Assistive Device for Freezing of Gait Episodes in Parkinson’s Patients

Jon Petersen\textsuperscript{1}, Shea Dillon\textsuperscript{2}

\textsuperscript{1}B.S., Mechanical & Materials Engineering, \textsuperscript{2}B.S., Mechanical & Materials Engineering

PROBLEM/OPPORTUNITY

Freezing of gait episodes are a phenomenon common in the advanced stages of Parkinson’s disease. These transient “freezing episodes,” in which a person spontaneously finds themselves incapable of movement are very difficult to predict, and the cause is not fully understood. Differing opinions exist as to the best way to improve a patient’s gait, and solutions that involve both auditory and visual cueing have been proposed to some success. Based upon research indicating that visual cueing may be beneficial, devices have been produced that project a laser line along the floor—providing a visual cue in the form of a target, or reference point, for the patient to step over.

These existing devices can take several forms: a cane that emits a laser light from its base, or an attachment that can be affixed to the handles of a walker, emitting a beam at the user’s feet. The shortcoming in such devices is that they are manually operated, either by an on/off switch or, in the case of the cane, by establishing contact with the ground. Both cases are far from ideal. A switch is not an effective means of activation as it is unlikely that a patient will be capable of manually flipping a switch during a freezing episode. In regards to the cane, no assistance is provided if the freezing episode occurs mid-stride and the cane is not firmly planted on the ground in the correct orientation. Moreover, a line is projected every time the cane comes in contact with the ground, not just during an episode.

Figure 1:
Side by side comparison of breadboard prototype and completed device, outside of enclosure, powered by 3.7V Li-ion battery.

SOLUTION

To compensate for the issues with manually operated visual cueing devices, our device will automatically shine a laser line in front of the user’s feet in the event of a freezing episode. Using both an accelerometer and a gyroscope hooked up directly to an Arduino microcontroller (fig. 1), the device senses the user’s footstep pattern and prompts a laser light to shine should that pattern cease (fig. 2). Resting inside an enclosure, the device can be attached to a user’s ankle and oriented to shine a laser line roughly 6” beyond their feet. This provides the same visual cueing as the manually operated devices (fig. 3). Other possible mounting locations, such as the waist, would work should the Arduino code be correctly calibrated.

Extrapolating from the notion that rhythmic auditory cues may also be helpful in freezing episodes, another element of the device is the inclusion of a small vibrating motor, also connected to the microcontroller, and programmed to emit a rhythmic pulse during an episode. This provides the rhythm to help a patient resume walking in the event of an episode, but silently. Ideally the device could be configured to allow for one or both cueing methods to be used.

Figure 2:
Live, unfiltered accelerometer/gyroscope data from device demonstrating a footstep pattern.

HUMAN IMPACT

Should a patient experience a freezing episode while equipped with the device, one or both cues will activate, encouraging them to progress. Replacing rhythmic auditory cueing with tactile cueing could also provide less distraction, and less embarrassment, in the event of a freezing episode occurring in a public place. Furthermore, the device can be outfitted with Bluetooth functionality: transmitting data on the user’s gait to a mobile phone in real-time. This holds a wide variety of potential applications for tracking the efficacy of the device, the frequency, and conditions under which a freezing episode occurs.

CONCLUSIONS

Similar automated devices have proven to be effective under testing. One of which described in an IEEE paper provided automated auditory cuing during a freezing episode. According to the paper, the majority of users indicated that this was beneficial. We suspect that our device will have similar success, with the additional benefits described above. The potential exists to not only aid in the cessation of freezing episodes, but also in the collection of data, perhaps leading to a greater understanding of the freezing of gait phenomenon and its root causes.

Figure 3:
Example of device functionality – laser line shown projected in front of user’s feet.