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Intelligent Mutable Advanced Automated Wheelchair

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ABSTRACT: While the needs of many individuals with disabilities can be satisfied with power wheelchairs, some members of the disabled community find it difficult or impossible to operate a standard power wheelchair. To accommodate this population, several researchers have used technologies originally developed for mobile robots to create “smart wheelchairs” that reduce the physical, perceptual, and cognitive skills necessary to operate a power wheelchair. We are developing Intelligent Mutable Advanced Automated (IMAGINE) wheelchair. This paper describes the design of a prototype, which has been evaluated on wheelchair.

KEYWORDS: smart phone, rehabilitation, disability, smart wheelchair.

I. INTRODUCTION

With the increase of elderly & disabled people, a wide range of support devices & modern equipments have been developed to help improve their quality of life. Some patients who cannot manipulate the wheelchair with their arms due to lack of force face major problems such as orientation, mobility & safety. There are various kinds of wheelchair which are being manufactured such as :-

- 1) Manual or self propelled wheelchair-It is normal chair arrangement having wheels which are present on both sides of chair and are dragged by patients manually and Joy-stick operated wheelchair in which joystick is used for operating the wheelchair.
- 2) Speech Recognition-It recognizes the verbal command given by patient and according to that wheelchair movements are controlled.
- 3) Image acquisition-It uses camera to detect hand movement and according to it movement occurs.
- 4) Sensor controlled- In this type of wheelchair sensors like accelerometer sensor and flex sensor are used.

Hence a wheelchair was developed rounding off all possible considerations:

- 1) It is user friendly technology that operates on variable user friendly modes.
- 2) Less force is required for operation i.e. single finger/voice/hand movement is enough to operate the wheelchair.

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II. LITERATURE SURVEY

(a) Alex Dev, Horizon C Chacko (2011) used EOG to control the wheelchair locomotion. A pair of electrodes is placed horizontally to left and right Eye. If the eye is moved from the centre position towards one electrode, a potential change occurs between the electrodes. Due to the changes in the potential the wheelchair can be controlled.

(b) Sangmeshwar S. Kendre (2010) used Voice control system to control the locomotion of the wheelchair. They store the default commands in the PIC IC (micro controller) by the usage this commands the wheelchair can move. Change in the words restricts the wheelchair movement.

(c) Chun Sing Louis Tsui, Pei Jia (2008) used EMG control for wheelchair locomotion. They used eyebrow muscle activity to obtain required signal. By using the signal the wheelchair movement has been controlled.

(d) S.Tameemsultana and N. Kali Saranya (2011) used head and finger movement for wheelchair locomotion. In finger movement they use flex sensor, placed on the finger. It is an analog resistor usually in the form of strip long variable resistance. Due to the bending of finger the resistance varies which controls the locomotion of the wheelchair. Bending the sensor at one point more than 90 may permanently damage the sensor which is a main drawback. The system already existing for the physically challenged person controlled by other different technologies has some defects:

- In Eye ball sensor they use infra red sensor to control the wheelchair where continuous fall of IR radiation in the eye causes irritation to the patient (Alex Dev, Horizon C Chacko and Roshan Varghese, April, 2012, ISBN.)
- In voice control the person must use the exact commands only to control the movement. Change in the words restricts the wheelchair movement (Manuel Mazo, 1995). All the electronic system and also the philosophy for functioning has been sufficiently refined to attain the subsequent performances:
 - To ensure easy, comfortable driving.
 - To reply to the speed requirements for a system of this kind (maximum speeds of up to three m/s).
 - To be simply adaptable to any kind of commercial wheelchair chassis.
 - To ease learning to handle the chair and getting most potency.
 - To ensure much constant speeds, to an oversized extent independently of the characteristics of the surface over that the wheel chair is moving (greater or lesser roughness of the ground and also slope of same) and the weight of the person using it.

III. SCOPE OF RESEARCH

Cases of patients on wheelchair are just not limited to paralysed patients. The user can be combination of paralysis, blindness, hands and legs fractured, musculoskeletal issues, balance problem, neurological issues, genetic disorders or Amputated legs and hands wherein the existing market products fail to resolve all the issues that reduce the physical, perceptual and cognitive skills necessary to operate a wheelchair.

Keeping in mind our aim of helping patients in all aspects, study was conducted to determine how to collaborate easy functioning wheelchair with low cost. Hence a wheelchair was developed rounding off all possible considerations to get a complete package of simple design, low cost and user friendly operations.

- The self propelled part of conventional wheelchair was removed and replaced by smart features. The joystick operative mode was replaced by touch mode wherein user can navigate by giving touch inputs to a smart phone.
- The wheelchair consists of gesture based movement which counters various forms of paralysis or if the patient is unable to control the chair with fingers.
- The third mode is voice incorporated for patients who are physically disabled or have musculoskeletal problems.
- For patients who are blind or have neurological issues, computer controlled mode is available wherein a host computer monitors all the movement of chair. The location of chair with visuals is obtained through smart phone/camera mounted on chair. Also if patient falls ill suddenly while travelling; the location of patient along with his position is sent through GSM to emergency smart phone and PC mode can be enabled just by pairing up with the required id and patient can be taken to a safe place.

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- Unlike all wheelchair products in market, this wheelchair does not just travels on flat, rough or slopes. It has reliable mechanism to climb/de-climb stairs without any effort by user or external human. This wheelchair is robust enough to carry the user through urban as well as rural pathways overcoming all types of obstacles.
- The wheelchair consists of three modifiable positions which includes chair position, bed position & relax position. The bed position helps the patient's burden to be reduced while being shifted from wheelchair to bed while sleeping; or incase there is bed shortage at paraplegic centre's. The chair position is the conventional position while relax position is for user's comfort to read books, watch TV, etc. A timely medication reminder facility is also made available for patient's personal health care.

The smart phone technology has significantly affected the lives of human and hence this technology has been implemented as an integral part of this wheelchair as smart phones are available with at least 4.77 billion members across the globe. Smart features have been included to counteract various difficulties faced by a conventional wheelchair user. Overall this wheelchair system can prove to be beneficial for all grades of people in all fields relating to military, hospitals, paraplegic centre's or even domestically or during disastrous situations like earthquake thereby making a patient totally self-reliant and self-dependent with high reliability, comfort, care, assistance & optimal low cost.

IV. PROPOSED METHODOLOGY

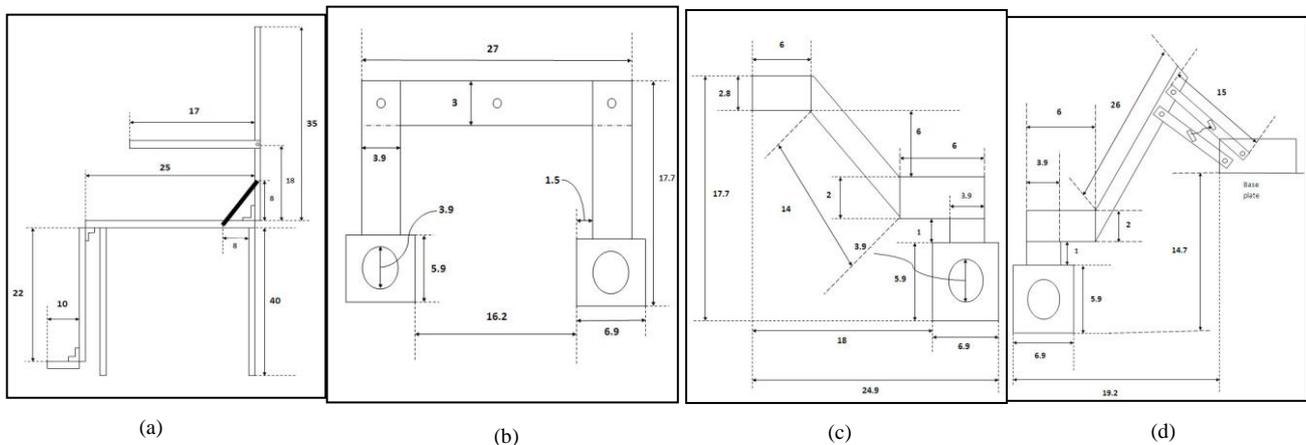


Fig. 1. Mechanical Design (a) Chair dimension (b) Centre bogie (c) Rear fork (d) Front fork. The original design details of mechanical section of the wheelchair with dimensions in centimetre representation. Fig. 1. (a) is the chair design showing details about back rest, legs of the chair, arm rests, leg support and base rest along with rigid position rod (black) to configure the chair to desired position. Fig. 1. (b),(c),(d) shows the construction details of stair climbing base section of the wheelchair. Installation of these individual sections on a common platform proves to be the base of the chair. The motorized wheels are attached to the circular slots in these sections.

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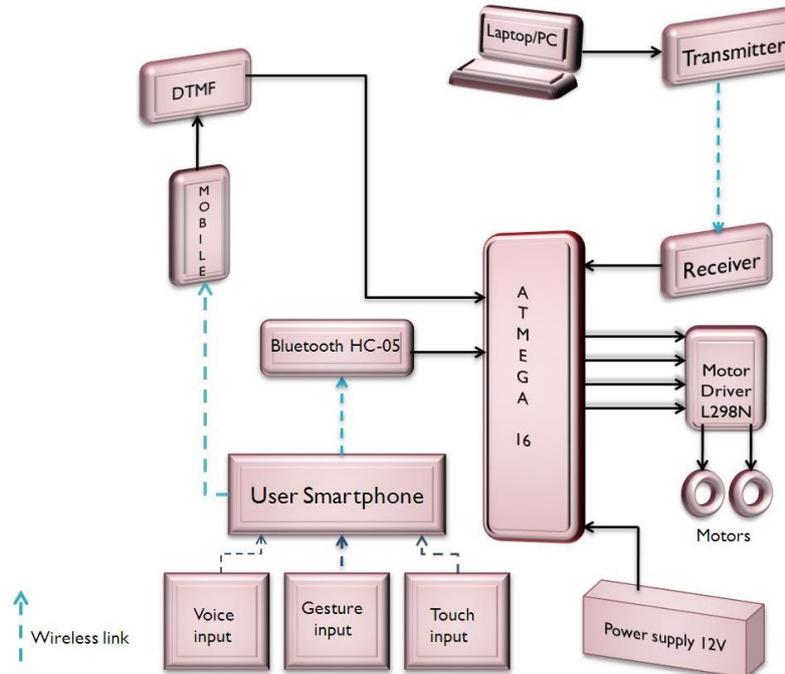


Fig. 2. Main Block Diagram. The controller used is ATMEGA16. For touch/gesture control, a user smart phone is used which is wirelessly interfaced to slave Bluetooth module feeding input to controller. For voice control, a user smart phone is used as input device. The Dual tone multiple frequency decoder is used to decode the voice commands and fed to controller. For PC/laptop control, a computer is used along with a 2.48 GHz RF transmitter to send commands to a RF receiver attached to the controller. To propagate the controls to the wheels there is interfacing between controller and motors via motor driver unit (L298N).

Description:

- The basic structure of our project consists of microcontroller, motor driver, smart phone, PC/Laptop, power supply and motors. The main aim of this project is construction of wheelchair having a direction control through voice commands, touches or hand gesture.
- The touchpad comprises a smart phone. When pressure is applied to the capacitive screen of smart phone, an XY co-ordinate location is produced and transmitted with Bluetooth available on smart phone to Bluetooth module (HC-05) available on wheelchair and the wheelchair will move in the desired direction.
- A change in location of the pressure will result in a corresponding change in direction. The touchpad also has a neutral or no movement point which will ensure efficient braking. This is very helpful for paralysed and physically challenged people.
- Similarly, voice commands can be used as input to a decoder which converts a particular frequency of voice into digital bits for controller to process it and take desired action. Using voice operative mode the user can operate the wheelchair using pre-decided voice commands. The voice commands will be transmitted via Bluetooth available on smart phones.
- In hand gesture mode the user will be able to manipulate the wheelchair using hand movements. This is achieved by using accelerometer sensor available on smart phone which are used for gesture gaming.
- The data, as above, will be transmitted via Bluetooth. In automatic mode, the wheelchair is controlled by a host PC to traverse the route. This is very helpful to navigate in places such as home or where user is fully paralysed. This feature can also be efficiently used if the patient feels ill and cannot regulate the wheelchair himself/herself. The patient will thereby be leaded to his/her home or paraplegic centre safely.

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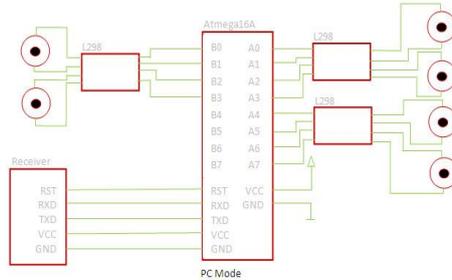


Fig 3. Simplified schematic of PC mode consisting of 2.48 GHz receiver attached to pins 9(RESET), 10(VCC), 11(GND), 14(RXD), 15(TXD). Motor driver is attached to pins 1(B0), 2(B1), 3(B2), 4(B3), 40(A0), 39(A1), 38(A2), 37(A3), 36(A4), 35(A5), 34(A6), 33(A7) of ATMEGA16.

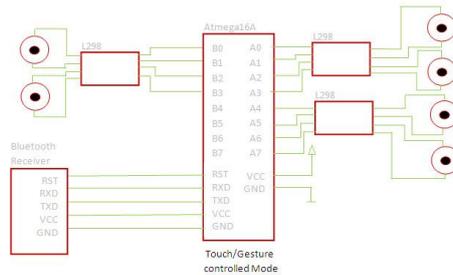


Fig 4. Simplified schematic of touch/gesture mode consisting of Bluetooth attached to pins 9(RESET), 10(VCC), 11(GND), 14(RXD), 15(TXD). Motor driver is attached to pins 1(B0), 2(B1), 3(B2), 4(B3), 40(A0), 39(A1), 38(A2), 37(A3), 36(A4), 35(A5), 34(A6), 33(A7) of ATMEGA16.

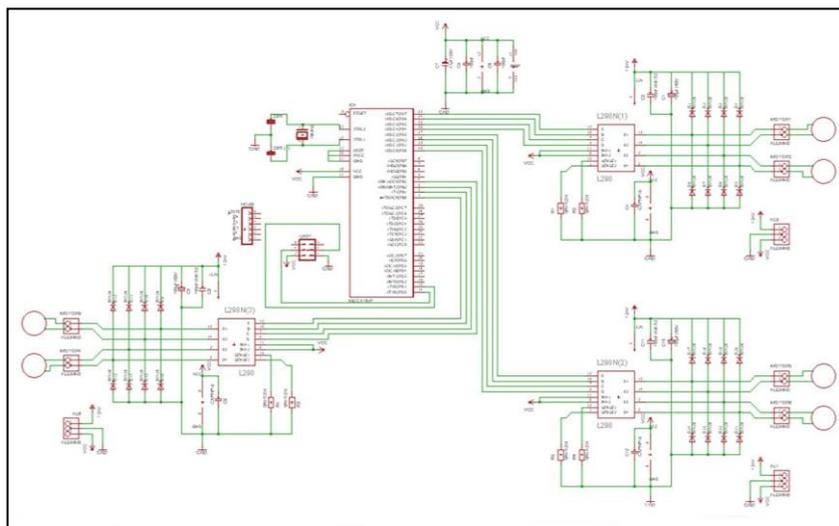


Fig. 5. Hardware Schematic. The controller ATMEGA16 is the main processing core of the circuit. Standard digital biasing (+5V) is applied to the controller for its proper operation. Serial communication is achieved by interfacing to pins 14 (RXD) and 15 (TXD) of ATMEGA16. L298N is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive loads such as DC motors. The L298N consists of protection diodes for blocking reverse current to flow back and damage the source. The motors used are 12V DC motors rated at peak (maximum) current of 2 Amperes with no load torque of 6 kg-cm.

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V. EXPERIMENTAL RESULTS

1. According to the structural design and mechanism the wheelchair is able to climb stairs and trespass small obstacles like stone, pot holes etc. easily. As per the height adjustment mechanism, user should be able to adjust height manually whenever it is required.
2. In touch mode when an input is given from a smart phone, the Bluetooth module available on wheelchair will receive the input and the wheelchair will move in the desired direction. A change in location of the pressure will result in a corresponding change in direction. The touchpad also has a neutral or no movement point which will ensure efficient braking. This is very helpful for paralysed and physically challenged people.
3. In personal computer/laptop mode, inputs are given from PC through an application installed on a computer. The receiver attached to the wheelchair will receive the inputs and the chair will move in the desired direction. If 'w' or '8' on keyboard is pressed then wheelchair will move forward, if '6' or 'd' is pressed then wheelchair will move right, if '4' or 'a' is pressed then wheelchair will move left, if '2' or 's' is pressed then wheelchair will move backwards, if 's' or '5' is pressed then wheelchair will stop. Also it can be controlled with the help of mouse movement in the desired direction. This feature will help efficiently if the patient feels ill and cannot regulate the wheelchair himself/herself. The patient will thereby be leaded to his/her home or paraplegic centre safely by monitoring in-charge.
4. In gesture mode when an input is given from a smart phone, the Bluetooth module available on wheelchair will receive the input and the wheelchair will move in the desired direction. When phone is tilted forward the wheelchair will move forward, if left tilt is given the wheelchair will move left and so on.
5. Similarly, voice commands will be used as input to a decoder (DTMF) which converts a particular frequency of voice into digital bits for controller to process it and take desired action. Using voice operative mode the user will be able to operate the wheelchair using pre-decided voice commands. The voice commands will be transmitted via Bluetooth available on smart phones.

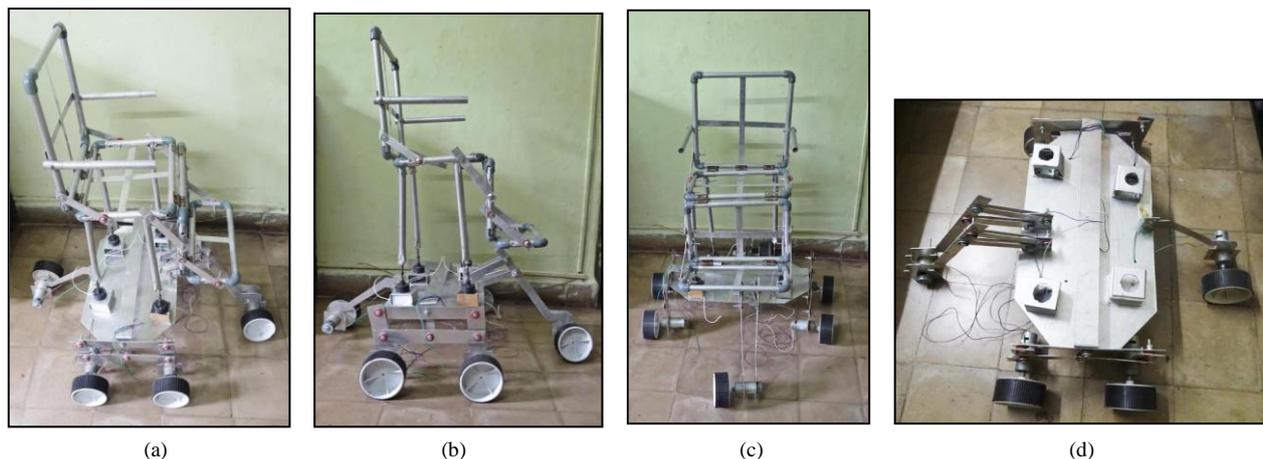


Fig. 6. Implemented Prototype (a) Top view of wheelchair (b) Side view of wheelchair (c) Front view of wheelchair (d) Base of wheelchair. The final implemented wheelchair as per the constructional details. The wheelchair base, as shown in Fig. 6. (d) is separable with the chair for easy maintenance. The common platform integrates all the sections as well as provides support to the chair.

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LOGIC	ACTION
00	Stop
10	Clockwise
01	Anticlockwise
11	Force stop

Table 1. Standard logic levels provided to L298N and corresponding responses in the form of direction of movement of the motor. Logic ‘0’ denotes 0V and logic ‘1’ denotes +5V.

ACTION	MOTOR1	MOTOR2	MOTOR3	MOTOR4	MOTOR5	MOTOR6
FORWARD	10	01	10	01	10	01
REVERSE	01	10	01	10	01	10
RIGHT	10	10	10	10	10	10
LEFT	01	01	01	01	01	01

Table 2. Measured logics for each corresponding direction of each motor simulated individually.

VI. CONCLUSION

This innovative project will come in handy for various people around the world who can't walk or are partially handicapped & are blind. The design structured for this wheelchair is a comfortable one where the patient will have no issues with comfort. Overall this wheelchair has the ability to travel anywhere with no human efforts except giving it direction controls. It operates on battery which can be recharged. We have described the system which is driven by the latest up growing technologies and advanced algorithms. Though main focus is on human-machine system interface, further advancements can be done through more research. The interface and software can be modified and re-developed according to the need in future. Further advancement in the wheelchair are possible by decreasing the power requirements of the wheel chair or finding a way to automatically charge the battery with the help of motion of the wheel chair or solar panel .

VII. ACKNOWLEDGEMENT

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BIOGRAPHY



Prashali Sharma was born in Pune, India, in 1994. She is currently pursuing her B.E. degree in Electronics and Telecommunication Engineering from P.E.S Modern College of Engineering from the University of Pune, Maharashtra, India, expected to complete in the year 2016.



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