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ROBOTIC VEHICLE MOVEMENT AND ARM CONTROL THROUGH HAND GESTURES USING ARDUINO

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Abstract - *Robotic vehicle movement and Arm control through hand gestures using arduino is an assistive robot system for user-friendly support, hospital operations, and hazardous environment and to increase the autonomy of physically impaired people. It is a kind of functional replacement hand integrated with the moving vehicle that aids the amputees often suffers from physical difficulties. The prime aim of this system is to make it feasible to interact with the robot through the recognition of hand gestures for the physically challenged people. This is an electromechanical system in which the robotic arm can be controlled by a simple inertial navigation sensor called accelerometer. Similarly the soft catching gripper connected to the robotic arm can be controlled by flex sensor. The gesture commands measured by the accelerometer and flex sensor are processed by the arduino controller. The arduino controller is used in both the transmitter and receiver circuits, it responds based on the input given through the hand gestures. The signals get transmitted and received by advanced wireless nRF communication system. The robotic vehicle can move in all possible four directions (forward, backward, right and left). The different operations performed by the robotic arm are picking and placing the objects from one location to another location. For the controlling of the motor, motor driver IC and arduino controller is used. This system provides more natural and convenient ways to express their intentions and interactions with the environment.*

***Key Words*: Gestures, Accelerometer, Flex Sensor, Arduino, nRF Module, Driver Circuits, Robotic Arm and Robotic Vehicle.**

1. INTRODUCTION

Present day industry is mainly focusing towards computer-based interaction and robots to improve their productivity and delivery of end products with uniform quality to remain one step ahead of competitors. Today's robots are quick, canny, prudent, accurate and more sensible than in the past years and are becoming increasingly viable for the high mix-low volume and low mix-high volume production. Collaborative robots, or "cobots", are capable of working together with the humans and physically interact with the humans in a shared workspace. In addition, cobots use sensor technology that enables the function safely alongside humans in a hazardous environment and prevents them from handling risky works. Generally robots are used to perform dangerous, tricky and highly repetitive task and it also reduces the presence of human. The robotic operations are tremendously increased and have been widely accepted by many countries due to its error free functioning. Apart from industries, robots offer best solutions for designing a home automation system for elderly people and supportive system for the physically impaired people.

Gesture recognition is a highly adaptive interface between the robots and users. It allows the operations of complex machines using hand movement thereby eliminating physical contact. The gesture controlled robots provides an opportunity to integrate disabled people into their normal working life as well as to increase the autonomy in activities of daily living. This kind of control could offer a practical way to give disabled people more independence. They can even help to meet challenges posed by military and defense operations. They can also be used in surgical operations. Under some circumstances surgeons were unable to be on time to perform operations which could be fatal in many cases and shifting of patients become impractical. This system can explore the remote robot in the diverse environment utilizing different motion orders.

1.1 Objective

The main objective is to develop a hand gesture based robotic vehicle with an end effector to pick and place objects controlled by nRF communication to increase the autonomy of physically impaired people by using MEMS technology. This is an attractive and compact embedded device with sensors to sense the activities of human hands and to capture motion information from accelerations in a form of analog voltage. This approach is focusing primarily on the task of grasping objects of different shapes and not that of manipulating or assembling objects. This type of grasping device has a variety of applications in object retrieval systems for the handicapped, planetary, underwater exploration and robotic surgery.

Also, to control the displacement of the robotic arm so that the arm can be used to pick and place objects from any source to destination.

2. LITERATURE REVIEW

There are numerous ways for controlling the robots with unique methods and design criteria exist. Robots are most often controlled using tether (wired), wirelessly or autonomously. Some of the traditional wireless controlling methods are using mobile phones, joysticks, keypad, computer terminal, even interfacing with the internet so that they can be controlled anywhere. The following are some of the widely used controlling methods for the robotic vehicle as well as the robotic arm.

A microcontroller based system which can be operated by android application. The user's friendly interface present on the operator's mobile phone can be used to control the robotic vehicle as well as its robotic arm. A Bluetooth module acts an interface between the mobile phone and robotic vehicle. This sends proper motional commands to the motors interfaced with the robot according to the signal received. This framework can be employed in chemical industry for handling of hazardous chemicals like sulfuric acid, nitric acid, sodium cyanide etc and prevents humans from inhalation, absorption through skin and ingestion. They can also be used for the movements of heavy objects in any industry [1].

A robotic arm integrated with microcontroller, LCD, DC motors and RF video camera controlled by Internet/LAN connection which is mainly used for patient operation. A proper averaging algorithm is used to reduce the amount of noise coming from the output of the sensors. The Ethernet adapter configured with particular IP address can receive the data from the particular computer. The adapter will send the received data to the microcontroller through serial port. After receiving the data, the microcontroller sends appropriate signals to the DC geared motors to control the robotic arm. This framework is mainly used to cut the skin of the patient using the high-speed blades which is nothing but the robotic arm [2].

The vehicle movement can be controlled based on the detection of motion of hand and refrains the movement of the vehicle if any obstacle is detected in its path. The user can make the vehicle to move around in all possible four directions by simply moving his hand in the desired directions. So that the user doesn't need to press any buttons. The gesture commands can be captured by a simple inertial navigation sensor called Accelerometer. This system also includes ultrasonic sensor which can be helpful to prevent the robotic vehicle colliding with any obstacle. The signals from the sensors are forwarded to the microcontroller and encoder circuit. The encoded signal is transmitter through RF transmitter. RF receiver receives the signal and decodes it. Finally the microcontroller gives appropriate signals to the motors to change the movements of the robots. This system can be used in the field of construction, hazardous waste disposal and field survey near borders [3].

The robotic platform and the robotic arm can be controlled by two separate accelerometers. One accelerometer is mounted on the human hand and another one mounted on the leg of the user capturing its gestures and postures and thus the robotic arm and the platform moves accordingly. The motions performed by the platform are forward, backward, right & left and the operations performed by the robotic arm are pick & place/ drop, raising and lowering the objects. The RF Module is used to transmit the different hand and leg gestures made by the user. The system is also equipped with an IP based camera which can stream real time video wirelessly to any Internet enabled device such as Mobile phone, Laptop, Tablet etc. The biggest advantage of this kind of robotic arm is that it can work in hazardous areas and also in the area which cannot be accessed by the human and also used to implement highly precise medical treatments [4].

3. SYSTEM SUMUP

The wireless gesture controlled robot dynamically navigated in all possible four directions i.e. forward, backward, right and left and it is equipped with a non prosthetic robotic arm for picking and placing operations. The robotic arm is mounted on a moving vehicle and the vehicle is able to move along any type of surface. The robotic arm accommodates all degrees of freedom, in order to reach all sides of the component, to take up position to any inclination. When user moves his hand in any direction then the robotic arm can move accordingly to the direction of the user hand. The arm equipped with an end effector can picks up the object with a strong grip and places it at the desired position. The wheels underneath the base help to move the robot to the desired location. The motors can be controlled by arduino which can provide required motional commands to the robot and controls the displacement of the robotic arm. Motors are seized based on desired torques/speeds, and are very constrained by physical size. The whole system is divided into two sections one is transmitter section and other is receiver section. This system provides an opportunity to increase adaptability and opens up new application areas and reduces the gap between the physical world and the digital world with an output more intuitive.

4. TRANSMITTING END

The transmitter section consists of Arduino Uno Rev3 SMD, 3-axis accelerometer (ADXL 335), flex sensor, push button switches and nRF24L01 with 2.4GHz transmitter module. A separate 5 volt power supply which may be a battery source or through laptop or pc is applied to the arduino controller. The arduino Uno, flex sensor, push button switches and transmitter module receives 5V power supply. Accelerometer takes 5V supply but a voltage regulator is inbuilt on the sensor which regulates power supply to 3.3V. The block diagram of transmitter prototype is shown in figure 1.

The accelerometer sensor and flex sensor are attached to the user's hand for capturing different types of gestures like movements of hand and flex of fingers. According to the movements of the hand, input is taken from the accelerometer sensor and flex sensor then the corresponding signal is sent to the controller. When the user moves his hand or finger, the sensors fixed to the hand outputs an analog voltage value. The Arduino Uno reads the analog output values i.e. x-axis and y-axis values from the 3 axis (ADXL 335) accelerometer sensor and flex sensor. The analog outputs values which were achieved by parts of the body must need to convert in digital form for further proceed. The converted digital values processed by the arduino controller. This signal is utilized for the displacement of the robotic arm and soft catching gripper. The push button switches incorporated with the system is used to drive the wheels of the robotic vehicle.

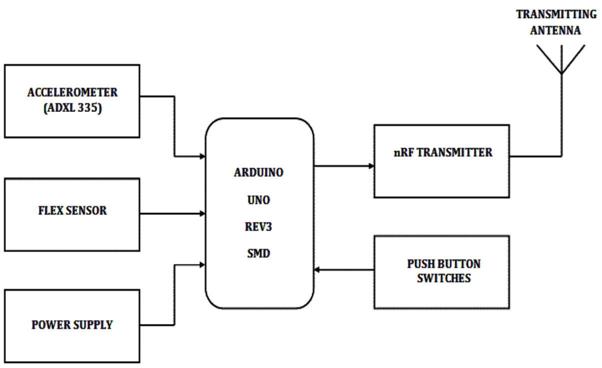

Figure 1: Block Diagram of Transmitter

4.1 Arduino Uno SMD

The Arduino Uno SMD is a version of Arduino Uno, but uses a surface mount version of the Atmega328P rather than the though-hole version. The board has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Simply connect it to the computer with a USB cable or power it with an AC to DC adapter or battery to get started with the arduino board.

Table 1: Specifications of Arduino

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recomd.)	7-12V
Input Voltage (limits)	6-20V
Digital I/O pins	14
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32KB (ATmega328)
SRAM	1 KB (ATmega328)
Clock Speed	16 MHz

4.2 Accelerometer

ADXL 335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned outputs. It has 6 pins namely power supply (VCC), ground (GND), self-test (ST) and remaining 3 pins are for X, Y, Z axis. By tilting an accelerometer along its measured axis, one can read the gravitational force relative to the amount of tilt. The accelerometer can measure the force applied on the sensor in all the 3 directions X, Y and Z axis. The sensor provides three values X, Y and Z which are calibrated for the four types of movement and a stopped position at center by use of the error values in the axis directions. It operates on 3.3V from the Arduino Uno board. In this project only 2 axes namely X and Y are used. X and Y pins are connected to A0 and A1 pin of the board respectively. The advantage of accelerometer is that the values do not change unless there is a change in position.

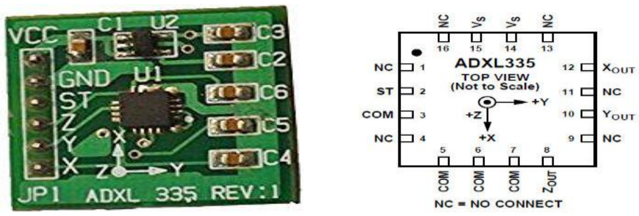

Figure 2: Accelerometer (ADXL 335)

4.3 Flex Sensor

The flex sensor also known as variable resistor but the resistance changes according to the bending i.e. flexing. It detects the bending movements and can be made unidirectional or bidirectional. It works on the principle of change of resistance. Flex sensor is basically a strip of carbon material having metal pads inside it which measures the amount of deflection caused by bending the sensor. Internally it consists of a carbon resistive element with thin substrate. As the substrate is flexed when it is bent, sensor produces resistive output which is equivalent to bend radius of the carbon strip having metal pads. To turn the flex sensor's variable resistance into a readable voltage, we will combine it with a static resistor to create a voltage divider.

Figure3: Flex Sensor

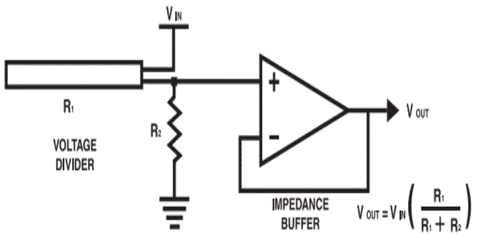

Figure 4: Circuit Diagram of Flex Sensor

To turn the flex sensor's variable resistance into a readable voltage, we will combine it with a static resistor to create a voltage divider. This resistor kit is handy for some trial and error testing to hone in on the most sensitive circuit possible. The flex sensor provides greater accuracy for small movements and smaller the radius, the higher the resistance value. The flex sensor is attached to the fingers of the human as the user flexes his fingers for particular application flex sensor also bends by same amount and performs the desired operation.

5. RECEIVING END

The receiver section consists of Arduino Uno with DIP package, Motor Driver IC L293d, DC Geared Motors, Servo Motor, 12V Rechargeable Battery Source, Robotic Platform, Robotic Arm and nRF24L01 with 2.4GHz Receiver Module. A separate 5 volt power supply which may be a battery source or through laptop or pc is applied to the arduino controller. The receiver module receives the modulated signal from the transmitter and demodulates it. Then the signal is fed to the arduino controller. The block diagram of receiver prototype is shown in figure 5.

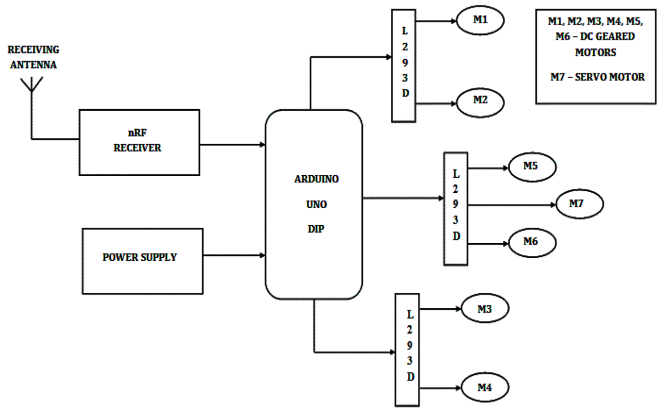

Figure 5: Block Diagram of Receiver

The controller drives the motor of the robotic vehicle and robotic arm through motor driver to control the displacement of the arm, opening & closing of the grippers and movement of the platform.

5.1 Robotic Arm

Robotic arm is the type of mechanical arm which is fixed to the receiver part of the circuit; the control signal came from the Arduino output based on the gesture input given in the transmitter part by using accelerometer sensor. The robotic arm can rotate about the axis of 360 degree, which is fixed to the one of the DC geared motor. The rotational control and the movement of the arm is based on the gesture input that is given from the transmitter section. The one part of hand is about 20 cm and another part of the arm (elbow part) which is 30 cm long. The certain load is applied at the end of the arm for lifting the objects of desired weight. The servo motor is used for the purpose of gripping and placing the objects, because the servo motor is used for the low torque application. The control of the gripper is from the flex sensor which is in the transmitter part. That voltage output is sent to the Arduino which processes that signal and given to the nRF transmitter. The robotic arm will be controlled via the designed controller and it will be able to grab, pick up and move objects according to their weights and shape. The manipulator design is mostly expected to pick up cubes and the geometric shapes like a box.

5.2 Robotic Vehicle

The vehicle consists of four wheels which are connected to the DC geared motor and which is controlled by the switches that are present in the transmitter part. The switches have the four operations (Forward, Backward, Left and Right) respectively in the series manner. These switches are pressed by the users for their needs and it sends the voltage signal to the transmitter section Arduino. The nRF communication system is used for the transmission and receiving purpose. The Arduino checks the input of the system and sends a 4 bit code to the Encoder IC. The Encoder passes the data to nRF transmitter and the transmitted data is received by the nRF receiver. The receiver sends the 4 bit code to the Decoder IC and the decoder passes it to Motor Driver IC. Later the motor driver makes the decision to turn the two motors in the required direction based on the input key which is pressed. L239D is an interfacing device which is used to interface the wheels of the vehicles. In a single chip we interfaced 2 motors, we are using six DC geared motors and a servo motor for the vehicle.

5.3 L293D Motor Driver IC

L293D is a dual H-bridge motor driver Integrated Circuit (IC) which is having 16 pins i.e. 4 input pins, 4 output pins, 4 VCC pins and 4 ground pins. We have connected VCC pins to the 12V DC supply which is nothing but a rechargeable battery source. Motor driver acts as current amplifiers since they take low current control signal and provides a higher current signal. This higher signal is used to drive motors. When an enable input is high, the associated driver gets enabled. As a result, the output becomes 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. The pin diagram of L293D IC is shown in figure 6.

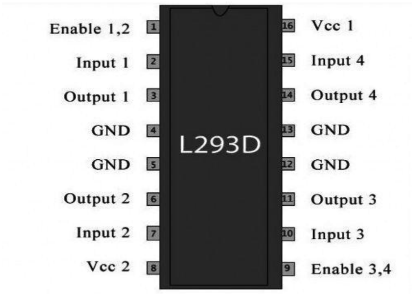

Figure 6: Pin Diagram of L293D IC

6. RESULTS AND DISCUSSION

The experimental setup of transmitter and receiver prototype is shown in figure 7 and 8 respectively. Experiments were done mainly in two parts. In the first part, we tested the transmitter module separately by connecting the Arduino controller to the PC/Laptop and observed the output for different movements of the accelerometer and bending of the flex sensor in the Arduino software (IDE). In the second phase we tested the receiver module by giving inputs from the transmitter and successfully observed the displacement of robotic arm, opening & closing of grippers and then the movements of the robotic platform in all possible four directions. From observation that has been made, it clearly shows that the movement of the robot is precise, accurate, and is very easy to control and moreover user friendly to use. The performance of the robotic arm and robotic vehicle was checked using different hand movements. The robotic arm design is very simple and has the ability to grasp light weight objects and also mimic the hand gestures almost flawlessly. This robotic arm can perform complex and hazardous operations with ease. Thus the assistive or supportive robot system was assessed positive in the subjective evaluation. The participants subjectively perceived that the hand gesture performance as easy i.e. robotic vehicle movements, robotic arm motions and opening and closing of grippers. This can be well suited for pick and place operations. Using this framework, a non expert robot programmer can control the robot quickly in a natural way.

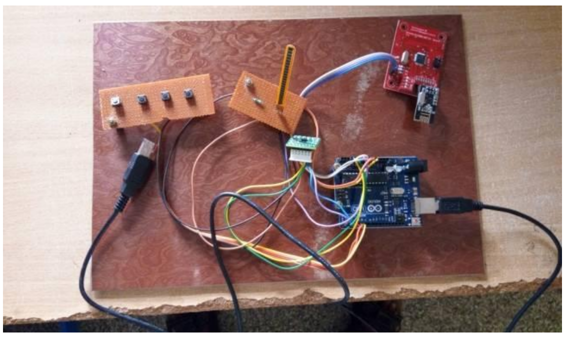

Figure 7: Model of Transmitting End

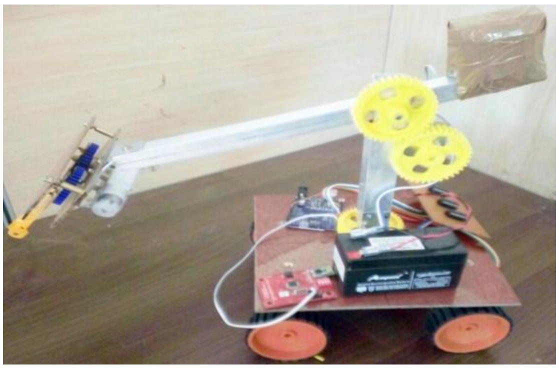

Figure 7: Model of Receiving End

7. CONCLUSIONS

The objective of this paper has been achieved which was developing the hardware and software for a gesture based robot. Gesture based interactions allow human computer interaction to be in a natural way as well as in intuitive manner. Therefore people were able to control the robot and gripper intuitively with hand motions. This type of control could improve productivity, reduce the effects of repetitive motions and improves safety. The performed usability study points out that the system is well-suited for the pick and place operations for physically impaired people and in laboratory environments and can be used where the humans are unable to sustain in the dangerous or harsh environments. This system can also be used in defense to load or diffuse bombs under emergency or war situation and cleaning agent in sewage and drainages.

Further developments like introducing an IP or Wi-Fi based camera in the receiver section which may be helpful for the end user to monitor or track the movement of the vehicle and performance of the robotic arm. This system provides an opportunity to increase adaptability and opens up new application areas and reduces the gap between the physical world and digital world with an output more intuitive.

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