Utilizing an Augmented Reality System to Address Phantom Limb Syndrome in a Cloud-Based Environment

Afeef Sheikh, Nikola Tesla STEM High School, Redmond, WA, USA

ABSTRACT

Phantom Limb Syndrome (PLS) is the perception of sensations, often including chronic intense pain localized to the site of an amputated or denervated limb. This syndrome is relatively common in amputees; the pain often reflects the amount of pre-amputation pain, and is often refractory to excision of amputation neuroma, rubbing, electrical stimulation, peripheral nerve or spinal blocks, narcotics, and sympathectomy (Alviar et al., 2011). Mirror therapy, a present method of rehabilitation, is estimated to be only 60% effective in upper limb amputees while also requiring expensive equipment and monitoring by a caretaker or technician. This paper is aimed at designing an affordable, effective, and accessible alternative solution to address the rehabilitation challenges associated with PLS. Using the power of Augmented Reality (AR) coupled with open source software, such as Unity3D and Vuforia, and commonly used devices like cellphones and computers, the prototype can read muscle activity and create an onscreen image of a virtual hand in place-of the individual’s lost hand and can mimic basic hand movements through the use of an AR camera. Due to the limited processing power present within most cellphones, the solution is being refined to capitalize on Cloud computing. In doing so, the hand model can be rendered offsite and streamed directly to the phone, resulting in a higher quality image. The efficacy of this solution has not yet been tested on human subjects by virtue of legal restrictions. This system is currently being forwarded to qualified individuals who have the necessary credentials to perform clinical trials in a certified lab environment.

KEYWORDS

Amputee, Augmented Reality, Mirror Therapy, Open Source Software, Phantom Limb Syndrome, Rehabilitation

INTRODUCTION

Given the large number of amputations performed annually, rehabilitation methods play a crucial role in helping individuals to adapt to their changed lifestyle (Rayegani et al., 2010). When compared with other areas of medicine, such as robotic surgery and body imaging, the current process for rehabilitating impaired upper limb patients is not nearly as advanced and lacks a modern technological touch (Prakash & Golwala, 2011). Present rehabilitation methods, although useful, are commonly limited by the fact that they require the patient to be constantly monitored by a caretaker or technician, and may require expensive equipment (Bach et al., 1988). One commonly used technique, mirror therapy, utilizes a mirror box to develop the user’s visual feedback skills (Karanikolas et al., 2011). The main application of mirror therapy is to alleviate issues with Phantom Limb Syndrome and aid in restoring functionality to the affected individual’s limb. Hence, the field of upper limb rehabilitation
is in dire need of rehabilitation methods that are a blend of innovation, easy access, and low cost to administer (Mao & Chen, 2000).

This research paper aims to contribute to the discussion of how modern consumer-grade software and hardware technology can be harnessed to deliver a low cost, easy-to-use solution that mimics the concepts of Mirror Therapy to address the rehabilitation of individuals affected by Phantom Limb Syndrome. The prototype is built using a mix of augmented reality, open source software, and commonly used devices, such as cellphones or computers, to create an affordable, effective, and accessible solution for the treatment of phantom limb syndrome.

Given the benefits that Cloud computing offers, this solution is designed to work in both pure and hybrid Cloud scenarios. Typically, a cellphone’s processing power is relatively limited when it comes to rendering complex 3D shapes and related aspects such as anti-aliasing. The Cloud-based solution offers high performance computing coupled with seamless data management. In order to create the most life-like limb experience, the proposed solution utilizes the Cloud to compute the complex calculations for the desired actions and then streams the runtime application and corresponding data to a user’s device. Additionally, it provides immense flexibility in administering therapy by enabling individuals to store their specific data in the Cloud and access it anywhere, anytime, and on any device.

With regard to the novelty of this solution, the utilization of augmented reality and Cloud computing are the most unique aspects. Augmented reality is a technology that is still being developed and has minimal usage outside of entertainment systems and is essentially unheard of in the field of medicine. The effective use of augmented reality demonstrates its potential application not only to phantom limb syndrome, but hopefully to other diseases, disorders, or challenges. Furthermore, Cloud computing has frequently found its uses in data management and software development, but has not been extensively integrated into rehabilitation methods. Much like augmented reality, the usage of Cloud computing in the prototype will hopefully instill a desire to search for more of its applications within the scientific community.

**KEY STATISTICS**

- There are an estimated 10 million amputees in the world (Diers et al., 2010).
- Over 185,000 amputations are performed annually in the United States (Reiber et al., 2010).
- For first major amputations, there are almost 1 per 10,000 women in Alabama to 4.4 per 10,000 men in the Navajo Nation [US data reported from 1992 to 1997] (Desmond et al., 2010; Nikolajsen et al., 2000).
- A US national survey of community dwelling persons with limb loss (n = 914) reported a prevalence ratio of 8:1 for lower limb loss compared with upper limb loss (Kooijman et al., 2000).
- Up to 80% of post-birth amputees reportedly experience Phantom Limb Pain (PLP) (Devor & Seltzer, 1999).
- Through traditional techniques such as acupuncture, hypnosis, and antibiotics etc., only about 10%-12% of amputees have any relief from PLP (Ezzo et al., 2000; Rasche & Tronnier, 2010).
- Perhaps the most promising therapy for treating PLP is Mirror Therapy (Davidson et al., 2010).
- Efficacy of mirror therapy is reported to be 60% in upper limb amputees (Dellemijn, 1999).
- Recent, high-quality, randomized controlled trials have also reported mirror therapy to improve motor function in 55% to 75% of patients with subacute and acute stroke (Halbert et al., 2002).
- A typical Mirror Therapy session is performed daily by the patient for 20-30 minutes to get relief from PLP (Jensen et al., 1983).
Automatic Partitioning of Large Scale Simulation in Grid Computing for Run Time Reduction
www.igi-global.com/chapter/automatic-partitioning-large-scale-simulation/64493?camid=4v1a

Key Technology for Intelligent Interaction Based on Internet of Things
www.igi-global.com/article/key-technology-for-intelligent-interaction-based-on-internet-of-things/218824?camid=4v1a