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Trajectory Path Tracking Evaluation of Smart Wheelchair By Image Processing Technique

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***Abstract* - Electrically powered wheelchair has basically two features, one is mechanical based movement system, and another is electrical drive to ease maneuvering rather than manually driven by assistant. In smart wheelchairs, third feature is added that would further simplify driving of powered wheelchair by conventional methods. In the recent years, *IoT* (Internet-of-Things) are dramatically changing the lifestyle of people which are being used not only for entertainment but also for actuating external devices as per their requirements. Smart phones are almost commonly being used by many people since they are affordable and are being added with multiple features like camera, video games, messaging, navigation facility and many more. We have previously developed a mobile phone application software to control the movement of an electrically powered wheelchair, thus making it as a smart wheelchair. In this paper, we reported the performance evaluation of the wheelchair control through the mobile app. A reference trajectory path was marked on the floor area and a route map was prepared on the Google Maps browser in the smart phone. The user of the wheelchair navigated its movement between source and destination points on the map to follow the reference track. The motion of wheelchair and the track was captured in a video clip. Then, by image processing technique, the wheelchair movement was tracked. It has been observed that during perpendicular turnings like corners inside the buildings or turnings on roads, there were slight deviations of the wheelchair with respect to the reference path. However, this can be minimized by proper training to the person using the smart wheelchair.**

Keywords: Wheelchair, smart phone, mobile app, image processing, path tracking, IoT.

I INTRODUCTION

Wheelchairs are considered as medical devices. Patients with impairment in mobility are prescribed by the clinicians to use the wheelchair for assisting in their movement independently. In the present competitive world, every individual wish to engage themselves either in jobs or educational activities irrespective of their disability. People with disability often are at risk of health problems which could have great impact on physical, mental, emotional and social activities. Therefore, they look for an improved ride in wheelchairs to become independent from family members and caretakers promoting self-reliance.

Traditional wheelchairs which need to be propelled manually for mobility are difficult to maneuver by individuals in confined spaces [1]. Due to the fact of manually operated wheelchairs are more physically demanding, electrically operated wheelchairs were emerged in the market since early 1970's [2]. Since then, a considerable research and development activities are being focused in the improvisation of electric wheelchairs. Several methods have been reported for the navigation and control of electric wheelchair such as joystick [3], voice controlled, vision based, and gesture controlled [4]. Several researchers have developed smart wheelchairs utilizing the trending "IoT" technologies. Traditional input methods such as joystick, pneumatic switches have also been incorporated in smart wheelchairs. It has been reported that the wheelchairs can be controlled from mind. The principle in the technique is based on acquisition of brain waves through electroencephalography electrodes positioned over the wheelchair user's head and then the processed signal is made to actuate the controllers of the wheelchair. The technique is also known as "brain-computer interfacing" (BCI) method of wheelchair control [5]. All these methods have been made possible because of advancement of sensors and control interfaces which has significantly increased during previous years.

Now-a-days, Smartphones are ubiquitous in human life because of their ever-increasing technology and affordability. Multifunctional mobile phones with superior display quality and internet accessing capabilities are being boosting them to play a vital role in human life. Emerged primarily as communicative device, the mobile smart phones are extending

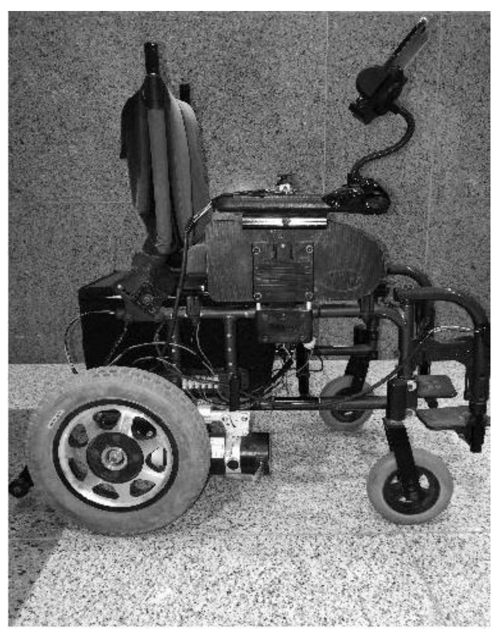

Figure 1. Smart wheelchair with sensors and a mobile phone attached on its armrest

their uses to medical applications too. Several application software (App) on Android platform are being developed for performing daily tasks [6;7]. We tapped the merits of the smart phone for navigating the wheelchair and an Arduino microcontroller is employed to control the sensors and motors in the wheelchair. We have developed a smart wheelchair which can be easily controlled its movements through a mobile phone [8]. However, its performance of following the desired trajectory need to be evaluated before its use in realistic world. In this paper, we have described an image processing based method for evaluating the motion control of the powered smart wheelchair.

II METHODOLOGY

Figure 1 shows the newly developed smart wheelchair equipped with sensors and a mobile phone in fixed in the holder which is attached over the right hand arm of the wheelchair. It can be shifted to left side easily if the user is a left hander. Figure 2 shown the block diagram for the proposed test to evaluate the wheelchair motion control along the pre-determined trajectory path.

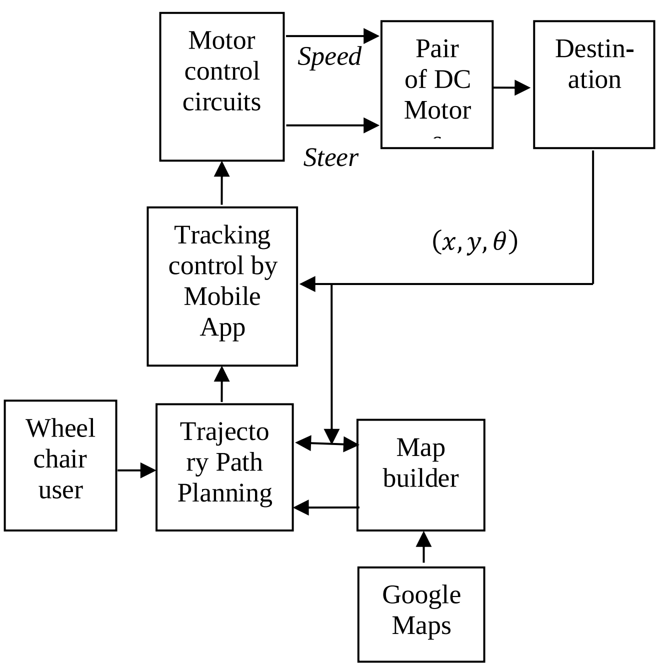

Figure 2. Block diagram for trajectory path testing controlled by mobile phone app.

In this experiment, we have marked a trajectory on the floor in our university corridor and we call is as 'desired path'. Then, we selected participants who are normal and healthy of an age group in the range of 20-25 years. We asked them to control and navigate the wheelchair from the mobile phone App on the desired path to reach the destination. The desired path was simulated by marking with white colored line over the corridor floor area. The corridor was 2 m wide and, on either side, the building pillars were protruded from the wall surface. These extended walls were treated as obstruction to be detected by the sensor of the wheelchair. During every trial, we noted the time to complete the task. We have estimated the required time at a speed to finish the task. Then, the performance was evaluated by two parameters (I) time of task and (II) tracking error.

As a reference point, an LED light source was placed on the middle of the seat. On the far end of the simulated track, a video camera was arranged to record the motion of the wheelchair.

III RESULTS AND DISCUSSION

Figure 3 shows one frame of the video recorded in which the tracking reference point and the laid desired path are seen.

Fig. 3. Single image frame of the video recorded during the wheelchair motion along the simulated track. The motion controlled and navigated by Mobile phone App remotely.

Figure 4 illustrates the desired path resembling a letter 'd', in which the total length was 12 m (4+3+2+3 m). Each image frame was processed and analyzed in MATLAB (MathWorsk, Inc.) software. At an interval of 20 cm on the track, (x, y) coordinates were measured with reference to the dotted line and then joined all these points by straight line to obtain the real path of the wheelchair movement. In Fig. 3 (b), the dotted line shows the median of the desired path and the blue line indicates the path traversed by the wheelchair controlled by the participant. It can be noticed that in the first 4 m. of the path, the wheelchair was deviated away from the central axis in 5 instances. The navigation was corrected immediately to bring the wheelchair on the track from the direction arrows in the mobile App. In the subsequent track lengths, there were no much deviations which indicate that the participant trained himself to operate the navigation App. This means that the control and navigation App is user-friendly and do not need special training to drive the powered wheelchair. At the constant speed, the time recorded to complete the track was 13 seconds and for the same time without any correction in the motion, the calculated time for the same track was 10 seconds.

So, the navigation error in this case is 3 seconds, which is acceptable because the error in time is only in the beginning.

IV CONCLUSION

An image processed method to evaluate the trajectory tractor path of smart wheelchair has be developed. The newly fabricate electric power wheelchair was equipped with sensors for the safety of its user. A mobile app has been developed for Android based smart phones and was used to navigate the wheelchair. Motion of the wheelchair from the mobile app was controlled by actuating the sensors through command signals. The wheelchair moving along the reference track was video graphed and then from image processing technique the faithfulness of the moving wheelchair on the guiding track was analyzed. It was observed that while turning at 90^o there were small deviations, otherwise the motion found to be according to the App navigations. By training and repeatedly using the tracking software on the mobile phone, the turning of the wheelchair becomes smooth and precise control of its motion.

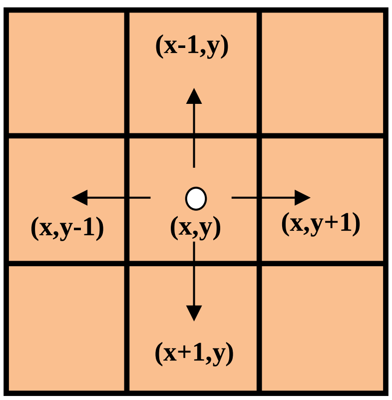

Figure 4. Plot of desired track and the real path of the wheelchair controlled by the participant.

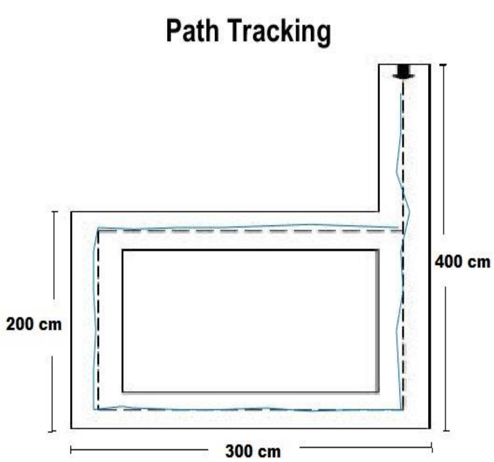

Figure 5. Path tracking algorithm.

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