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Cost-Effective Vision based Obstacle Avoidance System integrated Multi Array Ultrasonic sensor for Smart Wheelchair

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Abstract**:** ***A smart wheelchair (SW) is a power wheelchair (PW) consist of microcontroller, actuators, sensor, and implement the assistive technology in system architecture. Users with severe motor impairment may realize the difficulty to operate a wheelchair when they are in a tight space such as passing a doorway or when avoiding obstacles since, they are unable to control the wheelchair. This project embarked on an obstacle avoidance system of a wheelchair. This project developed a cost-effective system that alarmed the user to avoid obstacle on its path. The prototype includes a Kinect camera and ultrasonic sensors. Kinect camera was placed at the right side of the wheelchair for real time video obstacle detection. Four of the ultrasonic sensors was used to detect obstacle at the front and one ultrasonic sensor for rear obstacle detection. Any obstacle detected by the ultrasonic sensors triggered the buzzer. Obstacle detected by Kinect camera was displayed with specific command for the user in attempt for obstacle avoidance. The performance of the obstacle avoidance system was tested indoor to detect obstacles in a controlled environment. The accuracy of the ultrasonic system was tested at a specific distance of 20mm to 200mm at 20mm intervals. Real time video received from the Kinect Camera was used to analyse the depth of the environment and the location of the object.***

Keywords **:** ***Kinect Camera, Obstacle Avoidance, Smart Wheelchair, Ultrasonic Sensor.***

I. INTRODUCTION

Wheelchair is used by those with walking disabilities for their mobility to travel from one place to another. It does not only used at the hospital to transport patient but also at home and other places. Available wheelchair is moved by another person pushing the wheelchair or by the user pushing the side wheels. With some integrated system, there are also wheelchair that uses electric motor thus only require the user to navigate by using a joystick.

A smart wheelchair usually consists of a standard power wheelchair with combination of computers and sensors attached. Wheelchairs can be self-driven by the user or for those individuals who unable to safely operate a manual or powered wheelchair, they are pushed by a caregiver. For independent user of manual or power wheelchairs, navigation skill is important. However, there are users with neck injury or minor visual impairment will find it difficult to navigate through the surrounding which causes discouragement of prescribing power wheelchairs to them due to concern regarding injury to self and other [1]. Obstacles such as walls, steeping stairs or moving people needs to be safely avoid by the user. Thus, an obstacle avoidance system is needed to assist the wheelchair user in their daily life.

Smart wheelchairs that are designed to help with obstacle or collision avoidance are whether by completely autonomous or shared control operation system [2]-[6]. Obstacle avoidance system usually consists contact sensors or proximity sensors such as ultrasonic sensors and cameras. In obstacle detection, the system may deliver a warning to indicate the location of the obstacle, slow the device's movement or stop the movement altogether and the user is required to navigate away from the obstacle [7].

Sonars sensor are mostly used for obstacle avoidance system [8]– [10]. Ultrasonic or sonar sensor measure distance of the object in almost real time by the pulse-echo technique [11]. Sonar sensors could accurately detect objects as the sound wave emitted strikes the object at the correct angle. This was support by a study by Johann B. and Yoram. K. (1988) [12] that used ultrasonic range finders for obstacle detection and to provide information to detour the obstacle.

A study by F. Li (2014) used the information gained from the ultrasonic sensor that had been mounted on the wheelchair to processed a fuzzy logic algorithm in solving path planning problem [13]. The obstacle avoidance simulation was conducted in MATLAB. The study uses ultrasonic sensors with detection range of 0.15m~7m. The sensor was installed in the sensor angle of -90°, -45°, 0°, 45°, and 90°. The simulation shows that the intelligent wheelchair performs well in indoor obstacle avoidance.

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Ultrasonic sensors are proven to perform well in obstacle avoidance. However, even though the sensor could detect obstacle, it could not determine the direction of free passage [14]. Thus, to improve the performance of the system, additional component is required.

To solve the problem on locating free-space area, camera is also used as a part of obstacle avoidance sensor. Compact cameras enable it to be installed at various location. It is mostly used in dynamic environment. Cameras captures and record images of the environment. According to K. Van Workum and R. Green (2013) cameras are used to get the depth information of the surrounding [15]. It was support by study from J. Pu, Y. Jiang, X. Xie, X. Chen, M. Liu, and S. Xu (2018) that uses infrared camera to get image under low light conditions and depth data stream and RGB colour camera to retrieve light field frame under normal light condition. However, the drawbacks of using camera is the light intensity varies in each environment [16]. A study by J. Tang, Y. Liu, D. Hu and Z. Zhou (2018) uses Kinect Camera mounted on the wheelchair to provide the system with 640 X 480 RGB images at 20 frames per second [17]. The system operates on object no less than 2cm in size. The limitation during the study is the limited visual sight.

Despite there are many studies for obstacle avoidance system, there are no similar studies that uses ultrasonic sensors and Kinect camera. Ultrasonic sensors are relatively cheap and does not requires accurate analytical model of the environment to work [18]. By utilizing ultrasonic sensors and Kinect camera for the system, the obstacle could be detected easily in any light intensity. The objective of the project is to develop a cost-effective obstacle avoidance system and to evaluate the performance of the system within indoor application.

II. METHODS AND MATERIALS

A. System architecture

The obstacle avoidance network is consisting of 5 HC-SR04 ultrasonic sensors, Kinect camera, buzzers and LED. The camera is mounted at the wheelchair's right front position. Four of the ultrasonic sensors are mounted at the front of the wheelchair with two of them are facing downward for falling detection. One ultrasonic sensor is placed at the back of the wheelchair for rear obstacle detection. The network of the system is as shown in Fig. 1, Fig. 2 and Fig. 3 show the integration of the component onto a wheelchair.

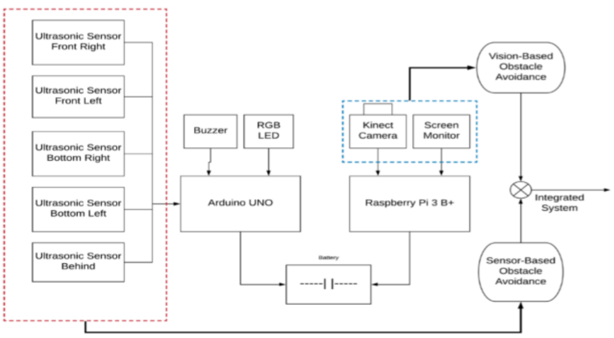


Fig. 1.The obstacle avoidance system workflow

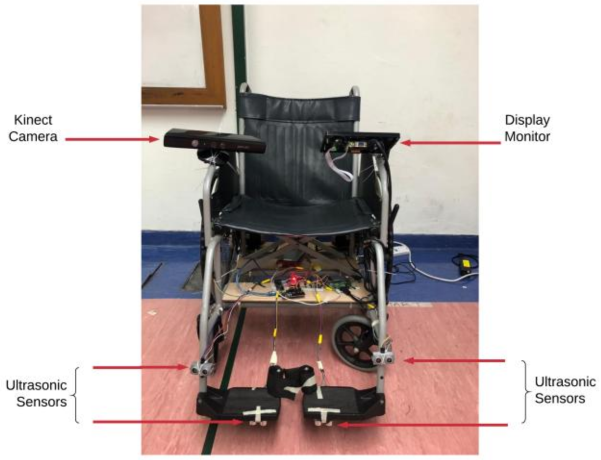


Fig. 2.Front view of the complete integrated system

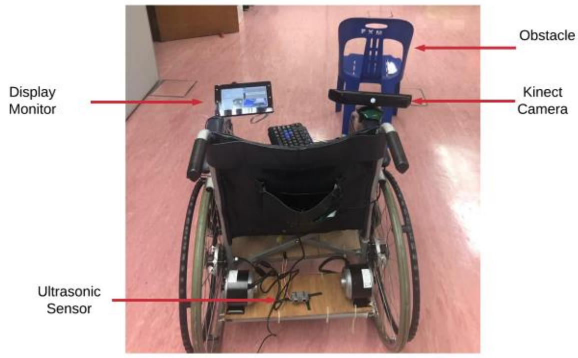


Fig. 3.Back view of the complete integrated system

B. Ultrasonic sensors

Ultrasonic sensor uses the principle of recording the time difference between the emission of transmission wave and echo received for distance measuring. The ultrasonic sensor works by transmitting a high-frequency sound wave. When facing an obstacle, the sound wave transmitted is reflected and the sensor will receive it. The time taken for the sound wave to be echoed back for distance calculation is as in (1).

$$\text{distance} = \frac{speed\ \ of\ \ sound \times time\ \ taken}{2} \quad (1)$$

Arduino Uno board is used to process the data received by the ultrasonic sensor. Arduino IDE software is used for programming the ultrasonic system so that the buzzer and LED will respond to specific distance detected. The ultrasonic sensor operates on +5V.

C. Kinect camera

Microsoft's Xbox Kinect is used to provide real time video for obstacle detection. The Kinect have three main components that work together for motion detection which are RGB colour VGA video camera, a depth sensor and multi-array microphone.

The camera captures red, green and blue colour components with pixel resolution of 640 x 480 and 30 fps frame rate. The depth sensor has a monochrome CMOS sensor and infrared projector that assist in creating 3D imagery. It transmits infrared light and measure the "time of flight" after it reflects on the object to calculate the distance of each point. The data from the Kinect camera is processed by Raspberry Pi 3 B+ with Python software that utilizes OpenCV library. The specifications of the Kinect camera are listed in Table I.

Table- I: Kinect camera specifications

Kinect	Specifications
Viewing angle	Field of View (FOV): 43° vertical x 57° horizontal
Vertical tilt range	±27°
Frame rate	30 frames per second (FPS)
Audio format	16-kHz, 24-bit mono pulse code modulation (PCM)
Audio input characteristics	4-microphone array 24-bit analogue-to-digital converter (ADC) on-board signal processing
Accelerometer characteristic	2G/4G/8G accelerometer configured for 2G range 1° accuracy detail limit

In the obstacle avoidance system, Kinect camera is used for real time video input for the user that are then display at the screen. Figure below shows the images captured by the Kinect camera in RGB, normal input and depth camera. By using OpenCV library, the data from the depth image can be used for obstacle detection and navigation assistant. Fig. 4 shows the images retrieved from the Kinect camera under normal light condition meanwhile Fig. 5 shows the images under low light condition with the subject being closer to the camera.

a
) **IR depth** **b) RGB image** **c) Depth image**

Fig. 4.Images data under normal light condition

a) IR depth **b) RGB image** **c) Depth image**

Fig. 5.Images data under low light condition

D. System workflow

The obstacle avoidance system is as shown in the flow chart of Figure. During the movement of the wheelchair, the obstacle avoidance network will use the ultrasonic system to detect if the return values exceeded a certain threshold set which indicates there are obstacle or falling risk. Any obstacle detected will trigger the buzzer and LED to alarm the user. Kinect camera works to provides real time depth video through the display with depth data. Upcoming obstacle detected will trigger the system to provide safe navigation for the user whether to move forward, reverse, move left or right. The overall workflow of the system is as shown in Fig 6.

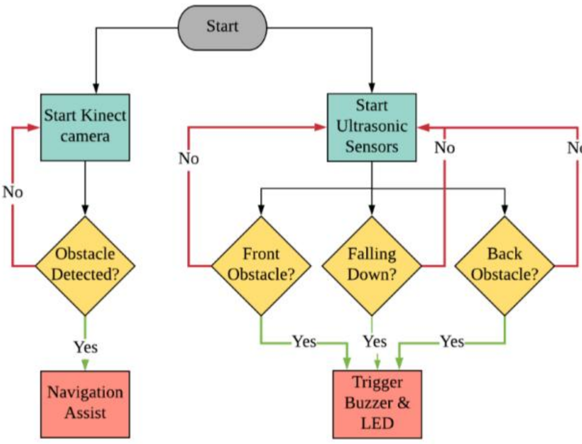


Fig. 6.Workflow of the system

E. Test environment and subjective questionnaire

Wheelchair user will often face object with variety of different shapes and sizes in their path. A scenario was set up whereby seven obstacles were placed in a room as shown in Fig. 7. Nine subjects were asked to operate the wheelchair by using the system to avoid obstacles. Three of the subjects were asked to operate the wheelchair in a low-light condition (LUX = 0). Any obstacle that was detected by the sensors, the alarm and LED would sound off with graphical warning on the screen to alert and assist the user in navigating to a safer direction. A questionnaire as listed in Table 2 was created to assess the user-friendliness and usability which was answered by the subjects after the test.

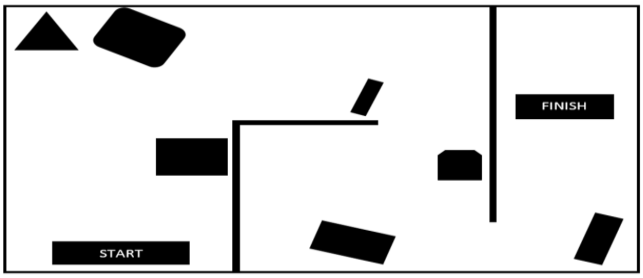


Fig. 7.Test environment with obstacle setting

Table- II: Questions and aspects from questionnaire

Questions	Aspects
Do you feel comfortable while operating?	Comfortability
Does the system function as you expect?	Predictability
Is the system easy to understand?	Ease of learning
Do you feel safe while operating?	Reliability
Do you require less concentration under the help of the system?	Trustworthiness
Is it helpful for you to avoid obstacle?	Effectiveness

III. RESULTS AND DISCUSSION

A. Ultrasonic sensors sensitivity and reliability

In preventing collision and falling down, it is crucial to have a sensitive and reliable close obstacle detection. Ultrasonic sensors that are facing forward, downward and at the back of the wheelchair are the main components for close obstacle detection in the system. The accuracy of the calculated distance from the ultrasonic sensors is important for the reliability of the whole system. Figure 8 show the result from the ultrasonic sensor experiment that were done in five trials [11].

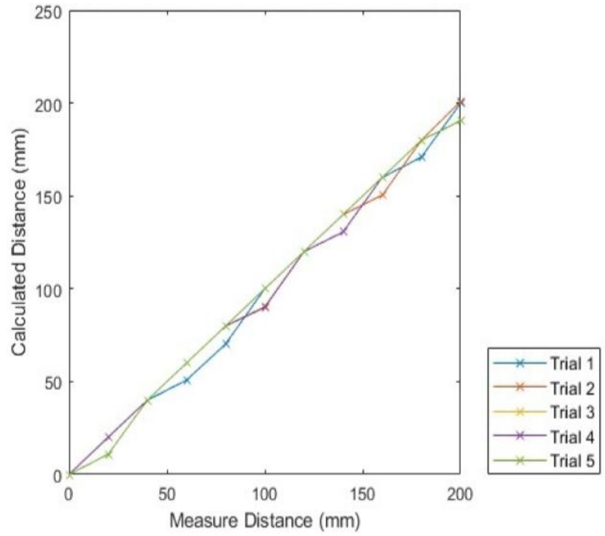
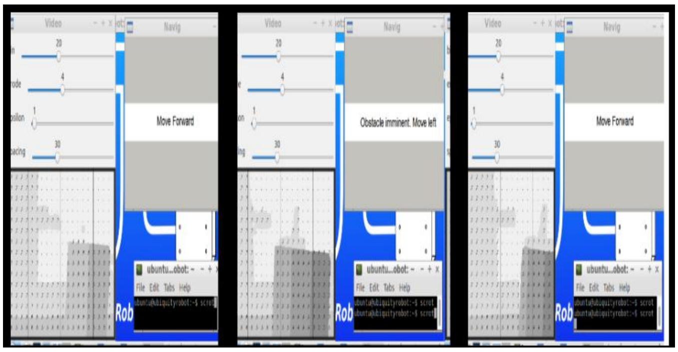


Fig. 8.Ultrasonic sensor data

The calculated distance from the ultrasonic sensor at specific distances between 200mm-2000mm at 20mm intervals were examined. For each distance in each trial, the value was taken 10 times. From the experiment, it shows that the calculated distance from the ultrasonic sensor were near to the measured distance. However, during the trials, there are a few negligible fluctuations in the accuracy. In the fifth trial, the calculated distance gained from the ultrasonic sensor were more accurate. The result from the experiment proves that ultrasonic sensors are suitable for close obstacle avoidance and falling detection.

B. Simulation scenario for obstacle avoidance

The main purpose of the proposed obstacle avoidance system is to aid users to operate the wheelchair while avoiding obstacles and risk of falling. In examining the reliability of the whole system, Figure 9(a) shows how the screen appears to the user. In the beginning of the simulation, the Kinect camera detected no obstacle and the navigation assist shows a "Move Forward" instruction.



a) Approaching obstacle b) Facing obstacle c) Obstacle not in path

Fig. 9.System's display during operation in test environment

After moving the wheelchair closer to the obstacle, the system detected an obstacle and "Obstacle imminent" appear at the navigation window. At the same time, the ultrasonic sensor detected the obstacle and trigger the buzzer as well as the LED. Due to the obstacle that was on the right side of the camera view, the navigation assists the user by showing "Move Left" instruction as shown in Figure 9(b).

When moving left and the obstacle is slowly moving out of the frame, the navigation assist shows a "Move Forward" instruction that indicated that the path is safe to be followed as show in Figure 9(c). At this moment, the ultrasonic buzzer is no longer triggered.

From the simulation, the result shows that the combination of the data from the ultrasonic sensors and Kinect camera helped to assist the user for obstacle avoidance. Different type of sensors worked with its own capabilities to create a reliable and safe obstacle avoiding system for the user.

C. User questionnaire

A questionnaire was designed to assess the user experience which was answered by the user after operating the wheelchair in a test environment. Nine subjects from the university students were recruited for the experiment. Three of the subjects were required to operate the wheelchair in low-light conditions. All of the subjects have no experience in operating a wheelchair. The subjects were given a quick brief on how to use the system before starting the experiment in the test environment. Fig. 10 shows the responses gained from the user after shared-controlling the wheelchair with the obstacle avoidance system.

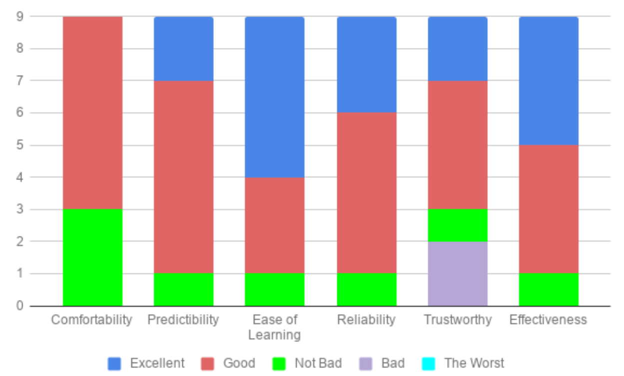


Fig. 10. Responses from the questionnaire

From the questionnaire, most of the subjects felt comfortable using the system while operating the wheelchair and the obstacle avoidance system generated outcome that are predictable. Five of the subjects reported that the system is easy to learn. Three out of nine subjects felt the system is reliable and feel safe while operating the wheelchair. However, only two of the subjects felt that they could trust the system and required less attention while operating the wheelchair. There are previous studies that stated a resemblance result [8], [12]. The study reported that the users tend to be helped rather than being controlled. Improvement such as user-friendliness interfaces could be improved to tackle the issue in trustworthy.

In assessing the system's effectiveness, the number of collision alarm that the system provided to the subjects were recorded and the result is shown in Fig. 11. Subject 7, 8 and 9 were required to navigate the wheelchair in a low light environment. There was a total of 7 obstacles in the test. The average alarm count was 5.7 for ultrasonic sensors and 6.1 for Kinect camera. The result proves that the system is effective for obstacle avoidance while operating the wheelchair. However, all the test subjects for the experiment are healthy university students and only requires a few helps to operate the wheelchair while avoiding the obstacles. For the wheelchair users with disability, the system may be more significant in helping them.

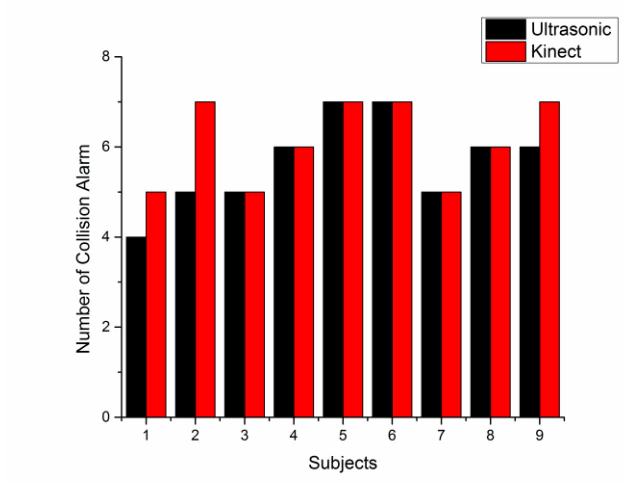


Fig. 11. The number of collision alarm triggered for each subject

IV. CONCLUSION

The aim of the cost-effective obstacle avoidance system for smart wheelchair is to develop a useful instrument that improves the capability of the wheelchair users in obstacle avoidance and falling prevention. The proposed system managed to alarm the user in upcoming obstacle and assist in navigating. Multiple experiments were done to examine the reliability of the system and the result proves the system's effectiveness. The obstacle avoidance system could help to reduce the requirement of attention from the user and improve the daily life of the people with physical disability.

V. FUTURE WORKS AND RECOMMENDATION

The proposed obstacle avoidance system could be improved by an advanced algorithm that enable the system to process the video input quicker with voice navigation assistance. Further improvements could include having an autonomous wheelchair movement that could avoid obstacles and able to attend the user's needs and preferences.

REFERENCES

1. I. Journal and O. F. Robotics, "Obstacle Avoidance with Ultrasonic Sensors," vol. 4, no. 2, pp. 213–218, 1988.
2. D. Sanders et al., "Simple expert systems to improve an ultrasonic sensor system for a tele-operated mobile-robot," 2011.
3. A. L. Robotics and J. Lee, "Obstacle avoidance algorithm for visual navigation using ultrasonic sensors and a CCD camera," pp. 132–135, 2003.
4. E. F. LoPresti, V. Sharma, R. C. Simpson, and L. C. Mostowy, "Performance testing of collision-avoidance system for power wheelchairs," J. Rehabil. Res. Dev., vol. 48, no. 5, p. 529, 2011.
5. A. Ohya, A. Kosaka, and A. Kak, "Vision-Based Navigation by a Mobile Robot with Obstacle Avoidance Using Single-Camera Vision and Ultrasonic Sensing," vol. 14, no. 6, pp. 969–978, 1998.
6. T. T. Q. Bui and K. Hong, "Sonar-based obstacle avoidance using region partition scheme †," vol. 24, pp. 365–372, 2010.
7. Y. Ji, J. Hwang, and E. Y. Kim, "An intelligent wheelchair using situation awareness and obstacle detection," Procedia - Soc. Behav. Sci., vol. 97, pp. 620–628, 2013.
8. S. District, "Application of Fuzzy Control Theory in Obstacle Avoidance Simulation of Intelligent Wheelchair Fang Li *," vol. 597, pp. 361–364, 2014.
9. K. Van Workum and R. Green, "Smart wheelchair guidance using optical flow," 2009 24th Int. Conf. Image Vis. Comput. New Zealand, IVCNZ 2009 - Conf. Proc., no. Ivcnz, pp. 7–11, 2009.
10. J. Pu, Y. Jiang, X. Xie, X. Chen, M. Liu, and S. Xu, "Low cost sensor network for obstacle avoidance in share-controlled smart wheelchairs under daily scenarios," Microelectron. Reliab., vol. 83, no. March, pp. 180–186, 2018.
11. J. S. Nguyen, S. W. Su, H. T. Nguyen, and S. Member, "Spherical vision cameras in a semi-autonomous wheelchair system," 2010 Annu. Int. Conf. IEEE Eng. Med. Biol., pp. 4064–4067, 2010.
12. J. Kim and Y. Do, "Moving obstacle avoidance of a mobile robot using a single camera," vol. 41, no. Iris, pp. 911–916, 2012.
13. J. Tang, Y. Liu, D. Hu, and Z. T. Zhou, "Towards BCI-actuated smart wheelchair system," Biomed. Eng. Online, vol. 17, no. 1, pp. 1–22, 2018.
14. D. P. R. D. Ms. Sejal V. Gawande*, "Raspberry Pi Technology," Int. J. Adv. Res. Comput. Sci. Softw. Eng., vol. 5, no. 4, pp. 37–40, 2015.
15. Y. Rabhi, M. Mrabet, F. Fnaiech, P. Gorce, I. Miri, and C. Dziri, "Intelligent Touchscreen Joystick for Controlling Electric Wheelchair," Irbm, vol. 39, no. 3, pp. 180–193, 2018.
16. I. Journal and O. F. Robotics, "Obstacle Avoidance with Ultrasonic Sensors," vol. 4, no. 2, pp. 213–218, 1988.
17. J. M. Maja and T. T. Z. D. Wang, "Real-Time Obstacle Avoidance Algorithm for Visual Navigation," pp. 925–930.

18. Y. Peng, D. Qu, Y. Zhong, and J. Gu, “The Obstacle Detection and Obstacle Avoidance Algorithm Based on 2-D Lidar,” no. August, pp. 1648–1653, 2015.
19. D. D. Bloisi, “Image Processing with OpenCV,” 2015.
20. N. M. Nor Adnan, M. N. A. Ab Patar, H. Lee, S. I. Yamamoto, L. JongYoung, and J. Mahmud, “Biomechanical analysis using Kinovea for sports application,” IOP Conf. Ser. Mater. Sci. Eng., vol. 342, no. 1, 2018.
21. P. Viswanathan, J. J. Little, A. K. Mackworth, T.-V. How, R. H. Wang, and A. Mihailidis, “Intelligent Wheelchairs for Cognitively-Impaired Older Adults in Long-Term Care: A Review,” RESNA Annu. Conf., 2013.
22. R. C. Simpson, “How many people would benefit from a smart wheelchair?,” J. Rehabil. Res. Dev., vol. 45, no. 1, pp. 53–72, 2008.
23. M. Islam, S. U. Azad, A. Alam, and N. Hassan, “Raspberry Pi and image processing based Electronic Voting Machine (EVM),” Int. J. Sci. Eng. Res., vol. 5, no. 1, pp. 1506–1510, 2014.
24. R. Tomari, Y. Kobayashi, and Y. Kuno, “Enhancing wheelchair manoeuvrability for severe impairment users,” Int. J. Adv. Robot. Syst., vol. 10, pp. 1–13, 2013.
25. W. Li, X. Hu, R. Gravina, and G. Fortino, “A Neuro-Fuzzy Fatigue-Tracking and Classification System for Wheelchair Users,” IEEE Access, vol. 5, pp. 19420–19431, 2017.
26. X. Li, G. Zhao, S. Jia, C. Xu, and B. Qin, “Velocity measurement for omnidirectional intelligent wheelchair,” Trans. Inst. Meas. Control, vol. 38, no. 11, pp. 1320–1333, 2016.
27. J. Leaman and H. M. La, “A Comprehensive Review of Smart Wheelchairs: Past, Present, and Future,” IEEE Trans. Human-Machine Syst., vol. 47, no. 4, pp. 486–489, 2017.
28. A. Erdogan and B. D. Argall, “The effect of robotic wheelchair control paradigm and interface on user performance, effort and preference: An experimental assessment,” Rob. Auton. Syst., vol. 94, pp. 282–297, 2017.
29. Y. Rabhi, M. Mrabet, and F. Fnaiech, “Intelligent Control Wheelchair Using a New Visual Joystick,” J. Healthc. Eng., vol. 2018, 2018.
30. M. H. Al Sibai and S. Abdul Manap, “A Study on Smart Wheelchair Systems,” Int. J. Eng. Technol. Sci., vol. 4, no. 1, pp. 25–35, 2015.
31. Ab Patar MNAB, Komeda T, Mahmud J. Force assisted hand and finger device for rehabilitation. In: 2014 International Symposium on Technology Management and Emerging Technologies. Bandung; 2014.p. 133–8. https://doi:10.1109/ISTMET.2014.6936493.
32. B Ab Patar, MN Azmi, H Ramli, J Mahmud, AH Yusof, Efficacy and safety testing of a new biologically based design ankle foot orthosis in healthy volunteer, Applied Mechanics and Materials Vol. 110, pp.1953-1957, 2012
33. Patar, M. N. A. A., Komeda, T., Yee, L. C. and Mahmud, Jamaluddin. 2015. Model-Based Systems Engineering of a Rehabilitation Device. Jurnal Teknologi. 76(4): 101-106 https://doi.org/10.11113/jt.v76.5496

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