ABSTRACT

Appropriate assistive technologies can have a significant impact on the level of independence of people with disabilities. Powered wheelchair is one such technology where these users feel very comfortable to navigate the environment being seated. The research work proposed is to ease the lives of those among us who are unfortunate enough to have lost the ability to move their limbs due stroke, significant amount of paralysis in the regions below their neck (SCI - Spinal Cord Injury), old age and other disabilities. Such physically challenged find extremely difficult for locomotion, so they depend upon various assistive aids. The most common choice for them is the use of seated wheeled navigation systems for indoor navigation. Although today various types of wheeled navigation systems, particularly powered wheelchairs, are available in the industry, there is a limit in the number of designs with features that suits for people who fall in the above category. As such they lack specific features and control methods to be used in the rehabilitation process of these people. In this research work, an integrated platform of Multi-Modal Control in Automatic/Semi-Automatic Navigation System for Rehabilitation of People with Mobility Issues including a Patient Monitoring System is proposed to provide mobility to users and assist in their rehabilitation process.

Voice based and EOG based wheelchair navigation control method is studied and analyzed. This can be used by elders, certain category of SCI patients and/or physically challenged. The voice of the person is detected by voice capture module which will be compared by voice recognition module with predefined voices loaded in to the system. According to the received voice, the destination is automatically understood and the wheelchair moves according to the route which is predefined. It is also equipped with obstacle avoidance technique, where the person may not be able to provide proper voices at the right time. The wheelchair can automatically navigate from one point to the other in the home as per predefined route based on the voice received. EOG signals usually acquired through a bi-channel signal acquisition system, namely the horizontal and vertical channels. The horizontal and vertical channels are correspondingly used to detect the horizontal and vertical movements of the eye. Movement of the wheelchair user's eyes are recognized as left, right, forward and reverse and accordingly used to control wheelchair navigation.
Continuous health monitoring is required for certain category of wheelchair users who might be stroke patients, SCI patients, and elders. A Patient Monitoring System, can be integrated with the wheelchair for such people which can continuously monitor the health condition of the patient by measuring body temperature, blood oxygen saturation in blood, heart rate and blood pressure (cuff-less) for which a temperature sensor, PPG technique and ECG are used. These three parameters are the crucial parameters of a body and help the doctor to diagnose easily. WPMS constantly monitor vital health parameters and identify critical situations to inform physicians, health care centers and relatives so that the users are taken care at the earliest.

An IR Camera Based gesture control method is designed, implemented and analyzed that can be used by anyone with mobility issues, who are able to move their hands even in the most minimal way. A gesture capture module is developed based on IR camera, a correlation based algorithm is designed for gesture recognition identification, and a controller for driving motors is implemented. The system is so simple that a user is expected to perform only four gestures. The hardware and software implementation, the response time calculations of the system, testing, performance evaluation, and safety evaluation are discussed in detail. Results suggest that the average success rate of gesture recognition is 97.8%. The system performance during live testing with users, the positive feedback about the user experience and the cost of implementation demonstrates the possibility of this hand gesture control as an alternative to joystick controlled wheelchairs.

A novel and simple hand gesture recognition method (Patent Pending) using IR sensors, to be used in rehabilitation of people who have mobility issues particularly stroke patients and patients with spinal cord injury (SCI). Keeping in mind the reach of such a system for a wider community of people with mobility issues, the proposed low cost control device called 'gpaD' - Gesture Pad provides alternative solution to the joystick based powered wheelchair control through hand gestures. In this method IR sensors are used for identifying the simple gestures to control the powered wheelchair to move in any direction. The design, implementation, the response time calculations of the system, testing, performance evaluation with stroke and SCI patients are discussed in detail. With the average success rate of gesture recognition above 99.25 % and response time as comparable to that of commercially available joystick controlled wheelchair, this system could be a possible alternative to the existing ones. With extensive experiments that
demonstrate the accuracy of the system, the user experience, testing with patients, and the implementation cost indicate the superiority of this method.

Automatic navigation of the powered wheelchairs with minimal input from the users with mobility issues is developed and evaluated. The system makes use of LARN Algorithm for indoor navigation. A Location Aware and Remembering Navigation (LARN) algorithm was developed which allows a wheelchair to pinpoint its location inside a house without the need for any wireless sensors or devices. The method is cost efficient and less complex compared to existing methods. The LARN Algorithm maps the floor space of the house into a number of grids by considering it as a polygon and assigns a specific coordinate to each of these grids. The wheelchair keeps track of its current grid position and updates its location as it navigates. The accuracy of this algorithm is determined by the size of the grid, the angle in which the wheelchair moves and the ability to remember the coordinates of the grid it is traversing. A simulator is developed to simulate various scenarios the wheelchair can undergo in real time including dynamic obstacles, rotation encoder sensor error to keep track of the distance travelled, wheel alignment error, error correction mechanism etc.

Thus various control methods for wheelchair navigation to be used by people with mobility issues - stroke patients, SCI patients, elders, physically challenged is investigated for automatic and semi-automatic navigation which would help in their rehabilitation process.

**Keywords:** wheelchair, navigation, stroke patients, SCI patients, elders, physically challenged, voice based, EOG, hand gesture, IR camera, IR sensors, automatic navigation