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Noise Cancellation in Flex sensors: An implementation of Flex sensor with Adaptive noise canceller

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Abstract: This unique idea of automated stroller strikes our minds after increased number of the paralysis cases, there are so many equipment available which are helpful for paralyzed patient but extra human effort is required. In this proposed solution no extra, human effort will be required to operate this stroller. This stroller was designed after the extensive research on disabled patients. For this purpose, we discussed the issues with neurologist experts, they advised us to maintain the speed of standing and sitting or movements, which were set under the guidance of experts. Several researches have been carried out to facilitate the complete paralyzed persons. Previously low-cost wheel chair has been designed by using the motion of the retina. Gear less motor for the wheel chair has been proposed by researchers in past. Extensive literature review shows that some authors presented a head gesture movement identification strategy to control the wheel chair. Accelerometers and wireless sensors have also been utilized by researchers to achieve the task. Voice controlled and remote-control methods have also been utilized. In this research paper authors have proposed a cost-effective novel solution with less false alarm rate. Flex sensor has been used to recognize the head gesture of complete paralyzed people. Wheel chair also possess the capability of being completely folded and in standing position therefore it can be used as a physiotherapy for the disabled persons. To reduce the false alarm and eliminate the noise, adaptive noise canceller has been applied. Results proved that our proposed approach performed better than the other existing techniques with less noise false alarms.

Keywords: Flex sensor; automated stroller; Electronic wheel chair; disable persons

1.0 INTRODUCTION

In past several years, following types of wheelchairs have been invented

- Manually wheelchairs
- Electronic control wheelchairs
- Eye ball control wheelchairs
- Hand gesture movement control wheelchairs
- Voice recognize base control wheelchair

There are so many varieties of wheelchairs in market but the novelty of our proposed solution is that it's position can be modified from sitting position to standing position. When the patient sits on the stroller with a 90 degrees' head position, it becomes rest position. If the patient wants to move in forward direction patient has to tilt the head 20 to 25 degrees downward for forward movement. As long as the user's head orientation bends downward, the wheelchair moves forward condition. Similarly, in the case of left and right conditions. Stand and sit mode can be switched by button, the button is installed in arm of stroller. It can be used for forward, backward, right and left movement. It can also be used for physiotherapy purpose. It has been fabricated to control the blood circulation and skeletal deformities of patient. This stroller was powered by battery and operation of stroller depends upon the user which gives the command to the controller either manually or to be operated by sensors. This stroller has the advantage of patient to move freely from one place to another without any help of human. The patient feels free and move without any human support.

The stroller is one of the most frequently used human aid equipment by people with disabilities, this automated stroller will provide free feel to move, because of balanced structure.

The authors have categorized this research paper into four sections section 1 explains about the background and introduction while section 2 discusses recent approaches

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which have been analyzed in past and the problem statement. In section 3 methodology of the proposed solution has been elaborated. Section 4 and 5 demonstrated the implementation of adaptive noise canceler and simulated results. Section 6 and 7 discusses the conclusion and innovation.

2.0 EXISTING APPROACHES

The electrooculographic EOG signals have been measured and fed to the microcontroller to control the movements of the wheel chair [1]. Low cost solution with the retina motion was proposed [1]. Usually traditional wheel chairs have the capability to be controlled by the hand gesture and joysticks. Acceleration sensor was used for the head movement identification and RF (radio frequency) circuit was connected for wireless signals transmission. Signals were sent wirelessly to the microcontroller that was interfaced with the motor driving circuitry to operate wheel chair [2]. Steering system was developed for the two-wheel chair to stabilize the balance and braking force [3]. Hybrid solar powered wheel chair was fabricated in which maximum power point tracking algorithm was introduced for fast and efficient solar charging of batteries [4]. A cycling wheel chair (CWC) wheelchair was constructed as a personal conveyance device for patients with hemiplegia [5]. Extended Kalman Filter was applied to localize the electric powered wheel chair with the use of the ultrasonic sensor also [6]. Fuzzy logic strategy has been developed for the balancing of the two wheels oh the wheel chair [7]. Upon receiving the voice, the controller understands that input voice and then acts according to it to reach the destination [8]. Linear quadratic regulator (LQR) has been implemented on a wheel chair to maintain the equilibrium of the two-wheeled chair [9]. Major errors contain in the controlling of wheel chair through joystick as it required more accuracy and precision. A novel technique has been proposed in which camera captures the laser and estimate the direction of the motion [10].

2.1 PROBLEM STATEMENT

The signals which were transmitted wirelessly to the microcontroller that can be Arduino or raspberry pie may contain complex noise which leads towards the false alarm. If the flex sensor was bent actually at 25^{o} and it transmitted the voltage levels of signal of 28^{o} because of the addition of noise then it can be regarded as false alarm. The variations in the observations of flex sensors have been observed. Secondly conventional wheel chairs are not capable of physiotherapy of the disabled persons.

3.0 PROPOSED SOLUTION

1. *Main Block Diagram*

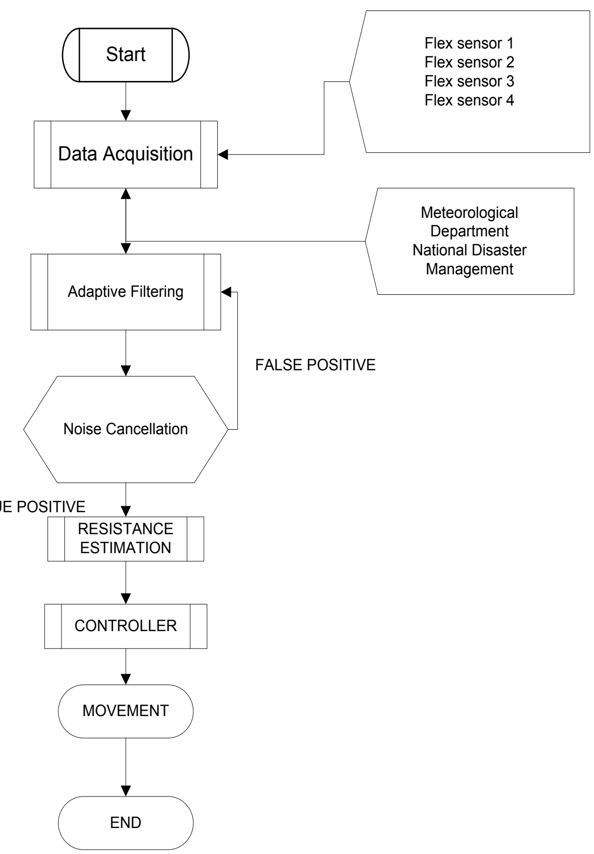

Figure 1. Block Diagram

Fig 1. explains the main flow and applications of this proposed research. The main component of head gesture is Flex sensor, which was deployed in neck collar. Flex sensor is a variable resistance device which provides voltage levels when it bends or changes the position. Flex sensor gives output signal into the Arduino. Arduino processed the information according to control algorithm that have been proposed. The processed information was sent to the H-bridge to drive the motors accordingly. The person moves head towards right the Arduino provides the signal to the position linear motors and stroller moved towards right side, when the patient head moved towards left, the Arduino gave the signal to move left, similarly when the patients move downwards the motors moved front side, when the neck was moved toward back side the stroller also moved backward.

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2. Schematic Diagram

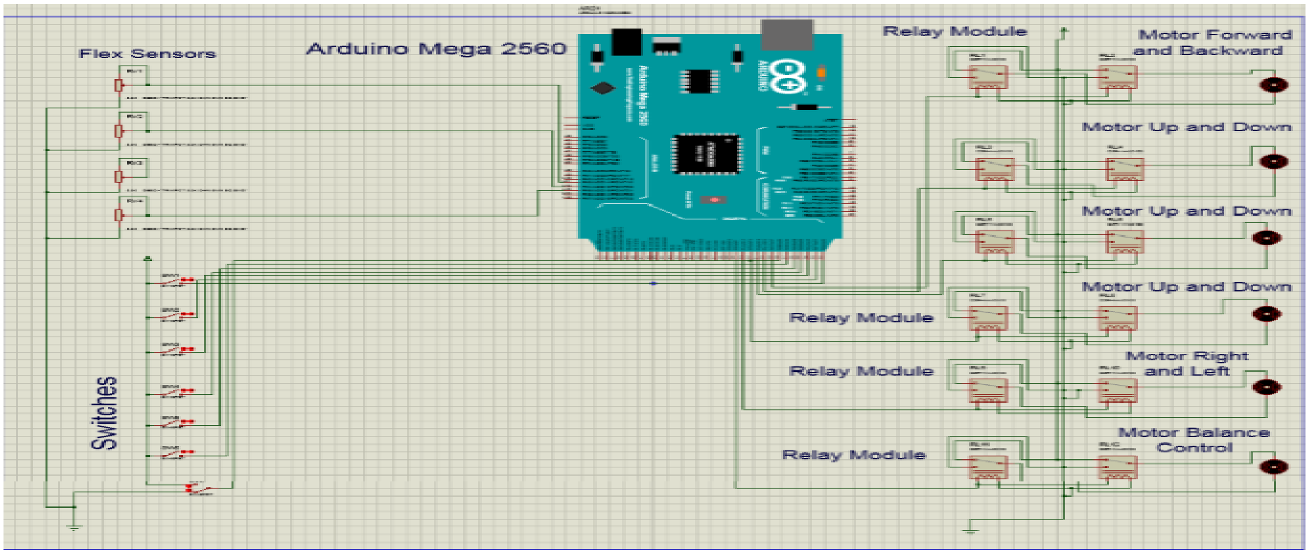

Figure 2: Schematic Diagram

In fig. 3 Arduino digital pins (23,24,25,26,27,28,29,30,31,32,33,34,35,36,38,40) and Analog pins (A0, A1, A2, and A3) have been adopted for controlling. Flex sensor (2.2") were connected to analog pin (A1-4), 6 Push buttons (3 Amp) connected to different digital pin. 6. Motor was operated through relay module and relay module was directly connected to Arduino.

3. Data Acquisition

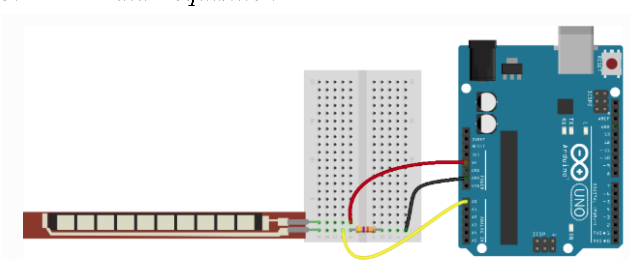

Figure 3: Flex sensor resistor measurement

Figure 4 elaborates that Arduino doesn't have the provision to observe the resistance readings of the flex sensor. Therefoer signal conditioning elements were required to measure the resistance data of the sensor. Voltage divider approach was applied to measure the resistance of the sensor. 0-5V with 10 bit resolution can be measure at Arduino ADC. Arduino was serially interfaced at the baud rate of 9600 bps and in the main function the ADC was converted into the actual voltage. The actual voltage was further changed into thre flex sensor resistance by using voltage divider rule.

Voltage was calculated by using the following instruction:

float flexV = flexADC × VCC / 1023.0 (1)

Resistance of flex sensor was calculated by using the voltage divider rule as given below:

float flexR = R_DIV * (VCC / flexV - 1.0) (2)

4. Hardware Implementation

a) Neck collar with flex sensors

b) Standing Position

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c) Implementation of head gesture movement in wheel chair

Figure 4: Final Mechanical structure

The designing of hardware material and to adjust the exact position according to the signal have been a very complex task. Fabrication of the structure according to the design has also been difficult. The assembling of base and chassis of wheelchair was very complicated task and to synchronize them both with each other was a major task. As discussed, that the chassis assembled for wheelchair was designed first then placed DC linear shaft Motors on it. Later on, chassis of wheelchair was assembled and DC gear Motor was Placed. During this phase some modifications have been made. Testing of motors was performed using step by step approach. First one sitting and standing position had been tested and then the gear motor was tested. Six motors were deployed in the whole Automated Wheelchair. There are two motors which were placed down the chair and one motor was deployed in the back side. One motor is place down the base and one motor which was placed top of the base and one motor was left which was gear motor place was back side of motor. Each motor will play a part to change the position.

Figure 5: Chain drive and Sprocket Gear

Chain drive was used for transmitting a mechanical power from one end to another end. It was often used to transmit a power to the wheels of the car in our case it was a stroller. Power was transmitting by a roller chain and passing over a sprocket gear. Gear was turned, and it pull the chain over a sprocket, thus putting a mechanical force into the system. The gear ratio was calculated as follows:

$$Ratio = \frac{Driven\ Gear}{Drive\ Gear}$$

And was found a ratio of 1:2 in our stroller that means that the speed of the stroller would be doubled as per the given torque.

5. *Flex Sensor Calibration*

Table 1: Flex sensor calibration

Bending Degrees	Description
Face bend downward > 20°	Stroller moves forward
Face bend upward >20°	Stroller moves backward
Face bend right > 20°	Stroller turns right
Face bend left > 20°	Stroller turns left

Table no. 1 represent the calibration specifications of flex sensor.

6. *Motor Interfacing*

Table 2: Motor interfacing ratings

Name	Voltage	Current	Torque	Speed
Gear Motor				
No Load	12v	6.0 Amp	8-10 Amp	80-100 rpm
Load	12v	4 to 6 Amp	4-6 Amp	70-90 rpm
DC Linear Motor (Sitting and standing Movement)				
No Load	12v	0.5 Amp	20 NM	12 mm/s
Load	12v	0.8 Amp	17 NM	8 mm/s
DC Linear Motor (Balancing)				
No Load	12v	0.5 Amp	20 NM	12 mm/s
Load	12v	0.8 Amp	17 NM	8 mm/s
DC Linear Actuator (Left & Right Movement)				
No Load	24v	0.3 Amp	10 NM	24 mm/s
Load	24v	0.44 Amp	8.7 NM	18 mm/s
DC Linear Motor (Back Movement)				
No Load	12v	0.9 Amps	50 NM	5 mm/s
Load	12v	1.1 Amps	44 NM	4.3 mm/s

Table 2. represents the load specifications of motors.

7. *Readings and Testing of Flex sensors*

We observed the phenomenon of flex sensor, when flex bends, it changes the resistivity of sensor. The resistivity of this sensor was 10k to 35k. We set the angle like 15° to 20° according to the need of operation. When flex sensor bends till 20° its change the resistivity like 13k to 15k the sensor activates it. The flex sensor provides the analog value to operate it, the changing value provide the signal in Arduino mega, the Arduino mega convert into the analog signal to digital signal and sent to the motors to operate it, all the calibration was set between 400 to 600 (analog value). It was very sensitive in nature.

Table 3: Calibration of flex sensor

Degree	R (Flex sensor)	Vout
7°-9°	35.48 kΩ	2.32 v
10°-11°	41.3 kΩ	2.36 v
13°-15°	52.0 kΩ	2.56 v
18°-19°	56.2 kΩ	2.69 v
20°-23°	56.7 kΩ	2.78 v

Flex sensors were fixed with the collar. They change their values accordingly with the movement of the head. Values are recorded at every position, so that the controller can be programmed. But the problem was the variation in the flex value, while recording the values. Let suppose at any particular position, one of the flexes gives value in between 400 and 570. It means the mid value of this range would be suitable that was 550. Scaling would also be a better alternative. If we define the range up to 500, means the maximum value 1023 would be equal to 799. It will surely reduce the fluctuation and the values can be easily recorded.

4.0 ADAPTIVE NOISE CANCELER IMPEMENTATION

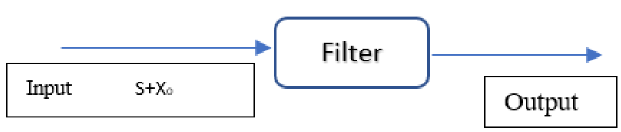

Figure 6: Adaptive noise canceller

Usually adaptive noise elimination approach works better than then the old one approach of filtration as it discards and subtracts the noise from the signal.

$$e = s + x_0 - d \quad (1)$$

Squaring Both sides, we get

$$e2 = s2 + (x_0 - d)^2 + 2s(x0 - d) \quad (2)$$

$$E[e2] = E[s^2] + E[(x_0 - d)^2] + 2E[s(x_0 - d)] \quad (3)$$

Adaptive noise canceller has been applied to the data set so that noise may be eliminated and there would be less false alarm due to the variations in voltage levels of the flex sensors.

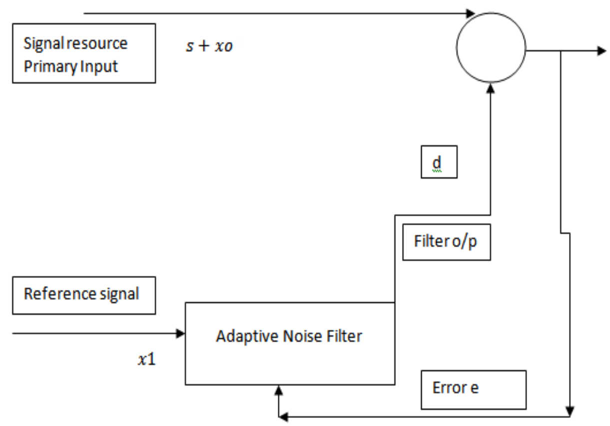

Figure 7: Adaptive noise canceller

The filter has been modified so that it gives the noise less signal. The iterations have been processed in MATLAB using adaptive noise canceller.

$$(e - s) = (x_0 - d) \quad (4)$$

5.0 SIMULATION RESULTS

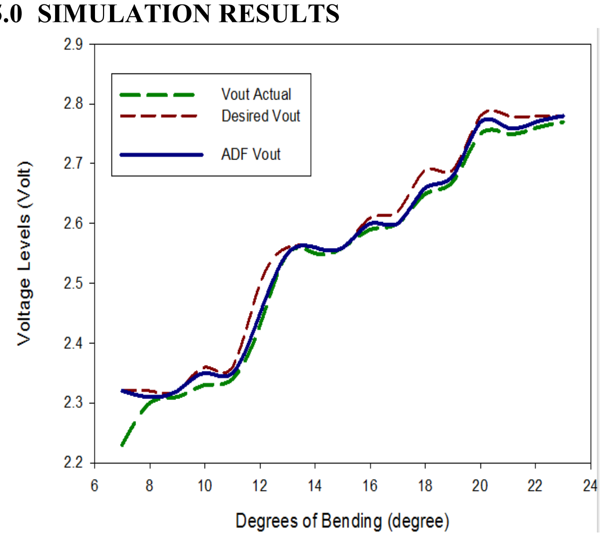

Figure 8: Comparative analysis of voltage levels in terms of bending (degrees)

Fig. 8 demonstrates the comparative analysis of voltage levels of flex sensors as it has a lot of variations in the output of the flex sensors. Green line shows the actual levels which

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were obtained by bending the flex sensor at different degrees. Blue dashed line shows the processed voltage levels by using Adaptive noise canceller at MATLAB. Maroon color line shows the desired values which were estimated by bending the flex.

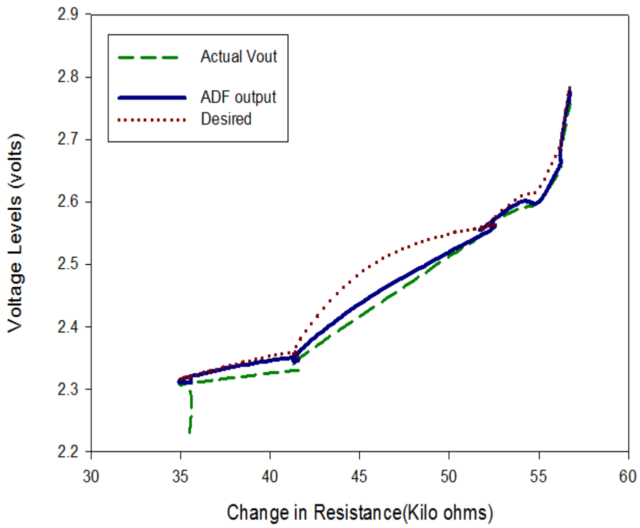

Figure 9: Comparative analysis of voltage levels in terms of bending (resistance)

Fig. 9 elaborated the voltage levels at various resistances produced by flex sensor. Green line shows the actual output voltage levels. Blue dashed line represents the values processed by the algorithm of adaptive noise canceller. Maroon line represented the desired output voltage levels.

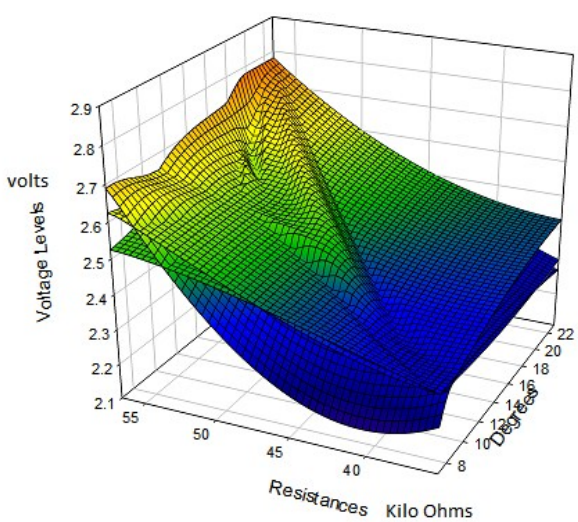

Figure 10: Comparative analysis of voltage levels in terms of both bending and resistances.

Fig. 10 shows the three-dimensional analysis of the output voltage levels of the flex sensors in terms of bending of the flex sensors by changing its degree and resistance values.

Table 4: Data values for the resistance and voltages

Degree of Bending°	Flex resistance (kΩ)	Output Voltage (Vout)	ADF output (V ADF)	Calculated Output (V desired)
7	35.48	35.47	2.23	2.32
8	35.47	2.3	2.32	2.32
9	41.2	2.31	2.31	2.32
10	41.3	2.33	2.32	2.36
11	45.7	2.34	2.35	2.36
12	52	2.43	2.35	2.5
13	52	2.55	2.45	2.56
14	52	2.55	2.55	2.56
15	54	2.56	2.56	2.56
16	55	2.59	2.56	2.61
17	56.2	2.6	2.6	2.62
18	56.2	2.65	2.6	2.69
19	56.7	2.67	2.66	2.69
20	56.7	2.75	2.68	2.69
21	56.7	2.75	2.77	2.78
22	56.7	2.76	2.76	2.78
23	56.7	2.77	2.77	2.78

Table 4 explains the calculation of the voltages in terms of the resistance. ADF has been applied to filter out the errors and omissions

6.0 CONCLUSION AND FUTURE WORK

Simulations results have proved that our proposed approach with less false alarm rate worked better and very close to the desired results. It may be further improved by adding some features like speed variations, obstacle detection system and health monitoring using sensors. The speed cannot be varied by users or patients. So, two types of modifications can be done i.e. either by Pulse width modulation (PWM) pins in the Arduino code or by providing variable voltage to the motors of the wheelchair. Currently there is no such mechanism for obstacle detection, however a system can be introduced in such a way that if some obstacle is detected the wheelchair should stop to avoid any collision or incident, there is an advance option for tracking through GPS or any other source.

A health monitoring system should be introduced in the wheelchair such that it can measure basic information about health, such as temperature, blood pressure and pulse etc. Upper and lower ranges should be defined and immediate emergency indication should be provided to the care taker on crossing these ranges.

7.0 INNOVATION

This research novelty is working in two modes either flex sensors or manually. User in standing position can also freely move where they want to go. Researches used flex sensor in neck collar to estimate head gesture movement. No one used this idea. The previous method head gesture movement detected through image processing, accelerometer, brain pulse detection. This technique was very costly and not reliable. The new idea is that this stroller gives support for standing and sitting position. We used new approach of recognizing face movement by flex sensor. The flex sensors were placed in human neck in vertical direction. The angle between sensors is 90 degrees. If the head is tilt in front, the flex bends and changes the resistance and sends the command to controller. Same thing happens with back, left and right. The linear actuator was used in solar panel and industrial equipment but we placed linear actuator in mechanical structure to carry human load easily. This approach is very useful to other normal gear motor and linear DC motor. For the present electronic wheelchair which have forward, backward, right and left movement. This stroller is designed according to the need of the patients and it is beneficial for physiotherapy purpose. Authors presented a development of hardware/software base structure that can provide hand free control of stroller through head gesture movement. The patients move easily anywhere where he/she wants to go without any human support. The paralyzed patients move using the head gesture by standing position.

REFERENCES

[1] U. Mohammad and M. Anas, "Design of a low-cost DIY moving wheel chair using ATmega1284P based on retina movement for the persons disabled with quadriplegia," *2015 Annual IEEE India Conference (INDICON)*, New Delhi, 2015, pp. 1-4.

[2] S. Nasif and M. A. G. Khan, "Wireless head gesture-controlled wheel chair for disable persons," *2017 IEEE Region 10 (R10-HTC), Humanitarian Technology Conference* Dhaka, 2017.

[3] S. Hamatani and T. Murakami, "A novel steering mechanism of two-wheeled wheel chair for stability improvement," *IECON 2015 - 41st Annual Conference of the IEEE Industrial Electronics Society*, Yokohama, 2015, pp. 002154-002159.

[4] P. Kishore, M. Ananth, S. Chidambaram, B. Vivekanandan and N. A. Gounden, "Solar Based Hybrid Electric Powered Wheel Chair," *2013 Texas Instruments India Educators' Conference*, Bangalore, 2013, pp. 18-24.
doi: 10.1109/TIIEC.2013.11

[5] N. Suqita *et al.*, "Evaluation of navigation skill of elderly people using the cycling wheel chair in a virtual environment," *2013 IEEE Virtual Reality (VR)*, Lake Buena Vista, FL, 2013, pp. 125-126.
doi: 10.1109/VR.2013.6549394

[6] K. Maatoug, M. Njah and M. Jallouli, "Multisensor data fusion for electrical wheelchair localization using extended Kalman Filter," *2017 18th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA)*, Monastir, 2017, pp. 257-260.
doi: 10.1109/STA.2017.8314970

[7] N. M. A. Ghani, A. N. K. Nasir, M. A. H. Hassan and M. O. Tokhi, "A dual phase modular fuzzy control structure for an auto-mode wheelchair in ascending and descending stairs," *IET Conference on Control and Automation 2013: Uniting Problems and Solutions*, Birmingham, 2013, pp. 1-6.
doi: 10.1049/cp.2013.0025

[8] M. S. Sivakumar, J. Murji, L. D. Jacob, F. Nyange and M. Banupriya, "Speech controlled automatic wheelchair," *2013 Pan African International Conference on Information Science, Computing and Telecommunications (PACT)*, Lusaka, 2013, pp. 70-73.
doi: 10.1109/SCAT.2013.7055093

[9] S. Ahmad and M. O. Tokhi, "Linear Quadratic Regulator (LQR) approach for lifting and stabilizing of two-wheeled wheelchair," *2011 4th International Conference on Mechatronics (ICOM)*, Kuala Lumpur, 2011, pp. 1-6.
doi: 10.1109/ICOM.2011.5937119

[10] Yoshihisa Fukuda, Yosuke Kurihara, Kazuyuki Kobayashi and Kajiro Watanabe, "Development of electric wheelchair interface based on laser pointer," *2009 ICCAS-SICE*, Fukuoka, 2009, pp. 1148-1151.