

# Development of Functional Electrical Stimulation Rehabilitation System Integrated with Game

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**Keywords:** Gamification, Upper Limb Rehabilitation, FES.

**Abstract:** Stroke is the main cause of chronic movement disorder as the aftereffect. Clearly, active participation for patients is critical to increase the motor ability. In this paper, we propose the virtual-reality based rehabilitation gaming system to increase the rehabilitation participation of stroke patients. The proposed system consists of Functional Electrical Stimulation (FES) device, webcam, and game. The webcam tracks the movement of patient's hand when the FES stimulates. The patients rehabilitate with the game which is operated by the hand movements and feels interest in rehabilitation. This work is the initial step towards achieving the stroke rehabilitation gaming system to maximize the patient participation.

## 1 INTRODUCTION

Stroke damages the nervous system and muscular system, and these damages engender aftereffects such as chronic movement disorder. Upper and lower limb movement disorder causes hemiplegia, balance disorder and difficulty in walking. Rehabilitation processes recover lower limb movement, but the majority of patients have insuperable difficulty with recovering the upper limb movement. Currently used treatments of upper limb paralysis are constraint induced movement therapy (CIMT), functional electrical stimulation (FES), joint tracking training, bio feedback, mirror therapy, robot-assisted therapy and virtual reality therapy. (Chung, JW, 2002) One of the most general and effectual clinical treatments for upper limb recovery is FES.

Neurons are electrically active cells. Presence of electric field in nervous tissue leads to the depolarization of neuronal lipid membranes and induces firing of action potential. FES takes advantage of this property of nerve cells. Passing of electric current through nervous tissue can lead to adverse effects such as decrease in excitability or cell death due to thermal damage, electroporation, toxic products from electrochemical reactions or overexcitation of neurons.

The use of FES for the treatment of upper limbs paralysis has increased recently and many studies of

its effectiveness are currently being conducted. (Eom, GM, 2003)

According to the study by Park and Oh, environmental factors in addition to patient's voluntary and active participation in the treatment are critical for the stroke patient's improvement in movement. (Cho, IS., 2009), (Park, RJ., 2002), (Bolton, D.A., 2004). However, there are limits to inducing such participation from the patients with the current FES-based rehabilitation treatments, which do not provide any visuals but simple patterns of electrical stimulation.

In this study, a gamified FES treatment system that encourages more active participation from the patients was developed.

## 2 METHODS

Wrists were the target areas for this rehabilitation system. The system is consisted of two parts: FES and data collection. According to the provided game scenario by the system, electrical stimulation will be applied to the target area. The patient's performances will be monitored by cameras and the collected data will be provided to the system as a feedback to the system's performance. Patients during the treatment will constantly receive instant visual feedback as they accomplish the assignments given in the game.

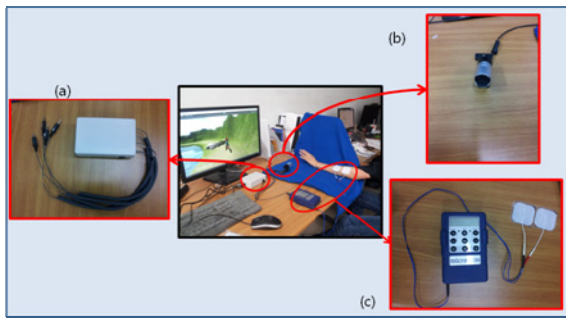


Figure 1: The Hardware (a) FES Controller, (b) Webcam, (c) FES device.

As shown in Picture 1, the hardware is consisted of FES device, FES Controller and webcam. The FES device used is Microstim of MED-EL GmbH. The FES controller was used to control the FES device from the work station. And the webcam was used in order to measure the angle of wrists.

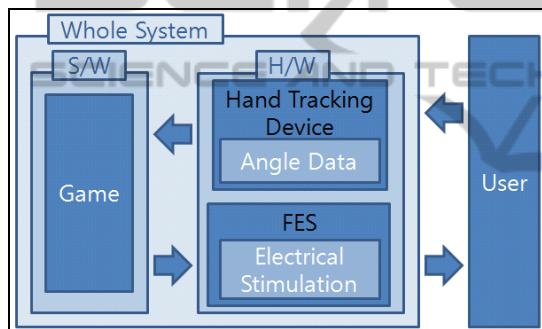


Figure 2: Diagram of system.

### 3 RESULTS

There are two separate game contents; one for the permanently paralyzed patient and another for the partly paralyzed. For the permanently paralyzed, the system visualizes the timing of FES, regardless of the patient's movement in the wrists, so that patients are aware of when they will receive stimulations. For the partly paralyzed, their movement will be monitored, and the FES will be applied when their movement is deemed inadequate.

### 4 CONCLUSIONS

In this paper, a new rehabilitation system for the upper limbs of stroke patients was introduced. This system seeks to supplement the existing treatments of which simple FES patterns lead to passive

participation of patients. The new system expects to promote voluntary and active participation, which are crucial for successful treatment of post-stroke paralysis.



Figure 3: The Scene for Setting (L), Playing Scene (R).

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