Design Recommendations For Electric Wheelchair Used By Cerebral Palsy Patients

Around five million people in the US have limited limb movement, making it challenging for them to use products, such as electric-wheelchairs. The user needs to continuously move the joystick for specifying the chair's trajectory and its speed. Unfortunately, users suffering from Cerebral Palsy lack these fine motor skills to use a joystick.[1]

Cerebral Palsy is a motor impairment disorder that limits activity. It is one of the most common lifelong lasting disorder which results from an injury to the brain before birth or in early childhood. It is caused by neural connections formed in an anomalous way and leads to abnormal limb strength, control, or both. The motor impairments disorder of Cerebral Palsy comes with impaired cognition, communication, sensory perception or a combination of these features, but this paper focuses on motor impairment disorder.[2]

Posture and movement limitations are common in different types of cerebral palsy. There are four types of Cerebral Palsy, such as one may affect one limb (monoplegia), one side of the body (hemiplegia), both lower limbs (paraplegia) or all four limbs (quadriplegia). The target users of this project are children with upper-limb physical impairments caused by Cerebral Palsy. [3]

The use of assistive devices, such as a powered wheelchair, plays a significant role in addressing the issue of mobility limitations. But, the users with CP have physical limitations which makes the two-axis joystick challenging to them.

For instance, those with cerebral palsy might not be able to navigate the wheelchair through narrow passages, such as a door entrance, without repeatedly colliding with the sides of the door. Furthermore, they might not be able to adjust their speed upon facing an obstacle. When a person suffering from Cerebral Palsy tries to use a joystick, their hands show abnormal movements, such as they start shaking, due to a lack of coordination between their hand and brain. The results of such movements are undesirable and it can lead the user to crash into any nearby object.

To address this problem the electric wheelchair needs to be installed with a system that controls the device even when the user is not able to provide any input. For instance, a semi-autonomous or autonomous system is required in the electric wheelchair for Cerebral Palsy users. This system would assist them in driving them to their respective destinations with less or no user interference. [4]

Experiments have been performed on users suffering from cerebral palsy, using a simulator, to check this approach. The experiments uncover the fact that it is very important to have aided controls for users with severe disabilities. The experiments also revealed that patients felt comfortable and in control over the wheelchair movement when using semi-autonomous control at a 50% level. [5]

Furthermore, extensive research on computer-controlled chairs has examined ways of

minimizing human-intervention by using sensors and embedded control systems. Wheelchair researchers have come up with different ways to reduce human intervention. One strategy is that the user directs the chair by giving voice commands and the autonomous system ensures safety by avoiding obstacles. Another strategy is to have the wheelchair perform specified behavior, such as following a person. At an even higher level, the wheelchair automatically navigates to the location on the map.[5]

My proposed design presents an integrated solution by installing an embedded system that may easily adapt to any electric powered and it consists of three different control methods: manual, semi-autonomous and autonomous. The interface consists of a conventional wheelchair joystick, mode selector, navigation system,voice-based controls that are integrated with sensors, cameras and actuators in the wheelchair. [6]

In the autonomous mode, the user commands the destination to the navigation system and the chair autonomously drives to the goal while avoiding collisions. In this mode, the wheelchair follows the circuit points on the navigation system and there’s just one user interaction.[7]

The basic concept of semi-autonomous mode is to interpret the user’s intentions and provide safer and easier navigation. For example, if a user is having trouble in adjusting speed, the system momentarily takes control and adjust the speed and direction based on data gathered from sensors and the commands from the users.

The manual mode is always there as an option for the user with the collision avoidance system active at all times.

Conclusively, my design recommendations for an electric-powered wheelchair provide a comprehensive solution to the Cerebral Palsy users, who are not able to use the joystick properly, due to upper limb motor impairment. Including three different control levels, with the collision avoidance system active at all times, it allows Cerebral Palsy users to navigate the wheelchair without moving their hands. With the implementation of these recommendations, the Cerebral Palsy users can easily overcome there limited upper limb movements and use the electric wheelchair.