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AI-based smart and intelligent wheelchair

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Abstract: The differently abled and/or old-aged people require assistance for their movement. Generally, such assistant providing tool is wheelchair. Normal wheelchairs are manually operated and heavy to move adding burden to the suffered. Hence, automated wheelchairs that are equipped with sensors and a data processing unit constitute a special class of wheeled mobile robots, termed as "smart wheelchairs" in general. In the existing system, the wheelchair movement that is controlled by joystick uses buttons to start and stop the wheel. This is difficult for the differently abled to press the required button with precision. Although there are smart wheelchairs with gesture control, it lacks accuracy in the calculation of the location. The proposed system uses artificial intelligence for its working and proves to be a unique combination of wheelchair and health monitoring system. The wheelchair can be accessed both in manual and automatic modes. In the manual mode, the wheel is controlled using joystick whereas in the automated mode, MPU6050 sensor and accelerometer is used to control the direction by gesture. SPO2 sensor attached to the wheelchair is used to collect the health parameters. Thus, enabling the self-dependency of the person. Further, deep learning analysis of the data from the sensors and the wheelchair usage pattern is compared with the dataset to determine the stress level. The signal from the sensors is monitored and the vitals data is updated in the ThingSpeak website via Bluetooth module serving as a digital health chart.

Keywords: smart wheelchair, artificial intelligence, health monitoring, gesture recognition, self-dependency, deep learning analysis, ThingSpeak, digital health chart

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1. Introduction

The medical conditions that require the use of wheelchair is termed as mobility-impairment. According to a medical website, the major ailments such as- amputation, cerebral palsy, paralysis, multiple sclerosis, muscular dystrophy, spinal cord injury leads to this condition. It is alarming to know that people with diabetes of Type-2 and Alzheimer's disease also require wheelchair for their mobility. It is proven medically that using a comfortable and well-suited wheelchair helps them to continue with their routine.

Traditionally used joystick controlled wheelchair is well preferred for persons diagnosed with paraplegia but is not possible in the case of quadriplegic patients who can use voice systems to control the chair (Khadilkar, & Wagdarikar, 2015).

This paved the path for gesture-controlled wheelchairs which requires less user strain. Pande, Ubale, Masurkar, Ingole, and Mane (2014) published a paper which involved Acceleration Technology employing the ADXL202 sensor.

Similarly, AVR microcontroller was used by Soni, Poddar, Sahu, and Suryawanshi (2016) in their proposed paper which aided in moving the wheelchair with respect to gesture.

Noman, Khan, Islam, and Rashid (2018) have developed an assistive device for lower body paralyzed persons. They have developed gesture control wheelchair with capacitive touch module as an alternative control system. Ultrasonic sensors is used for obstacle detection and to monitor the user, an IP camera is externally mounted.

With the help of technological developments, there exists the concept of obtaining the vitals of a patient without paying the hospital any visit. Even though, it can be done anywhere owing to the size of the equipments, the presence of an external is a must.POF sensors are immune to electromagnetic field and also possess advantageous properties such as lower Young's modulus, high flexibility, higher elastic limits, and impact resistance. Leal-Junior et al. (2019) showed the viability of using POF sensors in healthcare and its advantages makes it possible to be used in this research field.

The design, construction, and functional verification of a hybrid multichannel fibre-optic sensor system proposed by Fajkus et al. (2017) emphasized that the probe to be used particularly for basic vital sign monitoring such as heart rate, respiratory rate and body temperature. Incoming signals from up to 128 individuals could be continuously processed using such sensor system.

In our paper, we have employed artificial intelligence by exploiting the gesture controlled wheelchair mechanism and improvised a basic yet smart wheelchair to become even smarter by detecting stress level along with the provision to collect the health parameters as and when required without any external help.

2. Materials and methods

The proposed system is an amalgamation of wheelchair system with health monitoring system and can be operated in both manual (joystick) and automatic mode (gesture control using MPU6050 sensor). The following are the sensors used in the system –

- ✓ MPU6050 sensor: Controls the direction of the wheel of the motor.
- ✓ SPO2 sensor:
  - a. Blood oxygen sensors: Monitors the oxygen level of the blood in the patient's body.
  - b. Pressure sensors: Monitors the patient's heart rate.
- ✓ LM35 sensor: Calculates the body temperature.

Apart from the sensors listed above, the system comprises of a 12V battery, power divider, a motor driver, Arduino UNO, Zigbee transreceiver with Bluetooth attached to it as seen in Fig.1. The finished system looks like the one in Fig. 2., with all the modules connected.

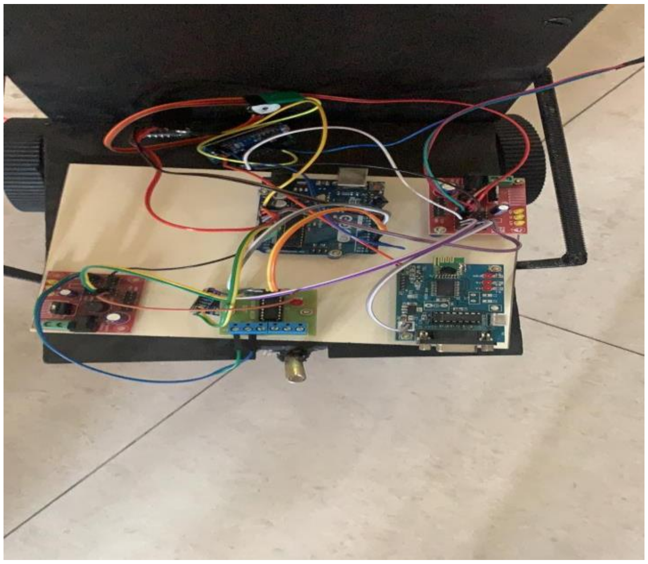

Figure 1. Hardware connection.

The location and distance of the system can be tracked anytime which is done using the accelerometer present in the MPU6050 sensor. This system has two beacons one is master and another one is slave. Master beacon uses INQ method (Zhou, Yao, Guo, Xu, & Chen, 2017) to find slave location. Thereby, enabling us with information about the whereabouts of the wheelchair and its movements.

The data obtained from these sensors are located inside the Arduino UNO which is fixed on to the wheelchair. This information from the hardware is communicated to the software, MATLABR2018a via the Zigbee technology. The software on receiving the data, reads and process data and extracts only the necessary data from the data received from the hardware. It is then analyzed and results are stored in the website which can be monitored and retrieved by the hospital personal or the care-takers.

The data obtained from MPU6050 sensors, SPO2 and LM35 is sent to the MATLAB IDE via Zigbee module. Using Beacon sensors, the location details of the user is mapped real-time.

In the software module, the data collected is processed and the required data is extracted from the noisy content received. This data is then recorded for the deep learning analysis. Here, comparison of the obtained data with the dataset that is already fed to the system during the testing phase is done. Thus, predicting the stress level of the user. The vitals detail is separately stored and the analysis report is made available online.

2.1. Working process

The flow chart in Fig.3. depicts the working process of the system. Once the power supply is switched on, the patient can either operate the wheelchair with the joystick or by using hand gesture.

The hand gesture is read by the MPU6050 sensor and sends the signals to the Arduino microcontroller and based on these signals, the motor is driven accordingly. Using Beacon sensors, the location of the wheelchair is known. The master Beacon sensor reads the slave Beacon ID and GPRS is used to track and monitor the patient's movement continuously.

Since the system is a combination of wheelchair and health monitoring system, SPO2 sensor placed on the handle bar is used to read the heart rate and oxygen level in the blood and LM35 sensor is connected as well to measure the body temperature.

With the help of the Zigbee module, the data collected from the hardware is dispatched to software module, MATLAB IDE. In the software module, the collected data is processed and the indispensable data is extracted from the noisy content received. This data is then inspected and documented for the deep learning analysis, where, it is matched with the dataset already fed for prediction of the stress level.

The vitals detail is separately stored and the analysis report is made available online. All the data is read and monitored through IOT and is available on the ThingSpeak website created for the user. As seen in Fig.4. the vitals of the patient is updated online and can be retrieved anytime and utilized as their digital health chart.

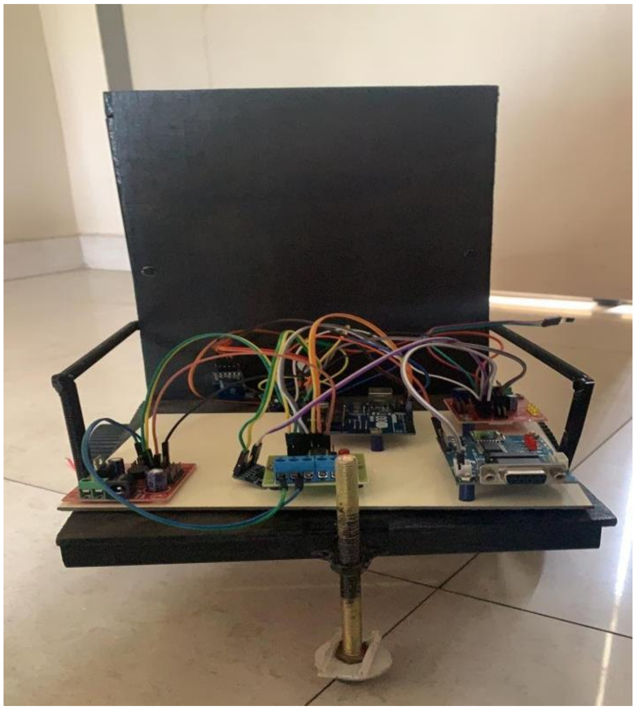

Figure 2. The proposed prototype.

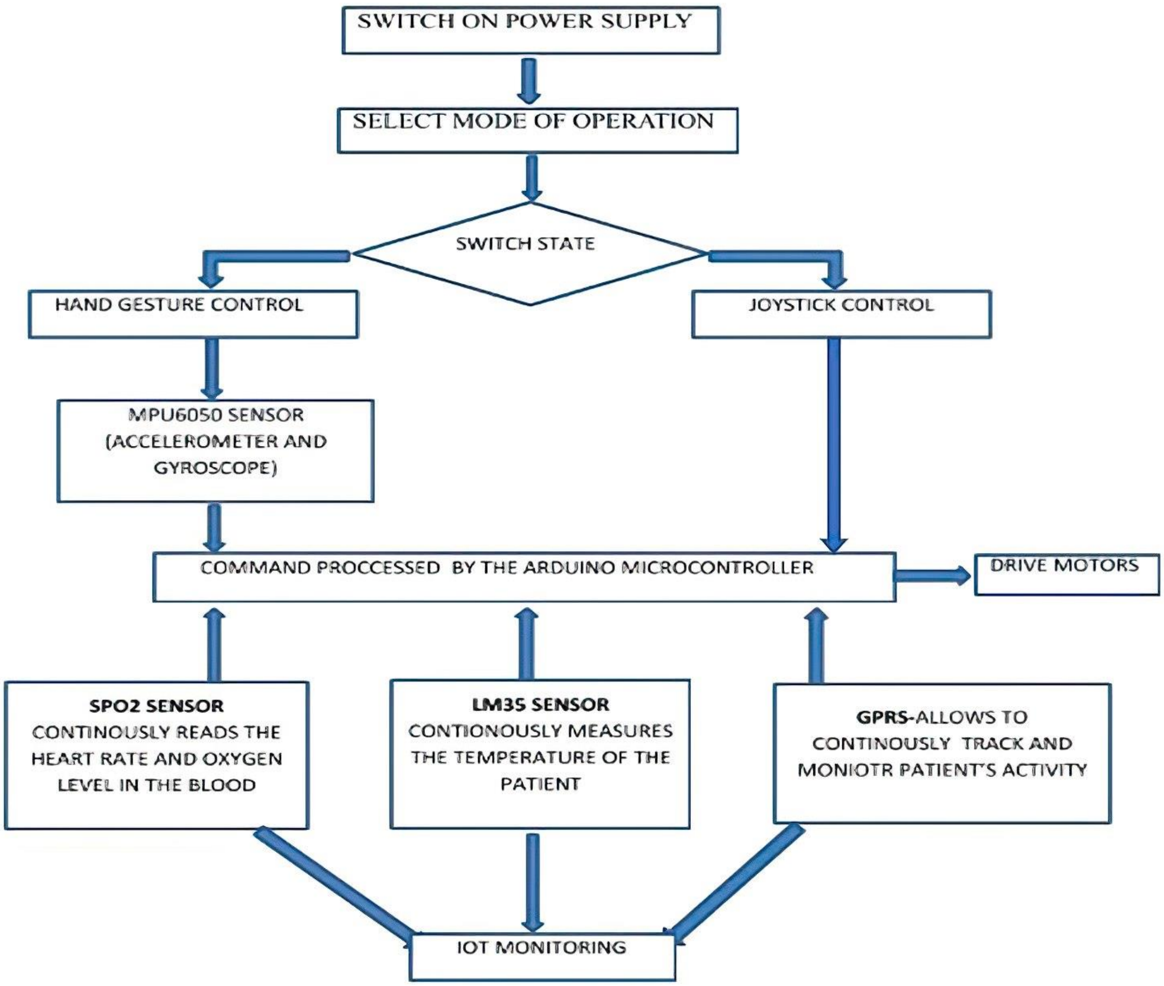

Figure 3. The flow chart of the proposed system.

Figure 4. Readings stored in the website.

3. Conclusions

A prototype version of the system proposed is built. This proves to be a single artificial intelligence-based system with the capability of acting as a wheelchair as well as a health monitoring system. The option of automatic and manual mode provides the user to utilize the wheelchair at their comfort. With the provision of SPO2 and LM35 sensors attached with the operating board, the reading of the vitals of the patient is possible without any external intervention. The location and distance of the system is calculated with a single micro-controller using a less complex algorithm with the help of INQ method. Health parameters, to be precise- temperature, blood oxygen level, and heart rate are measured when required by the patient themselves and updated in the website created for each patient as their digital health chart. Stress level is detected and/or predicted by analyzing the usage pattern such as frequency and related details with the dataset provided during testing phase and soothing music is played accordingly. All these data can be monitored via PC or phones which is implemented by using IOT.

Further developments can be made to this system so that smart devices can be controlled without having to move. Through automation, both passive and active devices can be activated and used with a master controller affixed in the wheelchair. Also, speakers or headsets can be attached to the chair so that soothing music can be played without the need for an external system to do so. More accurate detection and prediction of the stress level with the help of future technological developments is also possible.

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