INTELLIGENT WHEELCHAIR FOR PEOPLE WITH DISABILITIES

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***ABSTRACT*:- People make use of different languages to express their thoughts in a different way. But, it is difficult for the people who are affected by paralysis and stroke. Hence, there is a need to develop a platform for those people who are physically challengeable. An Embedded device shall address the above said problems. Based on the ARM processor the operation takes place. The device is designed with an intelligent wheelchair and the People With Disabilities (PWD) can direct it. By pressing the keypad (buttons) in the device, people with disabilities can move the wheelchair. In this process, the line following algorithm is implemented. To direct the wheelchair, L298 motor driver is used with the help of an ultrasonic obstacle sensor. By pressing a button, an automatic call to the doctor takes place if the PWD needs critical help. The GSM modem is used to forward the call. The LCD shows the basic needs of PWD which is already assigned in the buttons. On pressing the button, a text is displayed in the LCD with a buzzer sound. This device provides a unique mobility for the people with disabilities.**

Keywords – Wheelchair, ARM processor, AT89S52, L298 motor, Line following algorithm, GSM modem, LCD, Buzzer and RF Transceiver.

I. INTRODUCTION

In our fast moving materialistic world, people need to modernize and progress themselves. The world population is increasing faster and also the people with disabilities (PWD) ratio. They face barriers at their each turn and they need some helpers in their daily works. The assistive device acts as a boon for them. The most widespread assistive device is the wheelchair. All over the world, the usage rate of people with wheelchairs is nearly 3.3 million. Several researches are done for the people who uses wheelchair and various papers deal about it. The previous work done focused over the movement of wheelchair by flex sensor [1] and the drawbacks are overcome in the proposed work.

The Yee-Pien Yang *et al.* proposed a fuel cell power-driven wheelchair determined by rim motors. The wheelchair was light weighted, foldable, fuel efficient and low cost. The hybrid energy wheelchair had a fuel cell with two secondary battery storage packs which can work in enough power [2]. An automated wheelchair was designed by M. AL-Rousan *et al.* The wheelchair movement was guarded by joystick, SMS and voice command. The wheelchair speed was controlled by two buttons. The neural network and wavelets were used to recognize the voice commands [3]. A paper by Anwar Al-Haddad *et al.* projected a method to direct the powered wheelchair based on EOG signals. The Electro - Oculography (EOG) signals controlled the blinking and eye glazing of the user. By calculating the gaze angle, the designated distance was premeditated and based on it the wheelchair moved. The PoingBug algorithm controlled the wheelchair with the auto controlling process [4]. Eugen R. Lontis *et al.* designed an inductive pointing device and implemented in an oral interface [5]. Similar to joystick they used sensor pads for the movement of wheelchairs. Totally 8 sensor pads were used to control both the direction and speed of the wheelchair. The pads were encapsulated with electronics and a battery positioned on the upper oral cavity.

Chung-Hsien Kuo *et al.* manipulated a wheelchair with bimanual gliding control to measure the patient's heart rate. The bimanual gliding control interface measured the thoracic volume conductor current. An electrode pair was placed on the gliding sensor pair which measured the volume of the thoracic. To determine the heart rate a Bilateral ECG wave peak detection algorithm was used [6]. A wheelchair controlled by a hand glove was introduced by the Rini Akmeliawati *et al.* The joystick controlled wheelchair was replaced by the hand glove for efficient movement. The hand glove was made with bend sensor or flex sensor. Based on the finger bend the wheelchair movement was controlled. Through wireless media, the communication between the glove and the controller takes place. The Xbee transceiver is used for unidirectional wireless communication. It was placed in between the seat and the wheel [7]. The Thought-controlled Intelligent Machine (TIM) which acted as a semi-independent wheelchair system was introduced by the Jordan S. Nguyen *et al.* The stereoscopic vision was used to find the three dimensional intensity perceptions [8]. A spherical camera was implemented for the 360-degrees of monocular vision. A camera has to be placed in their forehead of people with disabilities.

With the help of both stereoscopic vision camera and the spherical camera, the PWD can move in an unknown place or in crowds.

Sho Yokota *et al.* introduced the wheelchair which was used to climb steps. The wheelchair caster unit was replaced with the conventional wheelchair caster unit which had assistive plates that can enlarge the radius of the caster imaginary part. The caster rotation of yaw axis had a lock-function which recognized climbing simply through oblique approach. The lock-function worked with the help of an electromagnetic tooth clutch. The wheelchair lock-function manufactured with solenoid which reduced the weight and the wheelchair climb step easily [9]. Giuseppe Quaglia *et al.* proposed a stair climbing wheelchair which can move in any unstructured environment. It can also used to climb any stairs. The wheelchair designed with a seat, a frame and four bars. The bar linkage mechanism avoids the wheelchair from overturning and collision. The linkage mechanism of kinematic synthesis was discussed using algebraic methods. To detect obstacle in the path, the wheelchair used a locomotion unit. The locomotion unit required one motor which controlled the both leg and wheel movement [10]. Monique A.M. Berger *et al.* developed a basketball wheelchair which was light weighted [11]. The frame weight of the wheelchair was reduced and they developed a program to measure anthropometric fit. It resulted that the conventional wheelchair with high end wheels was competent. The high ended wheels increased the propulsion efficiency with reduced rolling resistance. The constructed wheelchair was 30% lighter than the normal aluminium wheelchair. The less weighted wheelchair was easy to use and move for the basketball players.

F. Leishman *et al.* proposed a smart wheelchair which was controlled by the dielectric approach. The deictic approach acted as the control interface and it was used for a vision of the environment. Based on the user specifications in the environment, the wheelchair moved automatically. The smart wheelchair was constructed with a camera, a laser sensor and a computer [12]. Three different speed controlled methods for electrical power-driven wheelchair (EPW) was studied by the Hongwu Wang *et al.* The traction and velocity of the wheelchair were controlled by the kinematic model and the dynamic model based on 3-D. The smart wheelchair was designed with the computerized controller. The encoder is used to record the speed and to identify the slip. The EPW had a proportional-integral-derivative (PID) with an open-loop controller driven on four various surfaces at three particular speeds [13]. Mohd Razali Md Tomari *et al.* overcame the drawback of severe motor impairment by introducing a smart wheelchair. The smart framed wheelchair worked with two control modes. They are the semi autonomous mode and the manual mode. The manual switching functions allow the user to change modes freely. The movement of the wheelchair worked with safety map and collision was avoided [14]. A new powered driven wheelchair was proposed by the Ruoyu Hou *et al.* The torque sensor in a wheelchair was replaced with the infrared sensor to amplify the human force measurement. The brushless DC hub motors were used for trigger function. The novel wheelchair reduced the normal wheelchair force and it found an effortless path to drive in various road environments. The simulation output was done using MATLAB/ Simulink [15].

Seonhong Hwang *et al.* constructed a dynamometer wheelchair to measure kinetic parameters. This was to find the force torque (both lower and upper torque) and the power of the user. The experimental setup was done for over four different users and the torque parameter was measured [16]. Dirk Vanhooydonck *et al.* projected an intelligent wheelchair which was user friendly. Based on the framework the wheelchair continuously observed the user intension and it concluded whether the user needed any assistance to complete it [17]. Susan I. Fuhrman *et al.* evaluated the anthropomorphic test device (ATD) over the wheelchair users. The test is measured with three sled tests without headrests and three with slightly changed commercial headrests. The sled test measurement of the head and neck injury was improved by 34-70% compared with the tests without headrests [18]. Marieke G.M. Kloosterman *et al.* compared the shoulder load of the power assisted and hand rim wheelchair users. They concluded that the power assisted wheelchair worked in an effective way and it reduced the risk factors like shoulder injuries [19]. Hsin-yi Liu *et al.* surveyed the wheelchair Power Seat Functions (PSF). When the disability people use the PSF wheelchair, some risk factor such as pressure can be avoided [20]. The wheelchair was flexible to move in all directions and it was used vastly in the clinical environment.

II. PROPOSED SYSTEM

The intelligent wheelchair acts as a boon for the people with disabilities (PWD). It overcomes the limitations and drawbacks of joystick movement, flex sensor movement and all other problems in the existing systems. The Fig. 1 shows the operation of an intelligent wheelchair for people with disabilities. All basic requirements are pre assigned in the 4*4 keypad and by pressing the keypad (buttons), people with disabilities can direct the wheelchair.

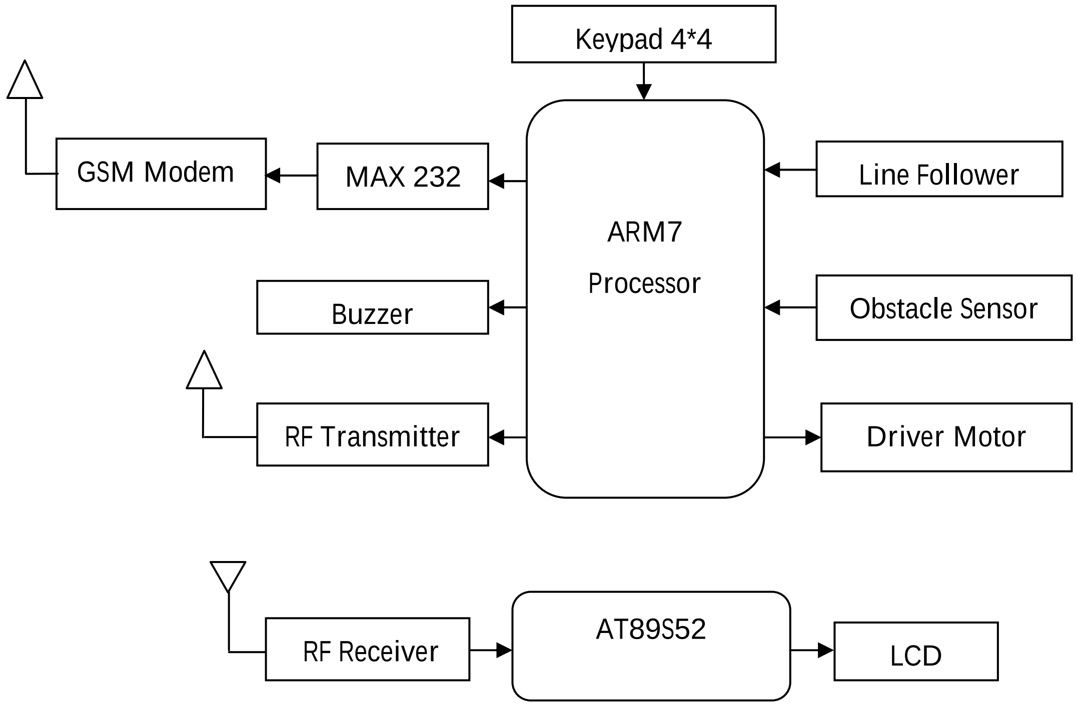


Fig. 1: Overview of the system

The keypad buttons are assigned for the movement of the wheelchair. For example, button 1 is assigned to hall and if the PWD presses it, the wheelchair moves to the hall automatically. Based on the line following algorithm the wheelchair recognizes its path. The L298 driver motor is used for the movement of wheelchair. The obstacle sensor is used to detect the obstacle in its path. The wheelchair acts as an intelligent device with the help of ARM7 processor. Another button is assigned for an automatic call to the doctor. Button 3 is assigned for the call and when the PWD presses it, an automatic call to the doctor takes place. The disable people can use this operation, if they face any emergency situation. To direct the call GSM modem is interfaced serially with controller using MAX 232 which is used to obtain the TTL compatible digital voltage. By pressing other buttons, the PWD get their fundamental desires like water, food, etc. Button 4 is designated for water and if the disabled person presses it, a buzzer sound with the text “water” is displayed in the LCD. This operation takes place using the RF transceiver and AT89S52. The buzzer sound alerts the helper and with the LCD display the helper recognizes the needs of PWD.

II.A. WHEELCHAIR MOVEMENT

When the designated button is pressed by People with Disabilities (PWD), wheelchair moves to the particular place. If the button 2 pressed, which is assigned for kitchen, the wheelchair reaches the place automatically. For this operation, line following algorithm is implemented in the ARM processor. The L298 operates the wheelchair movement with the obstacle sensor.

1. ARM7 PROCESSOR:

ARM7 processor is a RISC (Reduced Instruction Set Computer) which works in a 32 bit operation. It is a Von Neumann architecture which shares both data items and instructions in the same bus. RISC executes the instruction within a clock cycle at high speed. The processor has a thumb 16 bit instruction which improves the code density by 30%. ARM7 has 16 data registers with 2 processor status register. To execute the instructions the processor uses a pipeline mechanism. ARM7 processor has three stage pipelines such as fetch, decode and execute. The memory storage of the processor includes cache, main memory and secondary memory. ARM7 core has a memory unit which consists of non protected memory, memory protection unit (MPU) and memory management unit (MMU). The coprocessor15 register is used by ARM7 to control the TCM (Tightly Coupled Memory), cache and memory management.

2. LINE FOLLOWER:

The line following algorithm follows a path based on black and white surface (vice-versa) visibility. It also follows an invisible path like a magnetic field. The line follower has a sensor which is composed of various cells. Each cell has a sender and receiver to identify the path. As shown in Fig. 2 the sender/receiver passes a light and that particular path reflected the line which to be detected. If the white line is detected the motor moves and if it is black line the motor slows or stops. The sensor input signal controls the rotation speed of the wheelchair.

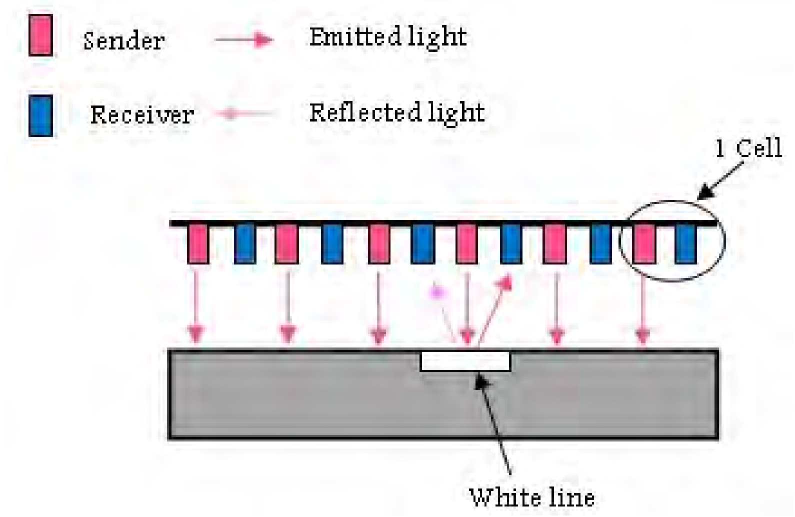


Fig. 2: Working principle of line following algorithm

3. L298 MOTOR DRIVER:

L298 motor driver is used to interface two DC motors with the host processor. The motor driver isolates the processor and it controls the current up to 2 A per motor. The L298 is a 15 lead multi watt with PowerSO20 package integrated into a monolithic circuit. The L298 has a dual full bridge driver with standard TTL logic levels. The enable and the disable signal of the motor are based on the input signal. The L298 operating voltage is up to 46 V and the DC current level up to 4 A. The input voltage of logical 0 is up to 1.5 V with high noise immunity. The L298 acts a heat sink with internal thermal shield circuitry.

II.B. CALL TO THE DOCTOR

If the people with disabilities suffer from health problem they can call the doctor from their wheelchair. A button is assigned for this process. For example if the disable people need doctor’s help, by pressing button 3 the wheelchair makes an immediate call to the doctor. The GSM modem is used to make a call. To obtain TTL logic level the MAX 232 is placed between the processor and GSM modem.

1. GSM MODEM:

Global system for mobile communication (GSM) network is categorized into three major systems. They are the operation and support system (OSS), switching system (SS) and base station system (BSS). The GSM modem acts like a dial up modem except the way of communication. The GSM modem which is a wireless modem send/receive signals through radio waves. The primary GSM upper link frequency is about 890-915 MHz and lower link is within 935-960 MHz. The GSM is a Public Land Mobile Network (PLMN) has subsystems such as network and switching, radio and operation subsystem.

2. MAX 232:

An integrated circuit which converts the RS 232 serial port voltage to TTL compatible logic circuits is MAX 232. It has a dual sender/driver with receiver (RX), transmitter (TX), clear to send (CTS) and request to send (RTS) signals. The threshold value is nearly 1.3 V and the typical voltage of 0.5 V.

II.C. TO OBTAIN BASIC NEEDS

The basic needs are fulfilled with the help of the intelligent wheelchair. The common requirements such as water, food, etc. are pre-designated in the keypad. For example button 5 is assigned for food and if the people with disabilities presses the button, with a buzzer sound the water text displays in LCD. By the buzzer signal the helper who is in the kitchen gets alert and from the LCD, the helper comes to know the needs of the disabled people. The LCD is placed in centre of the home which is visible to helper at anytime.

1. RF TRANSCEIVER:

The RF (Radio Frequency) is used to transmit and receive the radio signals. RF module includes 433.92 MHz, 315 MHz, 868 MHz and 915 MHz. The transmission rate of RF transceiver is from 1 Kbps to10 Kbps. The RF receiver module consists of super heterodyne and super regenerative receivers. The amplitude shift keying Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK) and OOK are the modulation techniques used in the RF module.

III. SOFTWARE DESCRIPTION

The Keil µVision4 software is used to run and debug the program. To enable faster and efficient development of the program, Keil IDE (Integrated Debug Environment) is used. The Fig. 3 shows the simulation result by using Keil software.

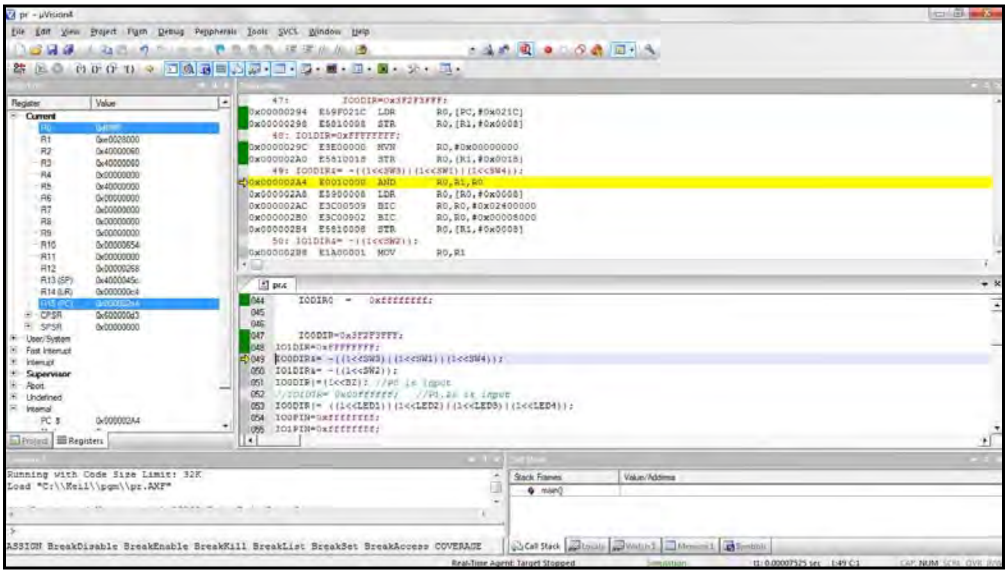
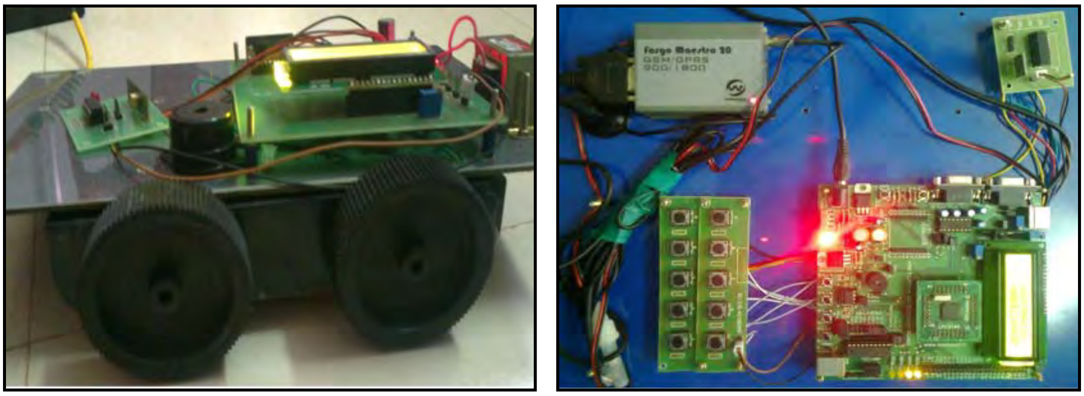


Fig. 3: Simulation Output

IV. HARDWARE RESULTS

When the People with Disabilities (PWD) presses the pre assigned button, the wheelchair moves to the appropriate place. The Fig. 4 shows the hardware setup of an intelligent wheelchair for people with disabilities.



(a) (b)

Fig. 4: (a) Side View of an intelligent wheelchair; (b) Top View of an intelligent wheelchair

When a disable person needs to move to the hall, button 1is pressed which is pre assigned and the wheelchair moves to the particular place. Similarly the button 2 is assigned for the movement to kitchen. The Fig. 5 proves the movement of wheelchair towards hall and kitchen.

(a) (b)

Fig. 5: (a) Movement of wheelchair to hall; (b) Movement of wheelchair to kitchen

If the people with disabilities need water from helper, by pressing button 4 a text displays with buzzer sound. As shown in Fig. 6, with text operation the helper comes to know the PWD needs. Similarly the button 5 is assigned for food.

(a) (b)

Fig. 6: Display shows the needs of people with disabilities (a) Water; (b) Food

As shown in Fig. 7, when the people with disabilities suffer from any health problems, they can press button 3 to automatically call the doctor.

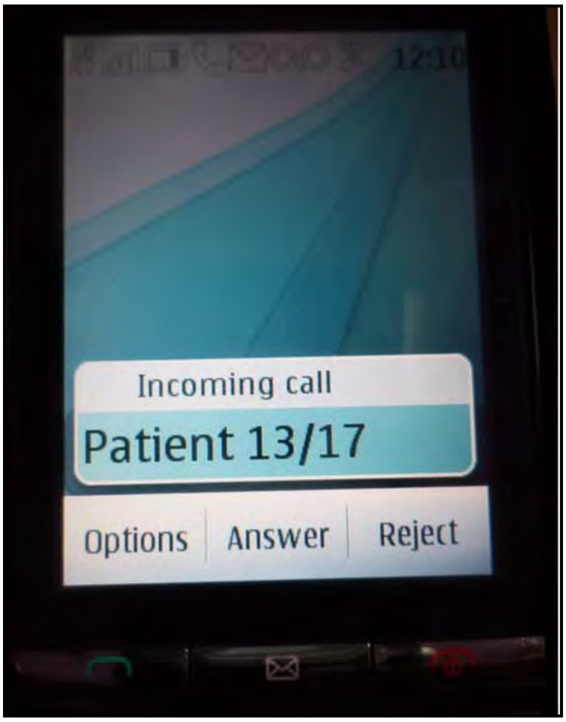


Fig. 7: Calling Doctor

V. CONCLUSION

The intelligent wheelchair helps the People with Disabilities (PWD) to lead their life in an uncomplicated way. The wheelchair overcomes the existing problems like joystick controlled movement and head controlled movement. The line following algorithm is implemented for the wheelchair movement. The disabled people can direct the wheelchair to the designation without any difficulty and send a call to doctor. The helpers at home shall fulfil the basic requirements of the disabled people by getting an alert. With this intelligent wheelchair, people with disabilities can lead their life easily in any environment. The wheelchair can be further enhanced by using the GPRS modem instead of the GSM modem.

REFERENCES

[1] S.Shaheen, A.Umamakeswari. "ARM Based 3-in-1 Device People with Disabilities", Journal of Artificial Intelligence, Vol. 6, pp: 82 – 88, 2013.

[2] Yee-Pien Yang, Ruei-Ming Guan, Yen-Ming Huang, "Hybrid fuel cell powertrain for a powered wheelchair driven by rim motors", Journal of Power Sources, pp: 192 - 204, 2012.

[3] M. AL-Rousan and K.Assaleh, "A wavelet- and neural network-based voice system for a smart wheelchair control", Journal of the Franklin Institute 348, pp: 90 - 100, 2009.

[4] Anwar Al-Haddad, Rubita Sudirman, Camallil Omar, Koo Yin Hui, Muhammad Rashid Jimin, "Wheelchair Motion Control Guide Using Eye Gaze and Blinks Based on PointBug Algorithm", Third International Conference on Intelligent Systems Modelling and Simulation, 2012.

[5] Eugen R. Lontis, Lotte N. S. Andreasen Struijk, "Alternative Design of Inductive Pointing Device for Oral Interface for Computers and Wheelchairs", Alternative Design of Inductive Pointing Device for Oral Interface for Computers and Wheelchairs, San Diego, California USA, pp: 3328 - 3331, 2012.

[6] Chung-Hsien Kuo, Ting-Shuo Chen, Jiann-Jone Chen, Yang-Hua Lin, Wen-Yu Liu, "Human-centered Wheelchairs: Bimanual Gliding Interface with Heart Rate Monitoring", Kaohsiung, Taiwan, pp: 208 - 213 , 2012.

[7] Rini Akmeliawati, Faez S. Ba Tis, Umar J. Wani, "Design and Development of a Hand-glove Controlled Wheel Chair", International Conference on Mechatronics (ICOM), Kuala Lumpur, Malaysia, pp: 1 - 5, 2011.

[8] Jordan S. Nguyen, Tuan Nghia Nguyen, Yvonne Tran, Steven W. Su, Ashley Craig, Hung T. Nguyen, "Real-time Performance of a Hands-free Semi autonomous Wheelchair System Using a Combination of Stereoscopic and Spherical Vision", Annual International Conference of the IEEE EMBS, San Diego, California USA, pp: 3069 - 3072, 2012.

[9] Sho Yokota, Hiroyuki Tanimoto, Junki Heguri, Kyohei Yamaguchi, Daisuke Chugo, Hiroshi Hashimoto, "Improvement of Assistive Wheelchair Caster Unit for Step Climbing", IEEE International Symposium on Robot and Human Interactive Communication, Paris, France, pp: 240 – 244, 2012.

[10] Giuseppe Quaglia, Walter Franco, Riccardo Oderio, "Wheelchair.q, a motorized wheelchair with stair climbing ability", Mechanism and Machine Theory, pp: 1601–1609, 2011.

[11] Monique A.M. Berger, Marieke van Nieuwenhuizen, Martijn van der Ent, Marc van der Zande, "Development of a new wheelchair for wheelchair basketball players in the Netherlands", Conference of the International Sports Engineering Association (ISEA), pp: 331 – 336, 2012.

[12] F. Leishman, O. Horn, G. Bourhis, "Smart wheelchair control through a deictic approach", Robotics and Autonomous Systems, pp: 1149 – 1158, 2010.

[13] Hongwu Wanga, Benjamin Salatin, Garrett G. Grindle, Dan Ding, Rory A. Cooper, "Real-time model based electrical powered wheelchair control", Medical Engineering & Physics, pp: 1244 – 1254, 2009.

[14] Mohd Razali Md Tomari, Yoshinori Kobayashi, Yoshinori Kuno, "Development of Smart Wheelchair System for a User with Severe Motor Impairment", International Symposium on Robotics and Intelligent Sensors, pp: 538 – 546, 2012.

[15] Ruoyu Hou, Xiaodong Shi, Mahesh Krishnamurthy, "Design and Implementation of a Novel Power Assisted Drivetrain for a Wheelchair", Transportation Electrification Conference and Expo (ITEC), pp: 1- 6, 2012.

[16] Seonhong Hwang, Seunghyeon Kim, Youngho Kim, "Torque and Power Outputs on Skilled and Unskilled Users during Manual Wheelchair Propulsion", Annual International Conference of the IEEE EMBS, San Diego, California USA, pp: 4820 – 4822, 2012.

[17] Dirk Vanhooydonck, Eric Demeester, Alexander Hüntemann, Johan Philips, Gerolf Vanacker, Hendrik Van Brussel, Marnix Nuttin, "Adaptable navigational assistance for intelligent wheelchairs by means of an implicit personalized user model", Robotics and Autonomous Systems, pp: 963 - 977, 2010.

[18] Susan I. Fuhrman, Patricia E. Karg, Gina E. Bertocci, "Effect of wheelchair headrest use on pediatric head and neck injury risk outcomes during rear impact", Accident Analysis and Prevention, pp: 1595–1603, 2008.

[19] Marieke G.M. Kloosterman, Hilde Eising, Leendert Schaake, Jaap H. Buurke, Johan S. Rietman, "Comparison of shoulder load during power-assisted and purely hand-rim wheelchair propulsion", Clinical Biomechanics, pp: 428 - 435, 2011.

[20] Hsin-yi Liu, Garrett G. Grindle, Fu-Chieh Chuang Annmarie Kelleher, Rosemarie Cooper, Dan Sieworek, Asim Smailagic, Rory A. Cooper, "A Survey of Feedback Modalities for Wheelchair Power Seat Functions", IEEE CS, 2012.