Chapter 5
Virtual Reality, Robotics, and Artificial Intelligence: Technological Interventions in Stroke Rehabilitation

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ABSTRACT

Stroke is a leading cause of death in humans. In the US, someone has a stroke every 40 seconds. More than half of the stroke-affected patients over the age of 65 have reduced mobility. The prevalence of stroke in our society is increasing; however, since stroke comes with a lot of post-hospitalization care, a lot of infrastructure is lacking to cater to the demands of the increasing population of patients. In this chapter, the authors look at three technological interventions in the form of machine learning, virtual reality, and robotics. They look at how the research is evolving in these fields and pushing for easier and more reliable ways for rehabilitation. They also highlight methods that show promise in the area of home-based rehabilitation.

INTRODUCTION

Stroke is one of the leading causes of death in humans, and the recovery process is long and arduous. Patients once discharged from hospitals after primary treatment for stroke are advised to go on a long-term rehabilitation program. This includes routine visits to hospitals and a home-based exercise regime. Studies have pointed out that many patients drop out of the outpatient rehabilitation program due to

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recurring costs and the added discomfort of traveling to and from the rehabilitation centres. There is also a large disparity in the distribution of rehabilitation centres. A large number of centres are usually located in big cities. These are some of the major obstacles that patients who want to participate in a rehabilitation program face. The ability of technology to bring standardized rehabilitation care to the comfort of their homes with little clinical intervention is the need of this age. In this chapter, we look at virtual reality, machine learning, and robotic assistance devices that have successfully been applied to the rehabilitation of stroke patients. This chapter is divided into three components: 1) Machine Learning based Rehabilitation Techniques, 2) VR based Rehabilitation, 3) Robotic Devices based Rehabilitation. In the first component, we look at how machine learning models can help with movement evaluation, which can improve home-based therapy while also lowering recurring costs. Such systems, on the other hand, require extensive training and testing. Any machine learning system must be trained using a reliable source of unbiased data. We will look at a technique that requires a few well-executed workout sequences. A depth camera will be used to capture the data. These movements provide first-order statistics, which are then used to provide feedback for future movements given to the model. This method also presents a novel way for aligning temporal data, which is critical for calculating accurate movement statistics over numerous video sequences. In the second component, we'll look into virtual-reality (VR) assisted rehabilitation options. One of VR's most important characteristics is its ability to gamify the repetitive training plans prescribed to patients at home. VR games can help patients establish a self-interest in playing the game, which can lead to better rehabilitation outcomes. For post-stroke therapy, we look at a virtual reality-assisted motor training system. The technology has been shown to actively alter human kinetic behaviour based on patient-specific rehabilitation goals. Patients' kinetic performance can also be accurately collected with this method. Five post-stroke patients were investigated over the course of three months. To track patient progress over time, three parameters were used: performance time, movement efficiency, and moving speed. Another VR assisted rehabilitation method recreates a virtual version of the buzz-wire game. The technology is intended to assist people with upper-body rehabilitation and fine motor skills improvement following a stroke. There were five different wires to choose from the game. Stability and fine motor abilities are required to navigate the game's wires. Patients can benefit from playing this game on a regular basis to help them improve in this area. The system was tested on six stroke patients with hemiparesis. The patients reported no negative side effects from playing the game. In the third component, we will look at robotic devices that aid in rehabilitation. In this section, we will look at a variety of technological solutions that provide various types of assistance, such as active, passive, haptic, and coaching. We go over the benefits and drawbacks of each system, as well as a few commercially available systems. The ability of such systems to engage the patient through touch and force is their primary advantage. These systems can aid in the delivery of more precise treatments. However, because these are highly complex systems. Their high costs make home-based rehabilitation impractical and what has been done to address this issue. We looked at a variety of techniques developed in the fields of machine learning, virtual reality, and robotic assistance devices. These technologies have been successfully demonstrated. Large-scale deployment in home-based rehabilitation scenarios, on the other hand, is still lacking. One possible explanation is that few companies are converting this technology into usable products that people can buy and use at home. A proactive collaboration between the medical and engineering communities, on the other hand, has the potential to turn much of the technology into a product that patients can use at home. We believe the reader will be well informed after reading the contents of this chapter, which aims to outline major innovations in the field of stroke rehabilitation.