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Multi-Mode Control for Assistive Technology Device

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Abstract:*This paper proposes the design and setup of a multi-mode control system for assistive technology device. Physically challenged people rely on assistive technological devices for their daily chores. But the currently available standard power wheelchairs are not customized. Since each individual person possesses unique needs and different level of disability, we propose a device taking into account, the degree of disability and their comfort. In this paper, the proposed system considers first, second and third degree of disability in the society. Using this system, an assistive device can be operated in four different modes. Joystick mode can be selected for users who fall in the third degree of handicap. This mode would be appealing to any disabled persons who maintain the complete use of their arms and upper body, but either permanently or temporarily lack the use lower body. The Caregiver mode and Auto gesture mode are proposed for users who fall in the first and second degree of handicap. The fourth mode, blind mode is used for self-manure of visually impaired people. In all the above modes of operation, safe maneuver is ensured by obstacle detection system.Theentire system is coordinated and controlled by microcontroller.*

Keywords–*IR sensor, Joystick, Mobile tilt, Accelerometer,Microcontroller, Ultrasonic sensor***.**

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I. INTRODUCTION

In our society, the number of people with disabilities is growing day by day due to a rise in chronic conditions such as Multiple Sclerosis, spinal cord injuries, road accidents, violence, aging, and other such factors.These sect, rely on assistive technology device like power wheelchairs for their mobility needs.The difference is, either they can't do it at all, or it is extremely difficult for them to participate in normal activities.But each individual person has unique needs and a special disability.So access to appropriate wheelchairs, that is comfortable, affordable and can be propelled efficiently can result in increased levels of activity and allows people with disabilities to work and participate in mainstream development initiatives.

According to the Convention on the Rights of Persons with Disabilities [1], personal mobility with the greatest possible independence for persons with disabilities can be ensured by facilitating the personal mobility of persons with disabilities in the manner and at the time of their choice, and at affordable cost.Even though power wheelchairs are available, a handful of the disabled community faces challenges to operate the same. As a solution to this scenario, customizing the design of the powered wheel chair based on the degree of disability level is a must to bring them to the forefront of the society.

This paper presents the design and development of a multi-mode controlled assistive technology device for non-specific mobility impaired individuals to reduce dependence on caretaker and to promote feelings of self-reliance and undependability among themselves. In this system, assistive device can be operated in four different modes. In our design we have taken into account different levels of dependency and have included four modes of movement control depending on this. Joystick mode can be selected for users who fall under the third degree of handicap(less than 50% handicap). This mode would appeal to any disabled persons who maintain the complete use of their arms and upper body, but either permanently or temporarily lack the use of their legs and lower body. The Caregiver mode and Auto gesture mode are proposed for users who fall under the first and second degree of handicap (between 50%-90% handicap). The fourth mode, blind mode is used for self-manure of visually impaired people. Based on the data captured from the ultrasonic sensors, microcontroller recognizes the proximity of the objects and sends commands to halt the vehicle and thus ensure safe maneuver. IR sensors identify continuities in its path and help to reach in the destination. This project increases self-dependency of the physically challenged user to some extent and bring them to the forefront of the society.

II. RELATED WORKS

In recent years,many efforts have beenconducted for improving the living status of physically challenged persons. JesseLeaman et al. [2] discussed about the evolution of power wheelchair and mentionedthe importance of taking the human factors into account. They have the opinion that the stage is set for humans and robots to interact in publicspaces in order to give people with disabilities the best quality of life possible, and the opportunity to maximize their human potential. The earliest research by Mai S. Mabrouk et al. [3] describes the design and manufacturing of EPW by using SolidWorks 3D CAD. In this system, a microcontroller is used to transfer control from the joystick to wheelchair. Bluetooth device is used for wireless control of the electric wheelchair and enables it to work as standalone device. Thomas R¨ofer [4] discussed about the control of an automated wheelchair via joystick/head-joystick movement. In this system, the driving assistant remembers the driving direction when the avoidance maneuver begins. If the user does not react to the change indirection during the avoidance action, i. e., he or she does not move the joystick, the system will return to the original path indicated by the user after the obstacle was circumvented. The wheelchair will avoid an obstacle if it can determine an avoidance direction from the direction indicated by the user and the position of the obstacle(s). D. Sharath Babu et al. [5] discussed about the control of a power wheelchair by gestures. Their system consists of microcontroller, 3-axis accelerometer, and encoder and RF transmitter. According to the tilt of the head movement, sensor which is attached to head the wireless transmitter sends the signal to the receiver and the wheelchair takes the direction of the movement. By using the 3-axis accelerometer the angle of tilt could be calculated with the help of ADC in the controller. The driver circuit was designed with two IR2101(S)/IR2102(S) are high voltage, high speed power MOSFET drivers with independent high and low side referenced output channels [5]. In this system [6], a wheelchair which can be controlled by using the android application and user's voice is described. The project was tested for the movement of the wheel chair using trained voice after the design and development of the self-automated wheel chair with its various interfacing units. Prof. D. S. Vidhya et al [7] describes about the identification of obstacles using ultrasonic sensors. In their project, they have made a small prototype of an automobile for Adaptive Cruise Control where the car prototype, whose heart will be the Raspberry Pi, a microcontroller, which when set, will lock the object/car in front of it [7].

III. Proposed Model

The system comprises of a microcontroller interfaced to a set of sensors and an android phone. Asour assistive device is designed for non-specific physically challenged persons, we have taken care of different levels of dependency and have included four modes of movement control. The selection of a particular mode is performed using toggle switches. The microcontroller based control and monitoring system acquire the data from different sensors attached to the system, perform the analysis of the acquired data, ensure safe maneuver of the wheelchair based on the data acquired, identifies continuities in its path and help to reach the desireddestination and control and coordinates the entire system. Figure 1 below shows the block diagram for the proposed system.

Joystick mode can be selected for users who maintain the complete use of their arms and upper body, but either permanently or temporarily lack the use of their legs and lower body. The joystick is basically a combination of two potentiometers, one for the vertical movement (Y-axis) and other for the horizontal movement (X-axis). This means, when the joystick is moved along the X-axis the resistance changes resulting also in a change of voltage.

The Caregiver modes and Auto gesture mode are proposed for users who fall in the first and second degree of handicap (between 50%-90% handicap). In care giver mode, the assistive device is controlled by tilting a smart phone by utilizing the accelerometer available in it. Based on the tilt direction, control signal sent by the mobile varies. Communication between the mobile and the microcontroller is done by a Bluetooth module attached to the system. HC -05 A Bluetooth module is installed in our system. This module is capable of communicating with PC, mobile phone or any other Bluetooth enabled device. It is interfaced with the microcontroller over the serial UART port of micro-controller [11].

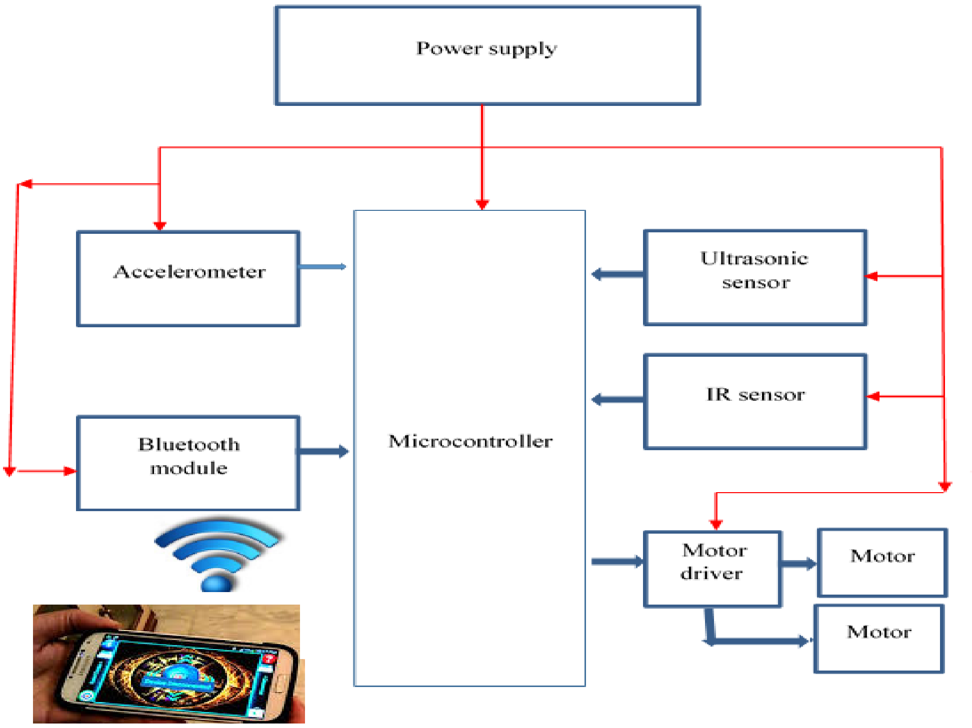

Figure 1. Multi-mode control of assistive technology device-block diagram

When thecaregiver, tilt the mobile phone, the accelerometer within the phone is regulated to generate maximum and minimum value for the movement of the hand in three dimensional co-ordinates depending upon the mode of tilt. Depending upon the values obtained, it sends a determinant value to the microcontroller using Bluetooth [11]. In auto-gesture mode we make use of accelerometer ADXL335 for generating control signals. An accelerometer is a device, either mechanical or electromechanical, for measuring acceleration or deceleration - that is, the rate of increase or decrease in the velocity of a moving object [8, 9]. The accelerometer is fixed on a hand glove. Based on the hand jester, signal send from the accelerometer varies. This sensor data is captured by the microcontroller and the assistive device movement is controlled accordingly.

The fourth mode, blind mode is used for self-manure of visually impaired people. In this mode, the assistive device follows a predetermined path. The device recognizes this path by a group of Infrared sensors attached to the system. In our system we used QTR-8RC for tracking the path. This sensor module has 8 IR LED/phototransistor pairs mounted on a 0.375" pitch, making it a great detector for a line-following application. [12]. The sensor output varies based on the color intensity value. It gives a maximum (2500) value for black surface and minimum (less than 100) for white surfaces. So based on the output data, it is possible to identify a black line on a white surface or a white line on a black surface.

Irrespective of the mode of control, we use ultrasonic sensors for identifying obstacle on its path. This system consists of two ultrasonic sensors (HC-SR04) in the front to identify the obstacle in the front path and two sensors are fitted on its rear for identifying obstacles in case of taking reverse. Ultrasonic Distance Sensor, HC-SR04, is a popular and low-cost solution for non-contact distance measurement function. It is able to measure distances from 2cm to 400cm with an accuracy of about 3mm [7]. The module contains a transmitter and receiver unit. To start the measurement, the trigger pin is set to be high for 10µs and then turned to low state. This action will trigger an ultrasonic wave at frequency of 40 KHz from the transmitter and the receiver will wait for the wave to return. Once the wave is returned after reflection by any obstacle, the echo pin goes high for a particular amount of time. This high state of the echo pin will be equal to the time taken for the wave to return back to the sensor. If there is an obstacle in-front of the module, it will reflect the ultrasonic burst. If the signal is back, ECHO output of the sensor will be in HIGH state (5V) for duration of time taken for sending and receiving ultrasonic burst. The amount of time during which the Echo pin stays high is measured by the microcontroller as it gives the information about the time taken for the wave to return back to the Sensor [14]. We have assigned a minimum distance for the safe manoeuvre. If the distance indicated by the front or rear sensors are less than the predetermined value, the microcontroller sends signal to halt the movement of the assistive device.

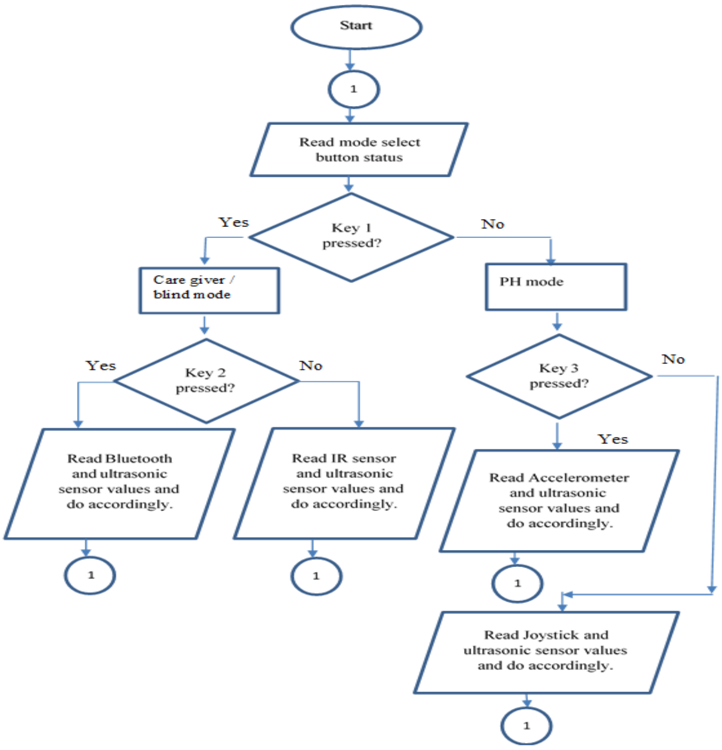

Figure 2. Multi-mode control of assistive technology device -flowchart

Flowchart for the system is shown in fig.2. The system waits for an input from the mode select button. When it receives a signal, first it identifies the source. Now it enters in caregiver/ blind mode. Again it reads the status of the next button for selecting the blind or caregiver mode. Based on the mode selected, it reads either from the Bluetooth or ultrasonic sensorsand based on the ultrasonic data it moves till it reaches the destination. In the same procedure it works in the gesture and accelerometer mode.

IV. Experimental Results

The performance of the system is evaluated based on the effectiveness of the modes of control. In the caregiver mode we used mobile tilt for controlling the assistive device. When the microcontroller is connected to the android phone through Bluetooth the status of the app changes to 'Connected'. Now it starts receiving commands from the user. The control was effective to a maximum of six meters as shown in table 1.

Table 1. Mobile tilt result

Sl. No.	Caregiver distance from the assistive device (m)	Device control result
1	3	Positive
2	5	Positive
3	6.	Positive
4	7	Negative

The test result for the auto gesture mode is shown below in Fig.3 and in table 2. The result was accurate for 90%. Based on the hand folding angle, a slight variation in the result occurred from the expected output

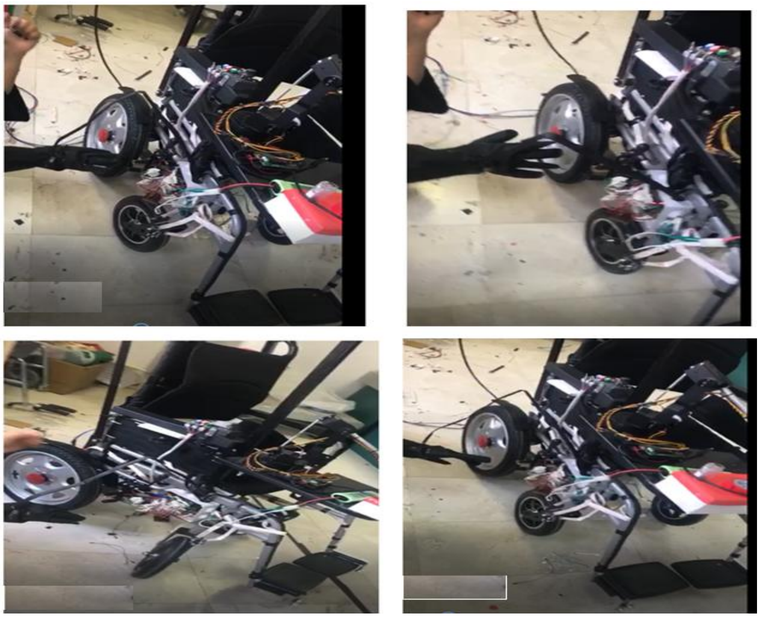

Figure 3. Auto-gesturemoderesult

Table 2. Auto-gesturemoderesult

Sl.No	Action performed	Expected result	Obtained result
1	Fold to front	Forward	Forward
2	Fold to back	Reverse	Reverse
3	Fold to left	Left	Left
4	Fold to right	Right	Right
5	Fold to front	Forward	Halt
6	Horizontal plane	Halt	Halt
7	Fold to left	Left	Left
8	Fold to right	Right	Right
9	Fold to front	Forward	Forward
10	Fold to back	Reverse	Reverse

In blind mode and joystick mode the performance was 100% accurate. The system accurately followed the given path in different illumination conditions. In all modes of operation, the assistive device was in halt state, when it identified an object at a minimum distance of 40cm.

V. Conclusion

This paper elaborates the design and construction of anassistive device that can be controlled by people having different level of disability effectively. The system effectively followsapredetermined path based on IR sensor in its blind mode of operation. The Bluetooth module interfaced to the microcontroller transfer signals from the android phone to the controller embedded in the system. Ultrasonic sensors attached to the system ensure the safe manoeuvre. Provision has given for selecting the mode of operation based on the degree of disability. The system can be enhanced by providing wireless control in the auto gesture mode. This proposed system enhances the self-dependency of disabled people by providing appropriate mode of control for their assistive device based on the degree of disability.

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