The Haptic Bracelets: Gait rehabilitation after Stroke

Conference or Workshop Item

The Haptic Bracelets: Gait rehabilitation after Stroke

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Abstract. Restoring mobility and rehabilitation of gait are high priorities for rehabilitation of neurological conditions. Cueing using metronomic rhythmic sensory stimulation has been shown to improve gait, but most versions of this approach have used auditory and visual cues. In contrast, we propose the development of a prototype wearable system for rhythmic cueing based on haptics. The main aim of this research is to investigate how real-time gait monitoring and rhythmic haptic cueing can assist with gait rehabilitation for neurological conditions.

Keywords: Entrainment; gait rehabilitation; stroke; haptic metronome

1 Introduction

Stroke is a sudden and devastating illness, affecting approximately seventeen million people world wide each year, with almost seven million people losing their life, making it the second single most common cause of death. Stroke survivors commonly experience what is called hemiparesis. With hemiparesis, one side of the body is physically weakened. This condition subsequently affects the survivor's gait, leading to what is called hemiparetic gait.

Hemiparetic gait is characterised variously by reduced walking speed, stride time variability, increased step length variability, and temporal and spatial gait asymmetry. Many health problems are associated with this disorder. For example, the non-paretic (stronger) limb may be exposed to higher vertical forces, which can lead to joint pains and bone degeneration. Besides the physical health issues, gait rehabilitation is also of paramount importance for the restoration of independence and thus an overall better quality of life.

Carrying out rehabilitation exercises regularly can significantly improve a person's recovery both in in the early days after a stroke and long after they return home. Research in rehabilitation techniques strongly suggest that home-based rehabilitation is more beneficial to the patients, but exercising in the home setting is not always easy as patients may have difficulty carrying out exercises effectively without suitable guidance.

Advances in technology mean that we are now in a position where it can be employed to assist individuals with day-to-day rehabilitation exercises. The field of research for improving gait rehabilitation is still open for further exploration, with

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strong evidence suggesting that metronomic cueing and entrainment are effective in the rehabilitation and re-training after a stroke.

Entrainment is a natural phenomenon where two rhythmic processes interact with each other until they adjust to a common rhythm. This forms the underlying theoretical basis of our research, as it makes walking to a rhythm possible.

Existing literature indicates that walking to a rhythm offers a number of gait-related benefits. Researchers exploring the idea of metronomic cueing using a variety of sensory channels, principally auditory, showed that immediate, though not lasting, walking benefits are possible. However, a number of impracticalities can be associated with these approaches making it difficult to move from the controlled environment of the lab to a self-managed home and outdoors setting, where it is important to keep the audio channel clear in order to remain aware of the environment, oncoming traffic or even when trying to hold a conversation with other people.

Even though rhythmic haptic cueing in our pilot studies has shown promising results and great potential of offering similar and immediate walking benefits, there is not much literature exploring how it can be used for motor movement rehabilitation. The literature concerning haptic cueing mostly focuses on stimulus response mechanism for conveying messages and notifications. Entrainment, on the other hand, can provide the fine-grained synchronisation that allows one's movement to synchronise to an external rhythm both physically and mentally.

In an earlier pilot study where rhythmic haptic cueing was used, the participant's step length was found to increase, while a range of other measures showed significant clinical improvement indicating improved gait movement and similar walking benefits to those of audio rhythm.

1.1 Demo

We will be demonstrating the Haptic Bracelets; the wearable prototype devices we design and manufactured for monitoring gait and delivering rhythmic haptic cue. The devices are designed to work in pairs, delivering the rhythmic haptic cue on alternating legs, but this may vary depending on the user's preference.

1.2 Technical requirements

One table (minimum 1.5m x 0.5m), *one* HDMI or VGA enabled screen with stand for playing back a relevant video we prepared, *four* power plugs, and *free space* of at least 3m x 1m in front of the demo area to allow people try out the devices.

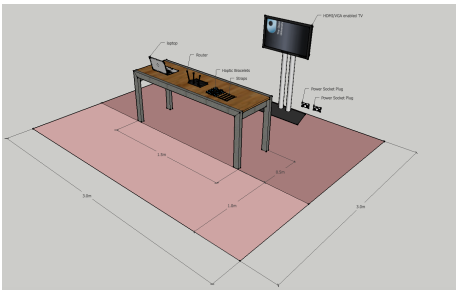

Fig. 1. Rendering of demonstration setup

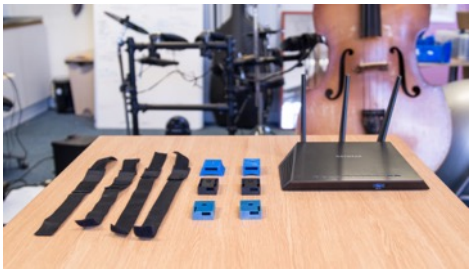

Fig. 2. The Haptic Bracelets (middle) with Velcro straps (left) and router (right)