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Hand Gesture Controlled Robot

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Abstract- **In this paper, hand gesture controlled robot is being proposed. Gesture commands freely trainable by the user can be used for controlling external devices with handheld wireless sensor unit. The accelerometer depends upon the gestures of hand. Through accelerometer, a passage of data signal is received and it is processed with the help of Arduino microcontroller. The microcontroller controls the robot to move in the desired direction.**

Index Terms- **Gesture recognition, Accelerometer, Gesture controlled robot, Accelerometer controlled robot, Hand controlled Robot**

I. INTRODUCTION

In recent years there is growing interest in robots. Robots have been used in many applications. The increase in human-machine interactions (HMI)in daily lives has made user interface technology progressively more important. Physical gestures as intuitive expressions will greatly ease the interaction process and enable humans to more naturally command computers or machines. Many kinds of existing devices can capture gestures, such as a Wii Remote, joystick, and trackball and touch tablet. Some of them can also be employed to provide input to a gesture recognizer. But sometimes, the technology employed for capturing gestures can be relatively expensive, such as a vision system or a data glove [1].

There are mainly two existing types of gesture recognition methods, i.e., vision-based and accelerometer and/or gyroscope based. Due to the limitations such as unexpectedambient optical noise, slower dynamic response, and relatively large data collections/processing of vision-based method, our recognition system is implemented based on MEMS acceleration sensors. Since heavy computation burden will be brought if gyroscopes are used for inertial measurement, our current system is based on MEMS accelerometers only and gyroscopes are not implemented for motion sensing [2].Finalizing the decision of making a gesture controlled robot that will be manoeuvred by a hand gloved mounted with the transmission circuit assembly[21]. The circuit assembly will consist of accelerometer & Arduino board along with an Xbee transmitter, which together function as an input device to the robot..The purpose of this project is to control a robot with human hands to enhance HMI. The robot is controlled based on gesture of hand, which becomes simple for any person to handle it. The basic working principle for our robot is passage of the data signals of accelerometer readings to the arduino board fitted on the robot. The program compiled in that Arduino runs according to the accelerometer values, which makes the robot function accordingly. While we have used three-axis accelerometer, in which, one axis will control the speed in forward or backward direction and other two axes will control the turning mechanism.

II. PROPOSED WORK

There are mainly five components as shown in the figure 1, used for processing & performing the action by the robot which is as follows:

1. MEMS Accelerometer (ADXL 335)
2. Arduino board with Atmega328 microcontroller
3. Arduino board with Atmega 2560 microcontroller
4. Xbee Transmitter and Receiver Module
5. Mechanical components

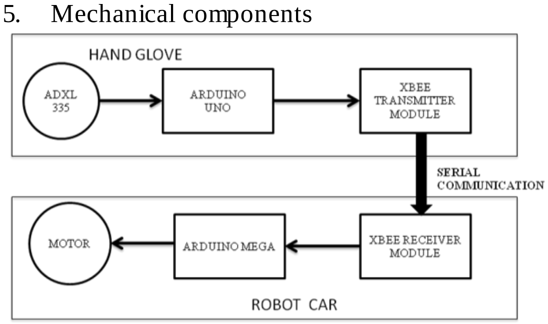

Fig 1:Block diagram

1. Sensing Device

An accelerometer is a device that measures proper acceleration. Single- and multi-axis models of accelerometer are available to detect magnitude and direction of the proper acceleration (or g-force), as a vector quantity, and can be used to sense orientation (because direction of weight changes), coordinate acceleration (so long as it produces g-force or a change in g-force), vibration, shock, and falling in a resistive medium (a case where the proper acceleration changes, since it starts at zero, then increases).Three axis ADXL335 accelerometer is being used [4].

1.1 Accelerometer ADXL335

The ADXL335 is a three-axis accelerometer with extremely low noise and power consumption (320µA). The sensor has a full sensing range of ±3g.There is no on-board regulation, provided DC power should be between 1.8 and 3.6V. The ADXL335 is a small, thin, low power, complete three-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3*g*. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis. The ADXL335 is available in a small, low profile, 4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale package as shown in fig 2.

Fig 2: ADXL 335

1.2Theory of operation of ADXL335

The ADXL335 is a complete 3-axis acceleration measurement system. The ADXL335 has a measurement range of ±3 *g* minimum. It contains a poly silicon surface-micro machined sensor and signal conditioning circuitry to implement open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration.

The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration. The sensor is a polysilicon surface-micro machined structure built on top of a silicon wafer. Polysilicon springs suspend the structure over the surface of the wafer and provide a resistance against acceleration forces. Deflection of the structure is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and unbalances the differential capacitor resulting in a sensor output whose amplitude is proportional to acceleration [5].Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration.

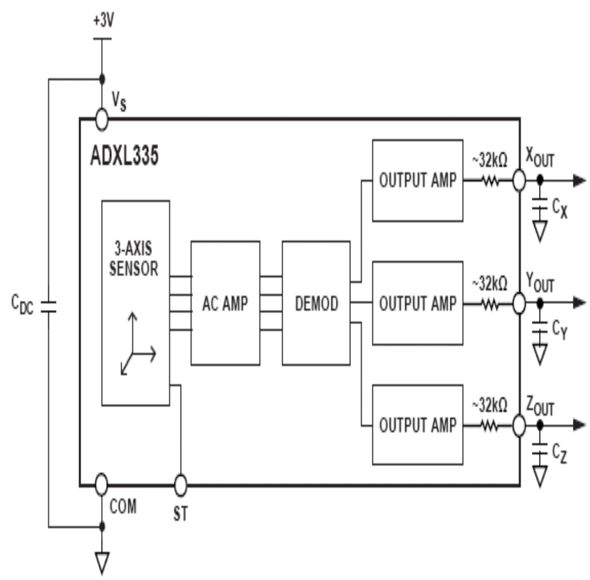

Fig 3: Block diagram of ADXL335

The demodulator output is amplified and brought off-chip through a 32kΩ resistor. The user then sets the signal bandwidth of the device by adding a capacitor.

This filtering improves measurement resolution and helps prevent aliasing.

2. Arduino

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer (e.g. Flash, Processing, and MaxMSP. It is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board[8]. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs.

Arduino projects can be stand-alone, or they can be communicated with software running on your computer (e.g. Flash, Processing, and MaxMSP.) The boards can be assembled by hand or purchased preassembled; the open-source IDE can be downloaded for free.

3. Xbee

The XBee/XBee-PRO ZB RF Modules are designed to operate within the Xbee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices.

3.1 Xbee specification

Xbee is the brand name from Digi International for a family of form factor compatible radio modules. The first XBee radios were introduced under the MaxStream brand and were based on the 802.15.4-2003 standard designed for point-to-point and star communications at over-the-air baud rates of 250 kbit/s. Two models were initially introduced—a lower cost 1 mWXBee and the higher power 100 mWXBee-PRO. Since the initial introduction, a number of new XBee radios have been introduced and all XBees are now marketed and sold under the Digi brand. The XBee radios can all be used with the minimum four number of connections - power (3.3 V), ground, data in and data out (UART), with other recommended lines being Reset and Sleep .Additionally, most XBee families have some other flow control, I/O, A/D and indicator lines built in. A version of the XBee called the programmable XBee has an additional onboard processor for user’s code. XBee Modules are available in two form-factors; Through-Hole and Surface Mount. All XBees (with the exception of the XBee 868LP) are available in the popular 20-pin Through-Hole form-factor. Certain XBee modules are also available in a 37-pad Surface Mount design, which is popular for higher volume applications due to the reduced manufacturing costs of SMT technology [9].XBee Modules typically come with several antenna options, including U.FL, PCB Embedded, Wire, and RPSMA.

3.2 Xbee Configuration

The XBee can operate either in a transparent data mode or in a packet-based application programming interface (API) mode. In the transparent mode, data coming into the Data IN (DIN) pin is directly transmitted over-the-air to the intended receiving radios without any modification. Incoming packets can either be directly addressed to one target (point-to-point) or broadcast to multiple targets (star). In API mode the data is wrapped in a packet structure that allows for addressing, parameter setting and packet delivery feedback, including remote sensing and control of digital I/O and analog input pins.In this project, Xbee is configured using XCTU software .Transmitter Xbee is configured as coordinator and Receiver Xbee as router with a baud rate of 9600.

4. DC Motor

A DC motor is based on the fact that like magnet poles repels and unlike magnetic poles attracts each other. A coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. By switching the current on or off in a coil its magnet field can be switched on or off or by switching the direction of the current in the coil the direction of the generated magnetic field can be switched 180°.

4.1 Description of DC motor

A simple *DC motor* typically has a stationary set of magnets in the stator and an armature with a series of two or more windings of wire wrapped in insulated stack slots around iron pole pieces (called stack teeth) with the ends of the wires terminating on a commutator. The armature includes the mounting bearings that keep it in the center of the motor and the power shaft of the motor and the commutator connections.

4.2 Working of DC motor

The winding in the armature continues to loop all the way around the armature and uses either single or parallel conductors (wires), and can circle several times around the stack teeth. The total amount of current sent to the coil and the coils size and what it wrapped around dictates the strength of the electromagnetic field created. The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a force on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor. At high power levels, DC motors are almost always cooled using forced air [10].

The commutator allows each armature coil to be activated in turn. The current in the coil is typically supplied via two brushes that make moving contact with the commutator. Now, some brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes to wear out or create sparks. Different number of stator and armature fields as well as how they are connected provides different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature

The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems which adjust the voltage by "chopping" the DC current into on and off cycles which have an effective lower voltage.Since the series-wound DC motor develops its highest torque at low speed, it is often used in traction applications such as electric locomotives, and trams. The DC motor was the mainstay of electric traction drives on both electric and diesel-electric locomotives, street-cars/trams and diesel electric drilling rigs for many years. In this project three motors have been used .Two of them are used for forward and backward movement and third one for tilting the robot in the left and right directions.

III.EXPERIMENTAL ANALYSIS

A. System Work Flow

The workflow of the project shown in fig 3 is explained as follows. When the sensing system is switched on, the accelerations in three perpendicular directions are detected by sensor. Thesequence of gestures is calibrated for each of the accelerometer data[15]. The sequence is then sent via Xbee and range test is done at the receiver side.

For each of the test condition any of the three motors is controlled accordingly .If the condition is not satisfied, the Range test is repeated until the true condition occurs.

B. Calibration of ADXL335

The accelerometer is calibrated on both hardware and software .The hardware values as shown in Table 1 are measured using a Multimeter. The accelerometer is calibrated by tilting it in different axes and planes to obtain optimized values[18]. Some of the axial values are listed in the Table 1. The accelerometer is calibrated using Arduino IDE software. Different values are observed for each axis.

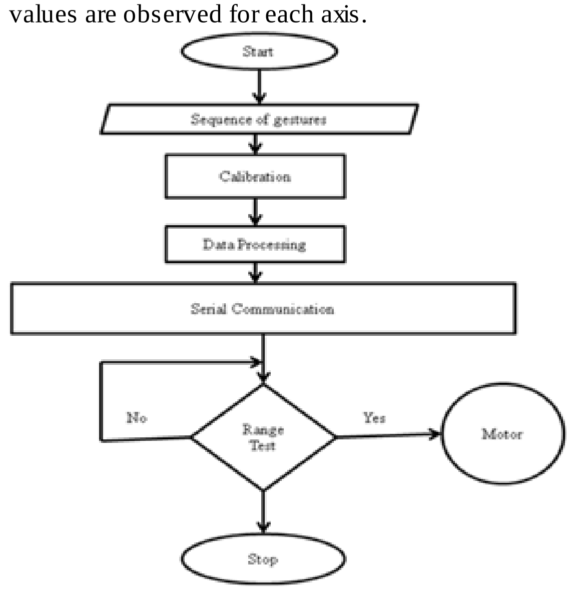

Fig 3: Workflow of gesture recognition

AxialValues : Along x-axis		
X axis	Y axis	Z axis
1.3	1.67	1.68
1.366	1.634	1.70
Along XZ Plane		
1.3	1.62	1.656
1.41	1.61	1.71
1.8	1.741	1.377
1.97	1.65	1.512
1.804	1.64	1.405

Table 1: Accelerometer values

C. Data Processing

Sensing device used in this project produces the analog values corresponding to the acceleration of three axes. The calibrated accelerometer values are transmitted using Xbee by assigning characters for each range of accelerometer values. Each incoming gestures values for all three axes will be compared with every predefined axis value. When the detected gesture is same as that of predefined one, arduino controls the motor accordingly thereby controlling the robot.

IV.CONCLUSION AND FUTUREWORK:

This paper has proposed a novel approach to hand gesture recognition which can be utilized in natural interaction between human and machines.This project is an accelerometer-based human-machine interaction method for controlling a robot car

The future work will focus on enhancing the system such that it can be used for archeological purposes. By fixing the surveillance camera in the robot the system can be used for research purposes. The working model of hand gesture controlled machine is proposed in this project .The further improvements can be made to implement it in the automobiles and other machines.

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