Step Kinection: A Hybrid Clinical Test for Fall Risk Assessment in Older Adults

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Abstract
In this paper, we describe Step Kinnection, an interactive step training system for the elderly that incorporates mechanisms to simultaneously perform a hybrid clinical test for fall risk assessment. The interactivity demonstration includes a simple stepping task along with three voice-enabled cognitive activities allowing for the assessment of stepping performance under the dual-task paradigm. CHI attendees can try out both scenarios to physically experience the interference caused by a higher cognitive load while stepping.

Author Keywords
Kinect; Elderly; Fall Risk Assessment; Reaction Time Test; Stepping Performance.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; I.2.1 [Application and Expert Systems]: Games.

Introduction
Since the release of the Microsoft Kinect, researchers and practitioners alike have both investigated its potential uses in the area of aged care and

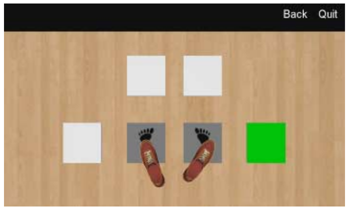

Figure 1: Stepping Task in which the user is intended to step on the green sectors and return to the center as quick as possible.

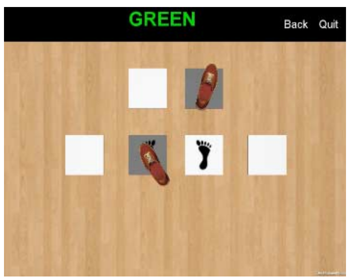

Figure 2: Screenshot of Stepping Kinnection while playing *'Name the Word'* Task. In this task the color and word are identical.

rehabilitation. This is mainly due to its capability to track real-time full body movements in 3D, a characteristic that was not accessible to the consumer prior to its release. In the area of fall prevention and safety for the elderly, the Kinect has also gained much interest. Kinect-based applications range from health and home monitoring systems [1], through unobtrusive fall detection platforms [11], to rehabilitation and therapeutic tools [4]. Kinect-based serious games, being one of the most popular approaches, have shown a positive acceptance among seniors [3]. The fun factor inherent in such games and their ability to promote physical movements are ideal to encourage the elderly to exercise [2]. For example in the work done by Kim et al. [6], an 8-week long intervention involving the use of a commercial Kinect game showed to improve hip muscle strength and balance control in older adults while increasing levels of motivation.

From a clinical perspective, the Kinect also possess the potential to implement low-cost methods to assess fall risk in older adults. This is achieved through the collection and measurement of clinical parameters that fulfill the requirements of several clinical tests such as posture control [9], gait [12], dual task ability [5] and mobility [7], among others. Overall, these methods rely on the Kinect to obtain information of the human body positions in real-time, which are shown to be fairly accurate.

The work presented here describes Step Kinnection, a game-like system that delivers step training to older adults and simultaneously measure stepping performance through the use of a hybrid version of the Choice Stepping Reaction Time (CSRT) task [8], a time-based clinical test that has shown to reliably predict falls in older adults.
The main motivation for choosing the Kinect as the primary input device is that it allows for: (1) a wider degree of freedom for the user; (2) an intuitive and natural interaction with the game as no controllers or wearable sensors are required for its operation; (3) a better provision of feedback allowing the display of a full body avatar to mirror the users' movements. All these features are ideal for elderly users with minimal or no computer literacy.

In addition to this, Step Kinnection also allows for the collection of spatial information such as postural sway and stepping accuracy. More importantly, the assessment of stepping performance under the dual task paradigm can also be achieved through the incorporation of a series of cognitive activities [10]. Poor dual tasking has been frequently associated with falls and balance impairments in older people, providing evidence for the importance of specific cognitive functions in postural stability [10]. These features make this system potentially useful in actual clinical practice to evaluate various dimensions involved in the diagnosis of fall risk in older people, all in a single system.

The Stepping Task

In order to start the game, the player is required to stand in front of a computer screen or TV connected to a Kinect PC. The representation of the player in the system is a pair of shoes mirroring the person's feet. Six symmetrically distributed square-shaped panels are then drawn on the screen surrounding the player's avatar. When one of the panels changes its color to green on the screen, the player is expected to step on

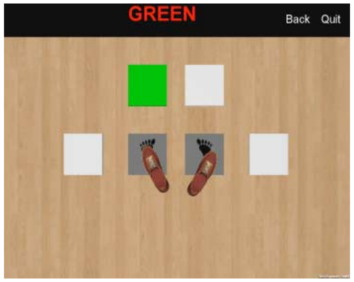

Figure 3: In the *'Name the Word'* task, the user must say out loud the color in which the word is written in.

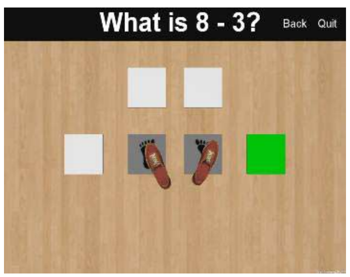

Figure 4: During the *'Solve the Equation'* task the system reads out a arithmetic equation and the participant must solve it and provide the answer verbally.

it in space and back to the center as quickly as possible. As soon as the player returns to the initial position the process starts over. The sequence is presented randomly as well as the time between trials so that the user is unable to anticipate the time and location of the next stimulus. It is worth mentioning that these virtual panels are dynamically located based on the user's height, making the stepping task equally challenging for short and tall participants. While playing, time based measurements such as reaction times are simultaneously collected. Also the positioning of the foot is recorded in order to determine the accuracy on stepping as well as the step length.

The Cognitive Tasks

In addition to the stepping game, three voice-controlled concurrent cognitive activities were incorporated to assess the performance of the patient under differing cognitive and motor conditions concurrently. The increased cognitive load affects the user performance while stepping, resulting in noticeably slower reaction times for users that are likely to fall. The three activities are:

'Read the Word' Task:
During this task the user is required to say the color out loud while performing the stepping exercises. As the color of the word and its semantic meaning are identical, this task creates a minimally increased cognitive load for the user.

'Name the Color' Task:
For this task the semantic meaning of the word and the color of the word do not match. Once again the user has to say the color out loud, but in this case there is interference between the meaning and the color of the word. While the mind automatically determines the meaning of the word, the player actually needs to identify the color that the word is written in. This means the player needs to consciously re-evaluate his/her instinctive response. This interference, also known as the Stroop interference, results in a delay and the extra processing required normally results in a slowing down of the stepping test performance.

'Maths Workout' Task:
This task requires the user to answer a math question that is read by the system. While there is no interference effect as with the Stroop test, the user is still required to interpret what they have heard to answer the question.

For all the above tasks, the accuracy of the answer is automatically processed by the voice recognition system built into the Kinect.

Audience and Relevance

Step Kinnection should be of interest to CHI practitioners and researchers exploring the use of interactive video game technology as a tool to improve the physical health of the elderly. The idea of utilizing the Kinect enhances the user interaction as no controllers or sensors are required to operate enabling older people with no computer use experience to play intuitively. Also, the Kinect capabilities to track human movements in real-time allow for the evaluation of several dimensions in the area of fall risk assessment making this system potentially useful in clinical practice. More importantly, the voice-enabled cognitive activities introduce a novel approach to assess stepping performance under the dual-tasking paradigm in which the user interacts in a natural way without the need of pressing buttons or performing additional physical movements. This work has broad relevance to the CHI community in terms of exploring novel cost-effective ways that promote physical activity in older adult while performance in continuously monitored in a unobtrusive way.

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