DEVELOPMENT OF A TELEPRESENCE WHEELCHAIR USING ADVANCED WIRELESS VIDEO STREAMING

By

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as part of the collaborative doctoral degree and/or fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

In recent years, assistive technologies, especially intelligent wheelchairs have played a crucial role in supporting the elderly and people with disabilities. Current smart wheelchairs are usually controlled by individuals sitting in the wheelchairs. There has been limited research undertaken on the ability to control the mobility of wheelchairs while people are not inside the wheelchairs. Along with intelligent wheelchairs, telepresence robots have been developed for various applications. However, there has been limited work in developing telepresence systems based on wheelchair platforms for assistive technologies. Thus, an effective integration of telepresence functions into a wheelchair would create an innovative health care support solution.

This thesis aims at developing a telepresence wheelchair using an assistive technology which is capable of providing two-way video communication and interaction. The telepresence wheelchair developed in this thesis can support independent mobility of the wheelchair users, especially in the scenarios where people with disabilities might use the telepresence function to move the remote wheelchair towards their positions without the help of caregivers. In addition, the system can allow users to look at the environment surrounding the wheelchair and to control the wheelchair to move around different places to communicate and meet other people. Thus, the designed system would be significantly meaningful and helpful for individuals with mobility impairment. However, designing and developing such an Internet-enabled telepresence wheelchair remain significant technical challenges in terms of implementing in real-time, providing remote control, and realizing a wide field of view.

The key contribution of this thesis is to develop a unique telepresence wheelchair system that provides high-quality video communication with a full field of view and efficient remote control over the wireless Internet in real-time. The current telepresence systems which are coping with one view direction at one time are not flexible and are cumbersome while operating in the reverse direction. To address these issues, this thesis investigates the advanced technologies to develop a telepresence wheelchair with 360-degree vision. To develop a complete telepresence wheelchair, this thesis has exploited technological advancement in image processing, wireless communication networks, and healthcare systems. There are three core tasks to be considered: Firstly, to investigate the data communication techniques to stream the views surrounding the wheelchair wirelessly from the unknown environment to the remote users to find the appropriate protocol for the real-time application. Secondly, to develop real-time communication and remote interaction with depth information for immersive experiences in telepresence. Thirdly, to implement the 360-degree field of view for a telepresence wheelchair and to develop an independent application based on emerging technologies.

Accordingly, in the first stage, the Internet protocol for transmitting video based on client-server topology over a wireless network has been developed and implemented as the first attempt. The experimental results with the video transmission based on client-server topology over a wireless network showed that the proposed method successfully streamed the *panoramic images* with the average peak signal to noise ratio (PSNR) of 39.19 dB.

In the second stage, the real-time video streaming based on the cross-platform, namely Skype framework has been explored for *multiple-video transmission* to improve the system performance. The experimental results also showed that the streaming rate was between 25 and 30 frames per second (fps) and the round-trip time varies from 3 to 271 milliseconds. In addition, the wheelchair can successfully navigate by remote control at different distances with the average accuracy of 97.72 %.

In the final stage, this thesis has performed the development and implementation of *360-degree video streaming* and remote controlling based on *advanced real time communication*. The experimental results showed that the round-trip time significantly decreased and fluctuated from 3 to 20 ms. Moreover, the proposed system is able to stream *a full field of view video* surrounding the wheelchair smoothly in real-time with the average frame rate of 25.83 fps, and the average PSNR of 29.06 dB.

The experimental results demonstrated that the proposed telepresence wheelchair is able to stream *a full field of view* video surrounding the wheelchair effectively and smoothly in real-time. Furthermore, the results showed the designed telepresence wheelchair could be controlled remotely via the wireless Internet with high accuracy.