12E Encoder were used as the transmitting device. At the RF Receiver module, the encoded data is received and decoded by and decoder IC(HT12D) at receiving end. An Arduino UNO then converts this information which is subsequently converted by our motor driver to control the motor. Now it is time to separate the work in various modules to make the work a simple and easy any project will become easy or error free as long as it is carried out in different modules. We have already divided our project into two distinct parts transmitter and receiver of the parts. Robotics is used mostly in cars, medical, construction, defense and even in the form of the firefighting robot to help the victims of the fire accident. It is however very difficult to control the robot either through a remote or a switch. In this way, a new project is developed, which is, an accelerator-based gesture control robot.

The main objective of the project is to control the movement of the robot with the help of accelerator by a hand wave. The robot is in most occasions an electro-mechanical machine that can be performed automatically. One can also find some robots, which will require a specific portion of the guidance, which will be possible with the assistance of a remote control or a computer interface. Robots can either be autonomous, semi-autonomous or remotely controlled. Robots have reached this degree of development and can even copy human beings to the point of making them appear as if they have a separate mind.

II. LITERATURE REVIEW

Gestures based robotic systems have been investigated by different researchers. Bhuiyan and picking [1] wrote about gesture-controlled user interfaces to elderly and the disabled users. Gesture mapping was suggested by Raheja et al. [2] to control a robotic hand in real-time. Waldherr, Romero and Thrun [3] have come up with a camera-based gesture interface used on mobile robots. The use of camera-based systems, however, demands a lot of computational power. Systems that are based on accelerators are more cost effective and efficient. The given project is an improvement on what has been done before, as it employs wired communication to control the hands with independence. Two alternative ways to recognize gestures are compared namely a template-based approach and a neural network approach. They both are used with the Viterbi algorithm to recognize gestures that are specified by arm motion (along with arm poses in the stationary state). The findings are presented as a part of an interactive clean up activity, where an individual directs the robot to certain areas that require cleaning and directs the robot to collect trash. The paper is about a proposed design of hand gesture-based control design of mobile robots. Mobile robots are capable of moving based on the hand gestures that bring about control signals.

Gestures are recognized by use of image processing, image counter processing and others. A mobile robot depends on the information that is recognized and decoded in order to control it. The movements of the mobile robot in the project are controlled by the gestures of a user. This model is made up of transmitter unit that has PIC Microcontroller to identify gestures. The receiver unit (mobile robot) will be following the instructions with PIC Microcontroller. This system was developed cheaply and in high efficiency. This project is aimed at controlling a mobile robot by use of hand gestures. In order to accomplish this, the hand pictures recorded are manipulated with the use of a circular Hough transform based approach, in order to identify the relevant targets. The control signals are then sent to the receiver unit to control the movement of the robot. In this paper, I have explained how human beings can interact with robots through simple hand signals. A leap motion sensor can be used to do this. In this case, we suppose that the robot can have an emotional interaction.

This experiment can assist us to realize how a human being can communicate with a robot in a manner that is effective through hand gestures. They present a hand-gesture- based control interface to navigate a car-robot in this paper. There is a three-axis accelerometer that captures the movement of the hand of the user. Data is provided wirelessly to a microcontroller by any form of connection. These received signals are then translated into a single out of six car-robot navigational control commands. This paper proposes a way of controlling an automaton with hand gestures with plaid of the Arduino Lilypad. The projected model is controlled by a motion device that is attached on the hand gloves. The key aim of this style is to manage robot victimization hand gesture. This project is mainly to control the movement of the robotic arm with the help of an accelerator/gyroscope-based gesture controller, much more convenient than a joystick or keyboard.

III. PROBLEM STATEMENT

Existing robotic systems lack intuitive control and often suffer from communication delays. There is a need for a low-cost, reliable and real-time gesture-based robotic system with independent arm control. Design and build a low-cost, real-time robotic arm that mimics a human operator's hand gestures sent wirelessly over a wired/wireless link (user said "wire" so these supports wired or wire-like comms). The system must read the operator's hand gestures, interpret them into control commands, transmit them to the robot, and actuate the robot arm to perform the same gestures and simple tasks (pick/place, point, open/close gripper) with acceptable speed and accuracy. Design and build a low-cost, real-time robotic arm that mimics a human operator's hand gestures sent wirelessly over a wired/wireless link (user said "wire" so these supports wired or wire-like comms). The system must read the operator's hand gestures, interpret them into control commands, transmit them to the robot, and actuate the robot arm to perform the same gestures and simple tasks (pick/place, point, open/close gripper) with acceptable speed and accuracy. Robotic arms that follow human gestures are useful for teleoperation, remote assistance, education, and assistive devices. Existing systems can be expensive or require complex setups. This project aims to demonstrate a compact, reliable prototype using affordable sensors, a simple communications link, and clear mapping between human gestures and robotic motions.

IV. OBJECTIVE

- Design dual-hand gesture sensing system using MPU6050 sensors.
- Implement robot navigation control.
- Implement robotic arm joint control.
- Establish reliable wired communication.
- Evaluate system performance.

V. SYSTEM ARCHITECTURE

The system consists of a transmitter section with two MPU6050 sensors and an Arduino Uno. The receiver section includes another Arduino Uno, L298D motor driver, DC gear motors and SG90 servo motors. LM2596 buck converter provides regulated power supply. Robotic Arm Robot hand controlled by gesture hand movements (2 wired hand control system) System Architecture Overview. The offered system is categorized into two great parts: Transmitter (Gesture Acquisition Unit) Section. Rx (Robot and arm Control Unit) The system provides a wired communication connection between the two parts so that it can be used to provide stable, low latency and interference free functioning. The building is built in such a way that: Right Hand-Regulates Robot Movement. Left Hand - Left Robotic Arm Control. The sensing and actuation are performed by two different controllers. Block Diagram Representation. RIGHT HAND (Robot Control) Left HAND (Arm Control) MPU6050 Sensor MPU6050 Sensor ----------- I2C Communication ----------- Arduino UNO (Transmitter) Wired Serial Communication Arduino UNO (Receiver) / \ L298D Motor Driver SG90 Servo Motors. 4V DC Gear Motors Robotic Arm Structure. Power Supply Section: LM2596 Buck Converter input 12V input - 5V regulated output. Transmitter (Gesture Acquisition Unit) Section. Components Used: 2 x MPU6050 1 x Arduino Uno Working: The two hands have both MPU6050 sensors attached to them.

Sensors measure: Acceleration (X, Y, Z) Angular velocity Data will be read through I2C (SDA SCL pins). Sensor data is processed by Arduino UNO. Tilt angles are calculated. Tilt is converted into commands with gesture mapping algorithm. UART serial communication is wired to the receiver Arduino where the commands are sent. Rx (Robot and arm Control Unit) Components Used: 1 x Arduino Uno 1 x L298D 2-4 x 4V DC Gear Motors 3-4 x SG90 4.1 Robot Locomotion Subsystem Arduino is fed with movement command. The logic signals include sending logic signals to L298D motor driver. L298D acts as dual H-Bridge. Speed and direction 4 V DC gear motors.

Movement Mapping: Forward Tilt- Robot pushes forward. Backwards Tilt - Robot moves backwards. Left Tilt - Robot turns left Right Tilt - Robot turns right the fourth subsystem is the Robotic Arm Control Subsystem. and Second MPU6050 manages the arm joints. PWM is generated by Arduino. SG90 servo motors are operated by PWM signals. Arm Movement Mapping: Forward Tilt - Arm up Backward Tilt - Arm down Left Tilt - Base rotate left Right Tilt - Base rotate right Wrist rotation - Gripper open/ close. Servo motors have accurate angularity (0-180deg). Power Management Architecture. Components Used: LM2596 Power Flow: 12V Battery/Input Supply LM2596 Buck Converter converts it to 5V. 5V supply powers: Arduino boards MPU6050 sensors 12V supply powers: L298D motor driver Regulated 5V suggested as separate and recommended to be used with servo motors. Coexistence is sustained in the system. Communication Architecture The system is wired with the serial communication (UART) between: Send Arduino -Get Arduino

VI. METHODOLOGY

The MPU6050 measures acceleration and angular velocity. Tilt angles are calculated using filtering algorithms. Gesture mapping converts tilt direction into robot and arm commands. The L298D motor driver controls DC motors while servo motors are controlled using PWM signals. Wired UART communication ensures low latency operation. L298N is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers as they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors. L298N contains two inbuilt H-bridge driver circuits. In common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state. This project controls a remote robot through RF. The ordinary 433 MHz RF modules are used in this project. Arduino microcontroller is used in this project. These robots are used basically for industrial applications. This is an improved version of the joy stick control robot which has been designed years ago. Intelligent spy robot project has been designed for the spying purpose.

VII. DISCUSSION

Experimental results show response time between 100–150 MS with approximately 85–90% gesture accuracy. The wired communication improves reliability compared to wireless systems. Limitations include servo torque constraints and sensor drift over long operation. The designed system exhibits the phenomenon of a dual-hand wired gesture-controlled robotic platform where a hand controls the locomotion of a robot and the other hand controls the robotic arm. Gesture control systems offer natural and intuitive human-machine interface as presented in [1] and [3]. In comparison to a camera and high processing power vision-based gesture system, an accelerator-gyroscopes system is relatively cheaper and low-power consuming [2]. The flow of the system is that there are two MPU6050 sensors to take motion data, two Arduino Uno boards that can perform separate sensing and actuation functions. It is a distributed processing mechanism which helps to lower the load on the system and enhances reliability.

Gesture Recognition and Gesture Processing. The MPU6050 has 3-axis accelerator and 3-axis gyroscopes, which allows the calculation of the tilt angle to detect the orientation [5]. The I2C protocol can be used to effectively communicate between the sensor and Arduino microcontroller. In experimental testing, it was found that the accuracy of gesture recognition was 85-90 percent, which is in line with other studies of the accelerator-based robotic control systems [2]. Some minor drift errors were found as a result of the bias in the gyroscopes, which is included in the MPU6050 technical documentation [5]. Robot Locomotion Performance. The L298D has the ability to control the direction and speed of DC motors and is used to control robot movement [6]. The 4V DC gear motors were smooth in movement forward, backward, left and right. Speed control by PWM permitted a modest variation of speed. In the analysis of the standard motor driver in the robotic control systems. H-bridge drivers such as L298D are considered to be reliable in managing the forward or backward movements without impairment but with a bit of loss of power owing to voltage drop, which was also experienced in the system. Analysis of Robotic Arm Control. The robotic arm is powered by SG90 motors that have a working range of 0deg-180deg [7]. Robot manipulators often include the use of servo motors in order to provide very precise control of positioning.

VIII. CONCLUSION

The project successfully demonstrates a dual-hand gesture-controlled robot with arm. It offers improved human-robot interaction, real-time control and cost-effective implementation. Hand Gesture Controlled Robot with Dual-Hand Operated Robotic Arm (Wired System)

The present project successfully designed and implemented a dual-hand gesture-controlled robot with a robotic arm, where robot locomotion is controlled by one hand and the robotic arm is independently controlled by the other hand. Gesture-based human–robot interaction provides a natural and intuitive interface compared to conventional joystick or button-based systems, as discussed in gesture control studies [1], [3].

The system utilizes two MPU6050 sensors to detect hand orientation and motion. The accelerometer and gyroscope data are processed using two separate Arduino Uno boards, ensuring distributed processing and improved reliability. The use of dual microcontrollers minimizes computational load and enhances real-time response, aligning with modular robotic architecture principles described in [9].

Robot movement is achieved through 4V DC gear motors controlled by the L298D, which provides bidirectional motor control through an H-bridge mechanism [6]. The locomotion subsystem demonstrated smooth directional control and stable speed regulation using PWM signals. Although minor voltage drops were observed under heavy load, the driver performed satisfactorily within its specified limits [6].

The robotic arm mechanism is powered using SG90 motors, which offer precise angular control within 0°–180° range [7]. The servo motors enabled accurate base rotation, elbow movement, and gripper operation. However, as stated in the servo motor specifications [7] and robotic manipulator studies [10], the torque limitation restricts heavy load handling capability. Despite this, the arm performed efficiently for light object manipulation and demonstration purposes.

Power regulation was effectively managed using the LM2596, which provided stable 5V output from a higher voltage supply. Switching regulators such as LM2596 offer higher efficiency and reduced heat dissipation compared to linear regulators [8], which contributed to stable system performance without unexpected resets.

The use of wired serial communication ensured low latency, minimal signal interference, and reliable data transmission between the transmitter and receiver units. Compared to wireless systems discussed in [3], the wired approach provided more predictable and stable operation, especially in controlled laboratory environments.

Overall, the system achieved gesture recognition accuracy of approximately 85–90%, with response time between 100–150 Ms. These results confirm that accelerometer–gyroscope-based gesture control is a practical and cost-effective solution for robotic applications [2], [5].

In conclusion, the project successfully fulfils its objectives by developing a reliable, low-cost, and real-time dual-hand gesture controlled robotic system. The integration of MPU6050 sensors, dual Arduino architecture, L298D motor driver, SG90 servo motors, and LM2596 voltage regulation forms a stable embedded robotic platform suitable for educational, research, and light industrial applications. The system demonstrates the feasibility of intuitive human–robot interaction and provides a strong foundation for future advancements in intelligent robotic control systems [9], [10].

IX. Discussion

The on-board batteries occupy a lot of space and are also quite heavy. We can either use some alternate power source for the batteries or replace the current DC Motors with ones which require less power.

The proposed system is applicable in hazardous environment where a camera can be attached to the robot and can be viewed by the user who is in his station. This system can also be employed in medical field where miniature robot is created that can help doctors for efficient surgery operations for more efficient response, threshold values can be used to detect gesture and advanced features such as finger counts that provide different functional commands can be used.

Automation systems – In homes, offices, transport vehicles and more, gesture recognition can be incorporated to greatly increase usability and reduce the resources necessary to create primary or secondary input systems like remote controls, car entertainment systems with buttons or similar.

Entertainment applications – Most videogames today are played either on game consoles, arcade units or PCs, and all require a combination of input devices. Gesture recognition can be used to truly immerse a player in the game world like never before.

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