WHEELCHAIR CONTROL USING 3 DOF HEAD GESTURE RECOGNITION

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Abstract- Due to some diseases as parkingson, paralyzed wheelchair users cannot independently move. This project presents a 3 DOF automated microcontroller-based system to assist wheelchair users in controlling the motion of a wheelchair using head movements. The proposed system will assist quadriplegic handicapped people who are incapable of moving their arms and legs to steer an automated wheelchair. In order to achieve this goal, a novel head gesture recognition technique based on Inertial Measurement Unit (IMU) sensor is used. The sensor device is mounted on the operator's head, where it permanently measures orientation angles that are converted into adequate steering commands. The reading of the IMU sensor is sent wirelessly to the wheelchair control unit that can steer the motion of the wheelchair in any of the four directions. The automated wheelchair consists of the sensor unit carried by the driver and the mechanical system that is controlled by Atmel Microcontroller. The system can be used with several types of standard electrical powered wheelchairs.

Keywords- Inertial Measurement Unit, Head Gesture Recognition, Wheelchair Control.

I. INTRODUCTION

Often, paralytic patients who lose the ability to move their body parts tend to be sitting down the whole day because of their incapability to move independently. The recent technology and the health-care societies have established several programs and projects to overtake the difficulties faced by paralyzed people.

Electrical wheelchair is one of the most common tools for disabled people. Since the most common way of running a wheelchair is by using a joystick connected to actuating elements, engineers have historically focused on improving aspects of these kinds of systems. Unfortunately, for a category of disabled people; the quadriplegics, who suffer from a specific spinal cord injury and become unable to use any of their limbs with the exception of the head; it is nearly impossible to control a wheelchair via the common joystick interface system that requires the user to push a joystick into the desired direction of movement. So, in this project, we propose the use of a head-mounted Three Degree of Freedom Orientation(3DOF) IMU sensor to give the target group mentioned above an easy way of controlling their vehicle by intuitive head movements. We will be using an IMU sensor which will be fixed at the operator's head, where it measures the orientation angles to convert them into steering commands. The MCU will read the angles via the IMU sensor, and send the readings wirelessly to the control unit of the wheelchair to move it in any of the four directions.

The aim of this project is to design and build a wheelchair control system that allows the paralyzed users to steer the wheelchair without using any external assistant. The user of the chair will be able to control the chair motion using head movements. The proposed system will be helpful especially to people classified as quadriplegics, who are not able to use any of the extremities. The main idea of the project is to control the direction of the motion of the wheelchair based on head movement orientation of the person using the chair. The orientations of the head movements will be captured using an Inertial Measurement Unit (IMU) sensor that is fitted on person's head. Based on head orientations, the handicapped person should be able to steer the wheelchair and make it move in the desired direction.

The proposed system consists of two units. The first one will be mounted on the head of the person who will operate the wheelchair. This unit includes the IMU sensor which will measure the orientation angles of the head (yaw, roll, pitch) as shown in Fig. 1.

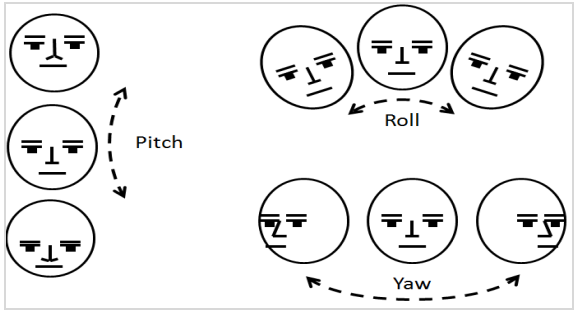


Fig. 1. Three angles output from the IMU sensor

These readings (yaw, roll, pitch) are then sent wirelessly to the second unit which is called the control and driving unit. The main role of this unit is to process the angles and send commands to move the motors in desired direction. Any person who has a problem in hands and legs to move the wheelchair in traditional way, can just sit on the chair and hold the orientation unit sensor and move it over to control the chair movements.

II. RELATED WORK

The control of powered wheelchairs for disabled people is an active research field that studies the methods of controlling and driving the chair. In this section we discuss the existing control techniques that used from researchers and developers. Some researchers depend on face and eye tracking using fixed camera that might block the sight of disable people. Other researchers propose to use voice recognition, touch key pad and tongue orientation.

A. Voice Controlled Intelligent Wheelchair

Masato Nishimori, Takeshi Saitoh and Ryosuke Konishi from Tottori University at Japan developed wheelchair controlling via Voice commands. The system depending on three type commands, the basic reaction command, the short moving Reaction command, and the verification command. The researcher were using a microphone that is connected with the laptop to get the orders voice commands, and after voice command is input, recognition process is starting, and recognition result is shown in the display of the laptop using software. The laptop will display if the voice command are accepted or not. After that the voice command would sent to the controller of the motors system. Fig. 2 show the prototype of their project.



Fig. 2. System overview of voice recognition commands

Although, this is a very effective way to control the wheelchair, the system is affected by the noise and voices around the wheelchair. So the user can't make stable control of the Chair. This approach needs a laptop and software for processing the voice commands, so may it is expensive. Paralyzed users with muteness disabilities cannot benefit from this system.

B. Face Orientation Recognition

Chanlit Noiruxsar and Pranchalee Samanpiboon from University of Technology Thonburi, in Thailand, developed a wheelchair control system for disable people depending on face orientation recognition. A USB camera was fixed in front of user's face that connected with the laptop to detect the Face area based on AdaBoost learning algorithm. The researcher depending on facial landmarks was detected using landmark detector. After processing the camera pictures, face orientations were classified by the normalized distance difference in horizontal and vertical axes between eyes, nose and mouth. The laptop will convert the Face orientation to commands electric wheelchair, consists of frontal, right, left, up and down. Fig. 3. illustrate example of face orientation recognition.



Fig. 3. Face Recognition Examples

Due to using this system, the disable people will suffer from long time focus problem of the face to camera. There should always be a camera or display in front of the users for detection or visual feedback, which may block their sight. It is considered a costly system because it needs laptop, camera and software for processing the face and orientation recognition.

C. Using Tongue Motion

Xueliang Huo, and Maysam Ghovanloo from USA have developed a new approach of wheelchair controlling system depending on the tongue orientation. Their idea consists of an array of magnetic sensors, mounted on a headset, and a small permanent magnetic fixed on the tongue. When the user move his tongue the magnetic field will be generated and the magnetic sensors will get different readings according the Tongue location, after processing the reading of the sensor, then will convert the tongue location to the commands of wheelchair. Fig. 4. illustrates the prototype of their work.

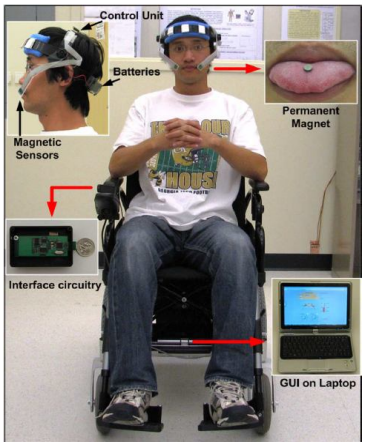


Fig. 4. Prototype of Tongue Drive System

In this way we need to fix a permanent magnetic on the tongue, which could be toxic and could raise health-related issues.

In our project, we will use an IMU sensor to read the angles orientation of the head without reading any signal from the brain. Then, the proposed system converts the head's orientation to orders steering the wheelchair in specific directions.

III. PROPOSED WHEELCHAIR MODEL

In this project, we used a mobile robot (Fig. 5) to replace the wheelchair for simplicity. The suggested model has four motors and wheels. The driver circuit is built to control the motion in all directions according the orders coming from the IMU sensing unit which fixed on the head of the user.

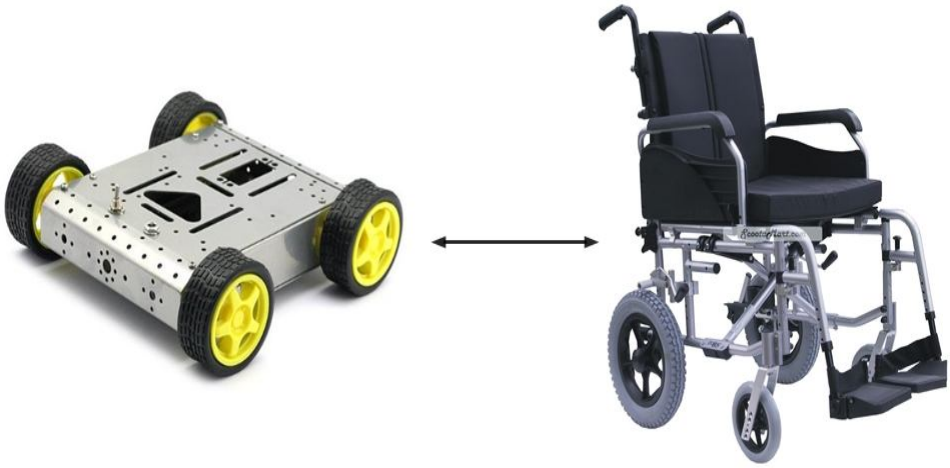


Fig. 5. Prototype wheelchair model

The system has two main components: Control unit including driver system on the wheelchair, and sensing unit including IMU unit at placed on the user head.

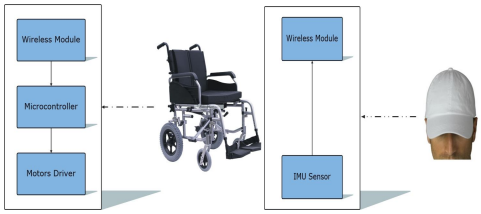


Fig. 6. Two main modules: Sensing and Control units.

When the disabled person move the head in the three axis (X,Y and Z) the IMU sensor will read the orientation in angles and readings wirelessly to the power control unit that will run the wheelchair. This unit consists of microcontroller, motor driver and wireless module as shown in the Fig. 6.

IV. IMPLEMENTED METHODOLOGY

As in Fig. 7, the IMU sensor will read the user's movements and send the readings to the wheelchair driver unit. The wheelchair motor system will move according to the commands sent from the user wirelessly.

At first we have to make configuration for the serial port of Microcontroller. After that it will start reading data coming to the serial port from the IMU sensors. The controller will check the data, and compare it with angles set points for (X,Y,Z) that are made by the user to get the orders that will be sent to the power wheelchair controller wirelessly . After that the controller will start reading data forwarded to the serial port from the wireless module. The IMU sensor will always read the head orientation of the operator and do the same steps. The controller will process the data; send orders to motor driver to run the motors in desired direction

V. HARDWARE REQUIREMENTS

A. Arduino Microcontroller

Arduino is an open-source physical computing platform based on a simple I/O board and a development environment that implements the Processing/Wiring language. The used Arduino Uno is based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

B. Inertial Measurement Unit (IMU) Sensor

IMU is mainly used to measure velocity, orientation, and gravitational force. The earlier technology consists of two types of sensors accelerometers and gyroscopes. The accelerometer is used to measure the inertial acceleration. While gyroscope on the other hand, measures angular rotation. Both sensors typically have three degree of freedom to measure from three axes. Later, IMU technology has advanced with another sensor type – magnetometer. Magnetometer measures the bearing magnetic direction, thus it can improve the reading of gyroscope.

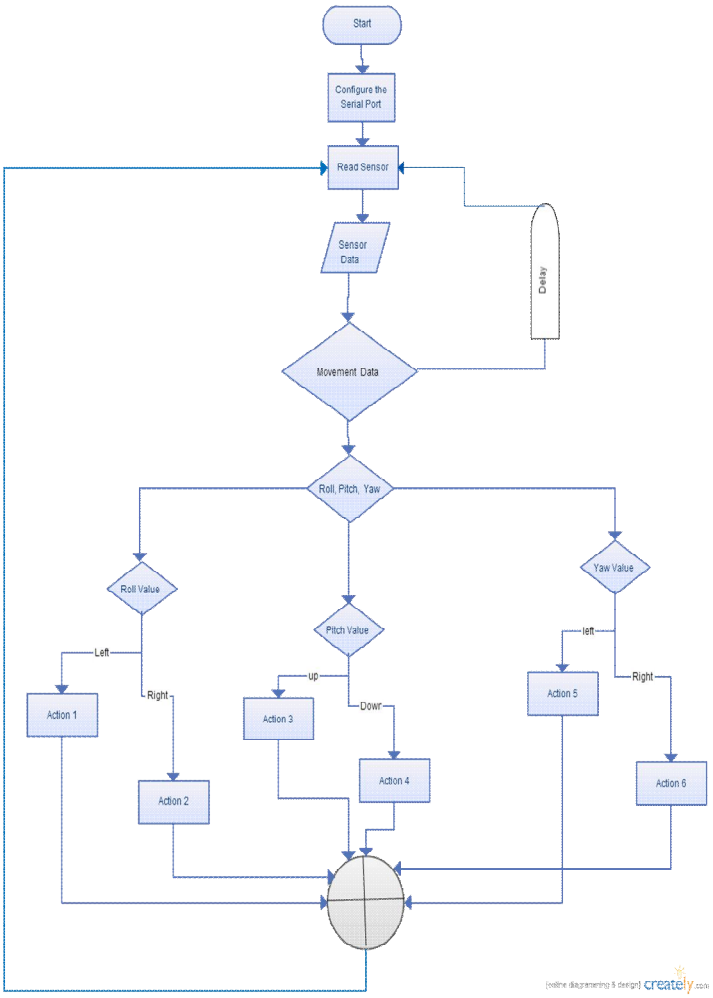


Fig. 7. Prototype wheelchair model

B.1 IMU with Two Sensor Types

This kind of IMU consists of gyroscope and accelerometer. Typically each sensor has between two to three degrees of freedom (DOF) defined for x, y, and z-axis. The accelerometer measure the acceleration of the object and the gyroscope measure the angular velocity, both readings are separately. Angles can be measured from both sensors, thus both data can be calibrated as shown in Fig.8 to get more accurate output data.

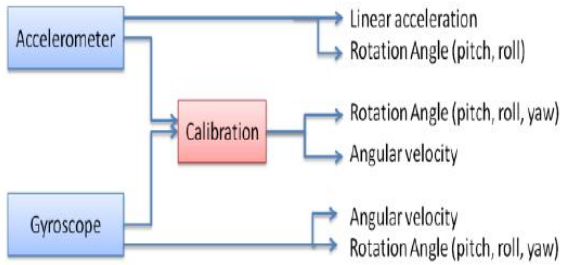


Fig. 8. IMU based on two types of sensors

One advantages of using this type of sensor, it will not be affected by external magnetic field around the sensor if it used in ferromagnetic conditions. But depending on accelerometer and gyroscope only, will not give the user full accuracy of the measurement due to sensors' noise and the gyros drift issue.

B.2 IMU with Three Sensor Types

This type of IMU consists of three sensors: accelerometer, gyroscope and magnetometer. The three sensors have tri-axial to get measurements in three different axes to make the total of 9 DOF. The magnetometer is used to measure yaw angle rotation, thus it can be calibrated to the gyroscope data to improve the big drift issue. The importance of this type of sensor appears when it used for dynamic orientation calculation in the short and long run when less drift errors occur. One disadvantage of using this sensor If the IMU is being used in the environment that is surrounded by ferromagnetic, the measurements might be affected due to the disturbance to magnetic field.

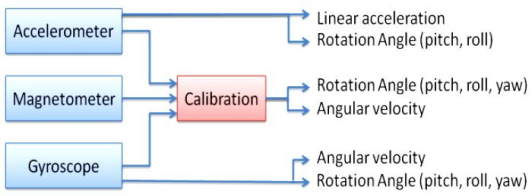


Fig. 9. IMU based on three types of sensors

C. Wireless RF Modules 433MHZ

Wireless serial port module is used to implement wireless data transmission instead of serial connecting wire. This serial port module carries out wireless communication via 433MHz frequency and supports peer to peer transmission modes.

D. Prototype Wheelchair Model

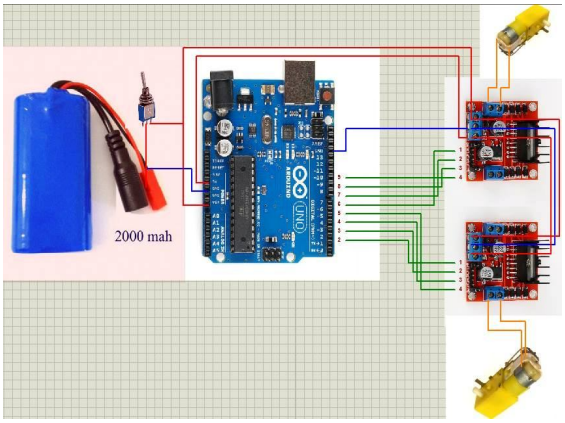


Fig. 10. Hardware connection of the main unit

Fig. 11, illustrates the hardware connection of main control unit of wheelchair automation control system. We have used two h-bridge modules in this project because we have four motors to control. Each H-bridge can control the direction of two motors.

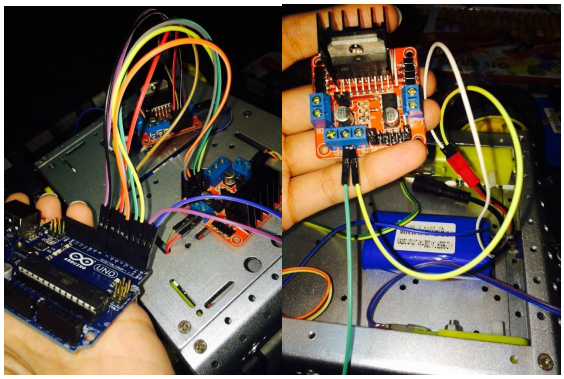


Fig. 11. The connection between H-bridge and Arduino Uno

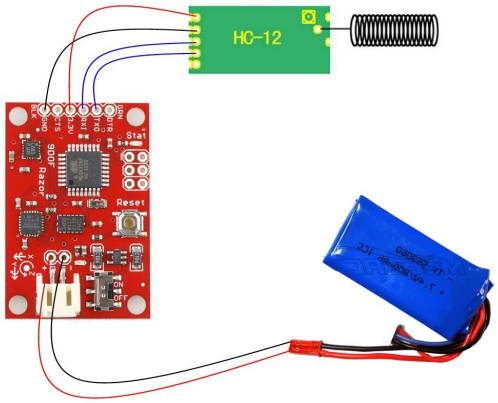


Fig. 12. IMU connection

As shown in the Fig. 12, the IMU is connected with RF module and Battery to send data wirelessly to the main until that is mounted on the mobile robot. The RX of the IMU is connected with the TX of the RF module and the TX of the IMU is connected with the RX of the IMU. The VCC and Gnd of the RF module are connected with the IMU unit on 3.3v and Gnd pins. The two lines of the battery are connected with the main socket power of IMU.

The system has shown a high accuracy in achieving it designed goals. We have tested the system functionality and repeatability; it demonstrated an outstanding prototype model for this application.

We will develop a real-life system to apply achieved goals onto an actual system to study unexpected limitations of this system.

CONCLUSION

In this paper, we presented a head orientation system to control the wheel chair depending. It will assist handicapped people who may not move their arms and legs to steer an automated wheelchair. This system also helps people with high level quadriplegia suffer from paralysis of all four limbs while still being able to move their heads. The model depends on a novel head motion recognition technique based on Inertial Measurement Unit sensor that will be mounted at the operator's head, where it measures orientation angles that are converted into adequate steering commands. The MCU will read the head motion angles via the IMU sensor, and send the readings wirelessly to the driving unit of the wheelchair that can be driven in any directions.

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