Harnessing Technology for Aging-in-Place.

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POSTER ABSTRACTS
WIRELESS CONTROL OF ROBOTIC WRIST EXOSKELETON USING SMARTPHONE AND COMPUTER APPLICATIONS

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Purpose: The purpose of this project is to develop software applications (apps) to wirelessly control and monitor a robotic exoskeleton wrist used for physiotherapy in Stroke rehabilitation. Stroke is the leading cause of disability in the senior population. The estimated medical expenses related to stroke recovery are $20.6 billion in North America (1). Therefore, the modern therapy is shifting towards robotic rehabilitation to enhance the early recovery and to decrease the health care costs (2). Our lab has recently designed a 2-degree of freedom wrist robotic exoskeleton (Robo-wrist) for wrist rehabilitation controlled by a microcontroller. However, the microcontroller has a small screen with joystick control and lacks visual cues to assist the user. Therefore, we present an Android smartphone application and a Windows computer application with graphical user interfaces (GUI) to control and monitor the exoskeleton. The purpose of this study is to test the feasibility of controlling Robo-wrist with our smartphone and computer apps by physiotherapist and the stroke survivor.

Methods: We built the smartphone and computer apps by using Java for Android and desktop respectively. The Arduino microcontroller of exoskeleton runs on C code. The apps connect to the microcontroller via Bluetooth and WiFi to send and receive data, signals, and commands wirelessly. The apps are designed with flexibility and extensibility as the core design principle, which may facilitate easy modifications for different needs. Currently, we are recruiting physiotherapists and stroke survivors to check feasibility of the apps for ease of the use, the graphic design and the control of Robo-wrist with our apps.

Results and discussion: The data collection is underway. The therapist and stroke survivor are learning the use and testing it in research lab environment. Our apps have several advantages:
1) control and monitor multiple exoskeletons in the clinic settings;
2) create and store multiple exercise protocols;
3) record and store patient’s therapy protocols;
4) provide visual feedback via a real-time graph plot and;
5) track patient progress via activity sheets to assess and re-evaluate the therapy strategy. Above all, the stroke survivor or caregiver can easily use the app on smartphone for in-home therapy. We hypothesize that the app can be easily learnt and used by both therapist and stroke survivor or caregiver that can accelerate the recovery process and immensely reduce the costs of the rehabilitation.
Figure 1. Robo-wrist controlled by software applications.

References

Keywords: rehabilitation, robotic exoskeleton, software application.

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THE EFFECT OF WINDOW SIZE AND LEAD-TIME ON PRE-IMPACT FALL DETECTION ACCURACY USING SUPPORT VECTOR MACHINE ANALYSIS OF WAIST MOUNTED INERTIAL SENSOR DATA

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Falls are a major cause of death and morbidity in older adults. In recent years many researchers have examined the role of wearable inertial sensors (accelerometers and/or gyroscopes) to automatically detect falls. The primary goal of such fall monitors is to alert care providers of the fall event, who can then commence earlier treatment. Although such fall detection systems may reduce time until the arrival of medical assistance, they cannot help to prevent or reduce the severity of traumatic injury caused by the fall. In the current study, we extend the application of wearable inertial sensors beyond post-impact fall detection, by developing and evaluating the accuracy of a sensor system for detecting falls prior to the fall impact. We used support vector machine (SVM) analysis to classify 7 fall and 8 non-fall events. In particular, we focused on the effect of data window size and lead-time on the accuracy of our pre-impact fall detection system using signals from a single waist sensor. We found that our system was able to detect fall events at between 0.0625-0.1875 s prior to the impact with at least 95% sensitivity and at least 90% specificity for window sizes between 0.125-1 s.

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QUALITY AND CONTENT OF ONLINE ADVICE FOR THE PREVENTION OF ALZHEIMER DISEASE

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Background: The World Health Organization declared dementia to be a public health priority in 2011, and it is estimated that 115.4 million people worldwide will be living with dementia by 2050. There is growing emphasis on the importance of lifestyle modifications as a way to potentially prevent or delay the onset of Alzheimer’s disease, as no cure currently exists (3). As there are many popular misconceptions regarding the prevention of Alzheimer’s disease (2), the Internet could be a powerful communicative tool to clarify these misconceptions, especially as the number of older adults turning to the Internet to find health information is rapidly increasing (5). However, concerns have been raised over the quality of online health information and the potential for the Internet to catalyze the spread of misinformation (4). As little is known about the content and quality of online information about Alzheimer’s disease specifically, our goal was to characterize and evaluate the quality of online articles containing information about the prevention of Alzheimer’s disease (1).

Methods: We retrieved 397 articles related to the prevention of Alzheimer’s disease from a location-independent keyword search on Google.com. Content analysis was conducted on a random sample of 102 of these articles to evaluate article features such as authorship and currency, as well as the informational content of the articles.

Results and Discussion: We found that 76% of the articles included the date the article was written or last reviewed and 60% mentioned an author, two criteria generally considered to be indicators of good quality in online resources. Twenty percent of articles included some form of product endorsement, a potential indicator of poor article quality. Nearly all (95%) of the articles discussed some aspect of nutrition, 77% provided advice related to lifestyle and exercise, and 73% mentioned cognitive engagement. Overall, we found that the quality of websites containing information about the prevention of Alzheimer disease varies greatly, even though most websites include at least one indicator quality. However, the quality of a given website does not necessarily translate to good advice. Internet users should ask their health professionals for recommended sources of online health information.

References:

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THE FLOORING FOR INJURY PREVENTION (FLIP) TRIAL: EVALUATING THE EFFECTIVENESS OF COMPLIANT FLOORING IN LONG-TERM CARE

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Introduction: Falls are the leading cause of unintentional injury deaths in older adults worldwide. Long-term care (LTC) is a particularly high-risk setting, as approximately 60% of LTC residents fall at least once per year and 30% of these falls cause injury. Despite these disturbing statistics, little attention has been directed to fall injury prevention in LTC. A promising strategy for reducing fall-related injuries is to decrease the ground surface stiffness, and the subsequent force applied to the body parts at impact. Laboratory studies have demonstrated that compliant flooring can substantially reduce forces applied to the hip and head during simulated falls, without impairing balance. Definitive evidence demonstrating that compliant flooring can prevent fall-related injuries in LTC is lacking. A randomized controlled trial is warranted to fill this evidence gap.

Method: The Flooring for Injury Prevention (FLIP) Study is a randomized controlled trial designed to compare compliant flooring with non-compliant flooring in 150 resident rooms at a LTC facility, to be followed for 4 years (ClinicalTrials.gov #: NCT01618786). This will provide power of 0.88 for a 40% reduction in the primary outcome. Results: FLIP’s primary outcome is serious fall-related injury. Secondary outcomes include all fall-related injuries, falls, cost-effectiveness, and acceptability. Conclusion: Results will provide insight about the potential of compliant flooring to reduce fall-related injuries in LTC and are expected to guide the development of safer facilities for vulnerable older adults.
AGING IN-PLACE: FROM UNOBTRUSIVE SENSING TO GRACEFUL AGING

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A rapidly aging population is an increasingly urgent issue for many countries around the world. No longer is the problem confined to well-known aging societies such as Japan. With the Baby Boomers retiring, the U.S. will have an average of 10,000 new retirees per day all the way until 2020. A major challenge is that most current healthcare models are not sustainable in the long-term. Technological solutions to facilitate aging in-place are needed to alleviate the burden of care and deliver high quality services to the elderly in their homes. Existing home based monitoring systems often rely on cameras. Such an approach has two main drawbacks: 1) most people are concerned about the loss of privacy and 2) transmission of video footage to a central location for monitoring and analysis requires a high communication bandwidth. In our project, we propose an alternative aging in-place technology framework which facilitates multiple heterogeneous sensor-based space-time behaviour trajectory tracking and analytics. The proposed technology framework consists of three major elements. The first is unobtrusive sensor deployment. Instead of using cameras to monitor an elderly’s activities of daily living (ADLs), we deploy sensing devices in the home environment. Many types of commercially available sensors (e.g., for monitoring temperature, humidity, pressure, luminosity, motion) can be used to capture an elderly’s ADLs in his/her living environment. We conduct human factors research to design sensor deployment strategies that can achieve maximum coverage at the lowest cost while dissolving the sensors into the living environment (Figure 1(a)). Secondly, based on the sensor data stream (which is much smaller in size than video footage), we conduct research in machine learning to identify conditions and trends related to an elderly’s physical, emotional and cognitive wellbeing (e.g., mobility level, likelihood of falling, mood). Thirdly, we have developed a data-driven visualization platform (Figure 1(b)) to enable caregivers or relatives to review an animated version of an elderly’s activities over a selected period of time. The actions performed by the 3D avatar is controlled by the data received from the sensors, while the annotations of the elderly person’s possible mental and physical states at different points in time are based on analytics results from the proposed machine learning algorithm.

We are currently in the process of evaluating the proposed technology framework in several elderly people’s homes. By leveraging on human centered design and big data analytics, the proposed technology has the potential to improve inter-generational understanding and support cost-effective personalized care for graceful aging.
Figure 1. Embedding sensors into everyday items

Figure 2. Data-driven behavior visualization

References

Keywords: aging in-place, unobtrusive sensing, behaviour trajectory analytics, data-driven visualization
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A TREMOR SUPPRESSION SIMULATION SYSTEM: TOWARDS AN ASSISTIVE DEVICE

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Purpose: Tremor is an involuntary rhythmic oscillation of a body part\(^1\). Despite not considered life threatening, pathological tremor can be a highly debilitating condition with significant effects on activities of daily living and social participation\(^2\)\(^-\)\(^3\). Essential Tremor (ET) and Parkinson’s Disease (PD) are among the most common pathologic tremors typically affecting the hands, though other body parts can be affected\(^4\). Standard therapy, which includes but not limited to medication and surgery, is not always beneficial. Several devices have been developed and researched to address the condition in an attempt to offer an alternative treatment\(^5\)\(^-\)\(^8\). Here we present a novel tremor suppression system. The authors have been developing a robotic system to be donned by a patient and potentially suppress upper limb tremors.

Method: The new approach was first tested on a workbench device that simulates the human movement composed of the voluntary and tremor motions, as well as the suppression component, shown in (Figure 1 a). A sinusoid data composed of a slow (voluntary) and a fast (tremor) motions was actuated by the driving motor. The algorithm decomposed the motion and activated the suppression motor to follow the voluntary component only.

Results and discussion: One of the major challenges in biomechanical systems designed to suppress tremors is to minimize the resistance to the voluntary motion. The results obtained thus far demonstrate a significant reduction (above 90%) of the tremulous motion with only a minor disturbance to the voluntary motion. Future work will involve implementing the approach on a wearable device and perform testing with tremor patients. A similar device developed previously is shown in (Figure 1 b).

References

*Figure 1 – a) Tremor simulation device. b) Wearable tremor suppression device.*

*Keywords:* Tremor suppression, simulation, robotic device, assistive device  
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CAN GALVANIC VESTIBULAR STIMULATION CHANGE FOOT SIGNATURE OF PEOPLE WITH PARKINSON DISEASE (PD)?

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PURPOSE: The primary purpose of the study is to investigate the therapeutic efficacy of Galvanic Vestibular Stimulation (GVS) on the dynamic gait parameters (foot signature) in individuals with Parkinson Disease (PD). Typically, people with PD present with asymmetrical leg swing with increased cadence and decreased step length. Dopamine is the drug of choice in PD, but it has limitations for dosage and tolerance, therefore in this study we introduce the new therapy - GVS.

METHOD: This study employs randomize, cross-over design. We are recruiting 20 individuals with PD (35-80 years), with neurologist confirmed festination and freezing diagnosis. All participants will receive GVS (Good Vibrations Engineering Ltd., Canada) via 2 cm² self-adhesive disk electrodes positioned over the both mastoid process and reference electrode on the C7 vertebra, controlled by LABVIEW software. Stimulation will be given at the same time in participants regular medication schedule (1). After determining cutaneous threshold under electrodes, all participants will receive 3 sessions of the bilateral bipolar 0.08 mA GVS or no current (sham) for 20-minute duration in sitting (2). Participants will wear foot sensors (Physilog®4) to record gait parameters (table 1).

RESULTS AND DISCUSSION: The data collection of this study is underway. To date, Lee et al (2015) (3) and Kim et al (2013) (4) have reported improvement in arm motor performance after single session of GVS by altering beta oscillations. Pal et al (2009) (5) showed reduction in body sway after GVS in PD by influencing vestibulo-spinal route. However, none of these studies have studied the effect of GVS on gait in PD. Therefore, in this study, we hypothesize that 3 sessions of GVS will improve stride length and velocity, foot clearance and cadence in individuals with PD.

REFERENCES

Table 1: Experimental design of the study

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<th>TIME</th>
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<td>PRE-Intervention</td>
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KEYWORDS: Parkinson Disease, Galvanic Vestibular Stimulation, Gait, Freezing.
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WEARABLE SENSOR FOR DETECTING FUNCTIONAL USE OF THE UPPER-EXTREMITIES IN TAKE-HOME OR TELE-REHABILITATION SETTINGS

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According to estimates by Human Resources and Skills Development Canada (HRSDC), the number of Canadians 65 years and older is expected to double to 10.4 million in the next 25 years [1]. This aging population leads to an increase in the prevalence of age-related ailments, such as stroke and thus increases the demand for rehabilitation services [2].

Purpose Functional gains made by stroke survivors during the rehabilitation process are often lost post-rehabilitation due to factors such as lack of stimulation, encouragement or an unsuitable physical environment [3]. A device that is capable of detecting functional motion could act as a motivational tool by providing feedback and positive reinforcement for the achievement of functional motion as part of a take-home or tele-rehabilitation program. We present an easy-to-use, wearable band capable of deciphering and providing quantitative, real-time feedback on a user’s functional activity.

Methods The system detects the successful completion of tasks that involve the grasping, movement, and subsequent release of an object. The device consists of force sensing elements, signal processing circuitry and a Linear Discriminant Analysis (LDA) classifier. The band is donned around the forearm for the purpose of detecting the onset of a grasp or release using Force Myography (FMG). FMG has been shown to be an effective method for detecting different upper-extremity postures [4]. The system requires a training step in order to characterize the FMG patterns associated with the grasp and neutral hand states of the user. The system’s ability to detect the completion of three functional tasks, involving pick and place in the three co-ordinate axes was evaluated with five stroke survivors. The participants picked-up, moved and placed a coffee mug in one of the three co-ordinate axes for each task. Participants completed twenty repetitions of each task. Data was analysed to determine the accuracy of the system and the optimal number of training repetitions required to obtain acceptable accuracy without requiring an arduous and lengthy training process.

Results and discussion The system obtained an average accuracy of 89.7% across all three tasks when presented with 6 pick & place training samples. Increasing training samples beyond 6 did not substantially increase system accuracy (Fig.1). These promising results show that the developed wearable sensor can be used for monitoring rehabilitation activity as part of a take-home or tele-rehabilitation program with minimal configuration and set-up effort.
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**Keywords**: stroke, Force myography, machine learning, wearable sensors, rehabilitation robotics  E: gsadaran@sfu.ca
CAN TECHNOLOGIES MATCH THE ABILITIES OF HUMAN CAREGIVERS? A MODEL FOR RESEARCH AND PRACTICE

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Within the Home Care population on Island Health, 47% of seniors live alone, 40% have a diagnosis of Dementia, 22% have moderate or higher cognitive impairment, 38% have experienced a recent fall, 38% of caregivers express distress, anger or depression. Caregivers are the heart of home care, with over 2 million informal (e.g., family member) caregivers in Canada. They contribute an estimated $25 billion of care to support individuals, often so that seniors can remain in their own homes (CIHI, 2010). When the informal caregiver is unavailable, there is a substantial risk of earlier transition to a residential care facility. Given the choice, even seniors with substantial health care needs much prefer to stay in their home and avoid institutional care. We believe that technology can supplement and, someday, stand-in for caregiving. Caregiving is a complex behavior for which humans are uniquely suited and technology is in its infancy. Still, sensor technologies already have great potential to support interventions that mitigate adverse events such as falls, wandering, and delirium (Mahoney, 2010; Kaye et al., 2011; Rantz et al., 2012; Rantz et al., 2013). Currently, a variety of technologies exist to support individuals in their homes, including, automated medication dispensers, remote monitoring systems (e.g., CareLink Advantage), medical alert systems, GPS tracking devices and behavioural interventions (e.g., SimpleC Companion). Although helpful, these technologies operate in data silos that impede their potential utility.

**Purpose:** Our objective is to develop a highly integrated suite of technologies that: (1) signal the need for intervention by detecting or predicting adverse events, and (2) deliver caregiver-like interventions.

**Method:** Our model (Figure 1) will use continuous measurement with passive home sensors along with a periodic burst of gold standard assessments to build algorithms for predicting risk of adverse events (e.g., falls) in the home. Three classes of algorithms (model based, machine-learning analytics and multilevel/multivariate) will cooperate to support caregivers as well as health care professionals. This approach will then be extended to develop an automated caregiving system, where remote-monitoring sensors will inform devices that provide intervention (effectors) mimicking human caregivers.

**Results and Discussion:** We have demonstrated the value of burst measurement design and multilevel models for falls prediction and have started toward home instrumentation to demonstrate the value of a tightly integrated village of technologies.
References

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Key words: remote sensor monitoring, home care, caregiver support

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