# VIDEOGAMES FOR INDEPENDENT LIVING
## A NOVEL APPROACH TO TELEHEALTH

***Stuart T. Smith***
Neuroscience Research Australia

In this article we address the health-related barriers to independence of older adults and review the evidence for the use of telehealth technologies to facilitate and promote continued independence. In particular we outline a program of research at Neuroscience Research Australia which aims to (1) design, develop and implement of broadband-enabled videogame technology framework to facilitate independent living in older adults and (2) assess the effectiveness of home-based videogame technologies to impact upon age-related health issues that significantly reduce independence in older adults. We show as an example work we are doing to address the issue of postural instability and falls in older adults.

## INTRODUCTION

The majority of the world's increasingly older adult population requires some form of care due to loss of function following failing health and the costs associated with this care are steadily increasing. In Australia, more than a quarter of Australian government spending is currently directed to health, age-related pensions and aged care. Without an intervention to curtail the increasing financial impact of aged healthcare, the Australian government spending on these areas is projected to increase significantly, pushing total spending to almost half by 2049-50 (Intergenerational Report 2010).

Declines in physical or cognitive function are associated with age-related degeneration of, or injury to, the brain and nervous system. Neurodegeneration and neural injury contribute to parallel declines in self-confidence, social interactions and community involvement. A cycle is set up, where social isolation leads to further loss of confidence, leading to further isolation. The social circle contracts as friends age or pass away, and a greater emphasis on family is often a result. Fear of a major incident such as a stroke or a bone-breaking fall (Delbaere et al 2009) can lead to the decision to move into a supported environment. Moving from an individual's private home into an aged care setting is then viewed as a major step in the loss of independence and quality of life.

Continued successful independent living is a high priority for older people and those who work with and for them (Leeson et al 2003). Therefore monitoring the physical, cognitive and social markers of health, and comparing them to clinical models, enables us to draw conclusions about the current physical, cognitive and social health of the individual and their capacity to remain living independently. However, assessment of these variables usually depends on labour intensive and obtrusive manual assessment by clinical professionals that require the individual to travel to a central clinic or hospital facility. In remote and rural communities, especially in a country like Australia, the distance, inconvenience and expense of travel often make routine assessment of health very difficult. There is therefore a pressing need to develop automated or semi-automated measures of health status that can be gathered from peoples' home environments, especially for those living in regional, rural or remote Australia.

Daily, weekly or monthly home-based monitoring of health provides the ability to detect and act upon changes in these markers of health should they deviate significantly from an individual's history or accepted clinical models of good health (Basilakis et al 2010). Telehealth (or telemedicine) technology, which combines digital data acquisition, information and communication technologies and the internet to monitor health status in the home, is gaining attention as a promising strategy for acquiring accurate, reliable and time critical health marker data (Koch 2005), reducing healthcare costs (Noel et al 2004), empowering patients and promoting disease self-management with resultant improved health care outcomes (Suter et al 2011). Furthermore, a recent systematic review of studies on telemonitoring of patients with congestive heart failure concluded, "patients were living longer without increasing their use of health-care facilities" (Clarke et al 2011). For individuals who may be isolated, either by distance in regional, rural or remote Australia, or functional impairment following neurological damage or disease, broadband-enabled telehealth technologies will also be critical for researchers to fully understand the progression of disease course, or the effectiveness of intervention strategies, over the long term (Moffatt and Eley 2009).

While telehealth technologies can provide opportunities to significantly alleviate the burden of healthcare and facilitate continued independence of the elderly, implementation of technology also faces barriers related to acceptance and use by older adults, their family and clinical support networks. Barriers may include lack of awareness of available technologies, problems in use of technology amongst older adults, lack of financial incentive/capacity to use or invest in technology, lack of adequate training or support, lack of consensus on the value of the technology, cultural obstacles and absence of adequate technology infrastructure (Mattke et al 2010). To overcome these barriers it will be important for designers of telehealth technologies to work closely with older adults throughout the design and development process in order to learn how their preferences, attitudes and capabilities relate to technology adoption and how products and services can be designed to promote their widespread and long-term use (Demris et al 2010; Bouwhuis 2003).

The dominant information and communication technology already adopted widely by older adults is the ubiquitous home television set. With the advent of digital television, apart from delivering news, information and entertainment, the television will soon also become the technology platform for delivery of health services to the homes of older adults (Blackburn et al 2011). In a new research program underway at Neuroscience Research Australia (NeuRA) we extend this concept one step further and consider ways in which devices that connect to the television, namely videogame consoles, can be leveraged as a telehealth technology. Videogames have already been proven to improve cognitive abilities of older adults (Gamberini et al 2008), shown to be a feasible alternative to more traditional aerobic exercise modalities for middle-aged and older adults (Guderian et al 2010) and can be used to train stepping ability in older adults to reduce the risk of falls (Smith et al 2011). In particular we explore ways in which videogames can be used to address a major health issue that significantly impact upon the continued independence of older adults: injury and disability resulting from a fall.

## BUT, AREN'T VIDEOGAMES BAD FOR YOU?

In the popular media, as well as the scientific research literature, the playing of video games has often been associated with negative health outcomes such as increased aggression and violence (Anderson & Bushman 2001), problems with addiction to gameplay (Grüsser et al 2007), social withdrawal (Gentile et al 2009), increased sedentary behaviour (Hardy *et al* 2009), increased risk of cardiovascular problems (Gwinup et al 1983) and even increased risk of epileptic seizures (Chuang 2006). With the popularity of exercise-based gaming systems such as the Nintendo Wii, there has also been a rise in reports of "Wii knee" (Robinson et al 2008), haemothorax (Peek et al 2008), ruptured tendons (Bhangu et al 2009) and fracture of the metatarsal (Eley 2010).

Despite the gloom surrounding the negative health consequences of engaging in video gameplay, there is an increasing interest in the potential application of video game and virtual reality technology to various health domains. A quick search using the terms "video", "games", "medicine, "rehabilitation", "pain" and "health" on the primary medical research database available from the US National Library of Medicine (Pubmed) reveals over 1000 recent research articles, many of which report significant beneficial effects of the application of video games to health. In the following we present readers with an overview of the *serious* side of videogame play, in particular with respect to rehabilitation of brain injury. We then outline a model for how video games could find a place as a telehealth technology could be used to facilitate and promote independent living in older adults or those living with a disability. Finally we explore how this technology could make use of the National Broadband Network.

## NOT AT ALL, GAMES CAN BE SERIOUSLY GOOD FOR YOU

The use of video games in health is one example of the emerging use of games for "serious" applications. Serious games offer an alternative to traditional means of informing and educating people across a range of domains from medicine to the military (Bergeron 2008). In health contexts, video games have been used to: train surgeons in laparoscopic surgery (Rosser et al 2007), teach children about a range of health and dietary issues (Lieberman 2001), educating medical students about fall risk in older people (Duque et al 2008) through to improving cancer-related knowledge in adolescents with cancer (Beale et al 2007).

## GAMES FOR HEALTHY WEIGHT

Many exercise videogames (exergames) or interactive gaming systems that are commercially available have had significant impact on the increasing problem of obesity and diabetes in children, adolescent and adults. Videogames are being used to promote healthy diets in young adults (Peng 2009), increase energy expenditure in young children (Graf et al. 2009), promote physical activity and decrease sedentary time (Maloney et al 2008) as well as promote weight loss among overweight children and adolescents and increase overall fitness (Warburton et al 2007). In a recent systematic review of the area, Barnett and colleagues (Barnett et al 2011) report that while exercise-based videogames can elicit physical activity levels of recommended intensity, sustainable play has yet to be demonstrated. They conclude that there is a need for high-quality investigations of maintenance of exercise-based videogame play, and the effect of this play on total physical activity levels and enhancement of bone and muscle strength.

## GAMES FOR PAIN DISTRACTION

One of the most interesting uses of video games is as a distraction therapy for the treatment of pain. Pain tolerance (in response to a cold pressor stimulus) has been shown to be improved while children and young adults (Anderson & Bushman 2001) play video games. The fear of pain (needlestick) in children has also been shown to be significantly reduced while children play self-distracting video games (Windich-Biermeier et al 2007). Distracting video games have also been shown to significantly ameliorate the subjective level of pain experienced by children in paediatric burns units during dressing changes (Hoffman et al 2000). Roy Kimble and colleagues at the Royal Children's Hospital in Brisbane have recently demonstrated that a handheld multimodal "game-like" platform is capable of reducing pain experiences for young children during burn care procedures (Miller et al 2011).

## VIDEO GAMES AS A REHABILITATION TOOL

In recent years one of the emerging rehabilitation tools that appears to meet the challenge of finding therapeutic interventions that are both purposeful and motivating, is the use of virtual

reality (VR) technology (Jack et al 2001). Virtual reality systems involve the use of a three dimensional computer simulation of the real world, or imaginary space, and allow the user to engage with this simulated environment through the use of various multimedia peripherals such as a keyboard and mouse, joystick controller, video camera tracking, inertial sensors (accelerometers), cybergloves and dance mat. Most recently, the Nintendo Wii controller has become a popular, low-cost method for providing individuals with an engaging virtual reality input device. Users experience virtual environments by interacting with displayed images, moving and manipulating virtual objects, and performing other actions in a way that engenders a feeling of actual presence and immerses their senses in the simulated environment. Users are provided with visual, audio and, in some instances, haptic (i.e.: tactile), feedback of their performance to further enhance the experience (Nash et al 2000).

Although virtual reality applications have been used in research and entertainment applications since the 1980's, it was only during the late 1990's that VR systems began to be developed and studied as potential tools to enhance and encourage participation in rehabilitation (Holden 2005). The use of virtual reality in rehabilitation has slowly been expanding since then, and is now being used successfully as a treatment and assessment tool in a wide variety of applications, most notably in the fields of motor, and cognitive, rehabilitation. For example, Merians and colleagues (Merians et al 2006) found that exercise conducted using a virtual reality interface enhanced the training of hand movements in patients post stroke, resulting in improved function of the fingers, thumb, and overall range of motion. The researchers also found that these improvements were later transferred to real world tasks, demonstrating that VR based therapy has the potential to encourage a level of exercise intensity and participation that is comparable to conventional interventions.

Virtual reality has also been used successfully in the cognitive rehabilitation of patients with traumatic brain injury (TBI). For example Grealy and colleagues (Grealy et al 1999) conducted research trials with TBI patients which required them to navigate around a variety of virtual environments, and found that patients performed better than no-exercise controls on verbal and visual learning tasks, as well as demonstrating improved reaction times. The researchers were able to conclude that exercising in a virtual environment offered the potential for cognitive gains; however it is not clear if the gains would have been observed using the same exercises in a conventional environment. It is also uncertain if the gains achieved were transferred outside the experimental setting, or lasted longer than the duration of the study. Virtual environments can also be used as a flexible assessment tool to safely determine patients' levels of ability in a variety of real world tasks prior to their return to a community setting, for example. Cristiansen and colleagues. (Christiansen et al 1998) found that a virtual reality kitchen proved to be effective in assessing the ability of TBI patients to operate safely in such an environment during a meal preparation task. Even though the research involved a prototype virtual environment it does highlight the potential utility of virtual reality in the training of very practical skills and patterns of behaviour that will allow patients to function successfully in the real world.

Although these examples provide only a brief overview of the variety of applications of virtual reality in rehabilitation, the end goal of these initiatives is to encourage and motivate patients to participate to their maximum capacity during therapy, and thereby develop the skills they need to function in their own real world environments in a more independent manner. Weiss and colleagues (Kizony et al 2005) suggest that virtual reality platforms provide a number of unique advantages over conventional therapy in trying to achieve this aim. First, virtual reality systems provide ecologically valid scenarios that elicit naturalistic movement and behaviours in a safe environment that can be shaped and graded in accordance to the needs and level of ability of the patient engaging in therapy. Secondly, the realism of the virtual environments allows patients the opportunity to explore independently, increasing their sense of autonomy and independence in directing their own therapeutic experience. Thirdly, the controllability of virtual environments allows for consistency in the way therapeutic protocols are delivered and performance recorded, enabling an accurate comparison of a patient' s performance over time. And lastly, virtual reality systems allow the introduction of "gaming" factors into any scenario to enhance motivation and increase user

participation (Holden & Todorov 2002). The use of gaming elements can also be used to take patients' attention away from any pain resulting from their injury or movement. This occurs the more a patient feels involved in an activity and again, allows a higher level of participation in the activity, as the patient is focused on achieving goals within the game (Sanchez-Vives & Slater 2005).

## VIDEO GAMING SYSTEMS FOR HOME-BASED REHABILITATION AND TRAINING

While the use of VR technology has been proven to be effective in laboratory or clinical based settings, the equipment used is often expensive, requires expert users and has a dedicated purpose. Furthermore, once a patient returns to their home environment following acute rehabilitation care, partial and unmet rehabilitation needs may ultimately lead to a loss of functional autonomy, which increases utilisation of health services, number of hospitalisations and early institutionalisation, leading to a significant psychological and financial burden on the patients, their families and the health care system (Vincent et al 2007). The potential for rehabilitation at home will enable patients and their clinicians to tailor their program of rehabilitation and follow individual schedules, potentially leading to a reduction in subsequent health care service provision. For example, Golomb and colleagues (Golomb et al 2011) recently reported on the maintained improvement in hand function and forearm bone health in a child with hemiplegic cerebral palsy 14 months after an in-home VR videogame hand rehabilitation intervention. Undergoing treatment at home gives people the advantage of practicing skills and developing compensatory strategies in the context of their own living environment. By leveraging the connectivity enabled by broadband technology and video game technology, it should be possible to build distributed communities of individuals undergoing rehabilitation as well as providing a mechanism for remote measurement and assessment of function.

Consumer driven forces for new ways to interact with videogames have lead to development of sophisticated video capture and inertial sensing devices for measuring movement of the human body. Until recently, such technology could only be found in expensive and dedicated laboratory facilities. Devices such as the Nintendo Wii and Microsoft Xbox Kinect are now at a price point ($400) that it is possible to inexpensively deploy motion capture and feedback technologies directly into the homes of patients for use in training and rehabilitation. Much of the recent work in home-based rehabilitation has been driven by the adoption of Wii-style videogames by rehabilitation therapists. For example, Gil-Gomez et al (2011) have recently shown that a modified balance training system based on the Nintendo Wii Balance Board improved standing balance in a sample of 17 patients with acquired brain injury. Furthermore McNulty and colleagues (Mouawaud et al 2011) have shown that an intensive 2-week intervention using off-the-shelf Nintendo Wii videogames resulted in significant and clinically relevant improvements in functional upper limb motor ability in people recovering from stroke. By combining video images and inertial sensor data with videogame technology, sophisticated analyses of an individual's movements will be possible and remotely located rehabilitation clinicians will be able to simultaneously provide meaningful and engaging feedback to their patients. This is particularly important for those people living in regional, rural and remote Australia where access to therapy is currently restricted or non-existent. In a new research program at NeuRA, (ViGILANT) we are exploring the effectiveness of videogames as a viable telehealth technology.

## VIDEO GAMES FOR INDEPENDENT LIVING: AN NBN TECHNOLOGY (VIGILANT).

ViGILANT is an integrated multidisciplinary technology program that aims to support older people to live longer and more independent lives, to enhance their general quality of life, to reduce their dependence on the healthcare services and on family and friends. It builds upon a framework for research established by the Technology Research for Independent Living

(TRIL) center in Ireland. TRIL is an active collaboration between researchers in academic, clinical and industry settings to tackle the problems associated with demographic ageing. ViGILANT significantly extends the TRIL framework by introducing the novel use of broadband-enabled videogames as a telehealth technology. It is an iterative, collaborative endeavour with 3 themes.

1. **Human Centred Design**. We draw from the field of Interaction Design to generate design specifications and prototypes of videogames that older adults will engage with. Interaction Design applies knowledge for creating solutions that connect people and their technological environments (Martikainen et al 2010). It is an iterative, creative process based around the "building up" of ideas where there are no judgments early on in the design process. This approach encourages maximum input and participation in the process. We work with older adult interest groups, such as the Australian Seniors Computer Clubs Association, to significantly engage them throughout the design process. The games we design are “owned” by older adults in the sense that they drive the conceptual design and development of the games and provide feedback throughout.

2. **Technology Development**. We engage with national and international videogame developers to work with researchers and clinicians to develop videogames that can be used in a health context. For example we have worked with the Brisbane-based HalfBrick Studios, developers of the popular Fruit Ninja game for the Apple iPad. Following our guidance, HalfBrick have modified Fruit Ninja sufficiently that individuals being rehabilitated for upper limb function following stroke are able to engage with the game. Initial pilot studies indicate that both patients and therapists alike enjoy using the game and spend considerable time using the game outside of normal rehabilitation gym times. We have also recently embarked on a partnership with Professor Glenna Dowling, from the University of California San Francisco and Red Hill Studios in California to modify a game their team has developed for balance training in Parkinson’s disease patients for use by older adults. Professor Dowling’s work has been supported by the National Institutes of Health and represents an example of how academic researchers can engage with industry partners to build videogames for health.

3. **Health Research**. As one of the fundamental aims of ViGILANT is to assess novel videogame technologies to facilitate independence of older adults, we have a strong empirical focus. At the core of our research programs are randomised controlled trials (RCTs) to assess the effectiveness of home-based videogame interventions for preventing falls. Systematic review of RCT studies have demonstrated that exercise can significantly reduce the risk and overall number of falls that occur in older people. In the following we describe one of ViGILANT’s current National Health and Medical Research Council funded project which explores the use of exercise-based videogames to engage older adults in daily exercise to reduce the risk and incidence of falls.

## FALLS IN THE ELDERLY: AN EXAMPLE OF HOW VIDEOGAMES CAN ADDRESS A GROWING HEALTH ISSUE.

A recent report commissioned by NSW Health (Watson et al 2010) has shown that in 2006/2007, an estimated 507,000 falls occurred in 251,000 people aged 65 and older living in NSW. The number of people in NSW aged 65 and older is estimated to be just over 931,000, which means that around 27% of the older population fell at least once during the 2006/2007 period. While the majority of older people live independently in the community, the 5.6% of older people who live in residential aged care facilities accounted for 10% of all those who fell.

Around 28% the falls that occurred in older people resulted in injuries requiring some form of medical treatment. One third of medically treated injuries presented to a hospital emergency department for treatment and of these, nearly 60% were admitted. For residents of aged care facilities who had fallen, the rate of hospitalization of 3.3 times the rate for those living in the community. Of the people previously living independently in the community and who were

admitted to hospital following a fall, 7% were then transferred directly to residential aged care rather than returning to their own home.

## THE COST OF FALLS

According to the NSW Health report, the total estimated cost of health care associated with medically treated fall injuries in older adults living in NSW during 2006/2007 was $558.5 million. 85% of the overall cost of injuries resulting from falls was spent on hospital admissions. Overall falls in older women accounted for $384.93 million and 15% of the total cost was for falls that occurred in residential aged care settings. The report also shows that the average health care cost of medically treated, fall-related injuries in older people living in NSW was $3906 per fall injury treated. Hospital admissions accounted for the highest average cost at $18,454 versus $369 for non-hospital treatments.

While the economic costs from this comprehensive report are sobering, the total burden of falls injury is likely to be significantly higher as the estimates do not include the intangible and indirect costs of fall injuries among older people. Falls can result in people experiencing a loss of confidence, self esteem and reduced independence. Falls can also often result in a 'long lie' for a person who is unable to get up from the floor. This can have potentially serious consequences such as hypothermia, broncho pneumonia and pressure sores. A 'long lie' of 12 hours or more can seriously affect a person's recovery from a fall.

## WHAT CAN BE DONE ABOUT FALLS?

The NSW Health report provides us with a comprehensive population-level estimate of the incidence and economic costs of falls amongst older people living in NSW from which we could extrapolate an estimate for the overall costs to the Australian community. Falls are a significant public health issue and therefore cost-effective fall prevention strategies and programs are required. Research conducted by the Falls and Balance Group of Professor Stephen Lord at Neuroscience Research Australia has shown that reduction of fall risk and prevention of medical complication resulting from falls is possible. Identification of those older adults who are highly at risk for having a fall is an important first step at Prof Lord's team have developed a well validated test of fall risk that is capable of predicting older people at risk of falling with 75% sensitivity and specificity in community settings (Lord et al 1994)

Once an older adults risk for having a fall is identified, it is important to put in place a strategy to ensure that their chance of having a fall is minimized. As with most things in life, exercise is the key to better health, and no more so than in relation to fall prevention. A number of randomised control trial studies have demonstrated that exercise, particularly of a kind that challenges the balance control system, can significantly reduce the risk and overall number of falls that occur in older people. While randomised control trials that include muscle strengthening and balance training show that the risk of falls can be significantly reduced, compliance with fall prevention interventions is often disappointing, suggesting some reluctance on the part of older adults to take part in such programs. Barriers to adherence to exercise programs may include lack of interest in the program, low outcomes expectation, fear of falling and even the weather.

## SO HOW WILL VIDEOGAMES HELP PREVENT FALLS?

In the Falls and Balance Research Group at Neuroscience Research Australia, we are exploring the possibility of using video games to reduce the risk and incidence of falls in older adults. The activities of every day life frequently involve moving about in one's environment and the ability to make timely, appropriately directed steps underpins our ability to maintain our balance and move unaided through our environment. Stepping (changing the base of support (BOS) relative to our centre of mass (COM)) also provides the means by which we are able to counter potentially destabilising events such as slips, trips and missteps

and avoid obstacles. Protective stepping may be initiated volitionally when a threat to balance is perceived, or induced reflexively when a disturbance moves the COM relative to the BOS at a speed that prevents engagement of volitional strategies.

Initial studies suggest that both volitional and induced stepping abilities are significantly impaired in older versus younger individuals and are good predictors of falls. Compared to younger adults, older adults, particularly those with a history of falling, tend to be slower in initiating volitional step responses (Lord and Fitzpatrick, 2001), make inappropriately directed or multiple short steps in response to an external perturbation of balance (McIlroy and Maki 1996) and in response to lateral perturbations have an increased chance of collision between the swing and stance legs during compensatory stepping (Maki et al 2000). Lateral falls are those which are most likely to result in hip fracture and as such, lateral balance control is of particular importance for fall prevention strategies (Sambrook et al 2007).

Like any physical function, stepping ability can be trained. We also know that any exercise that specifically challenges balance is successful in reducing the risk of falls in older adults, the challenge however is to get people to adhere to their exercise routines. We are therefore exploring use of a modified version of the popular Dance Dance Revolution (DDR) video game to engage older adults in a step training program (Figure 1).

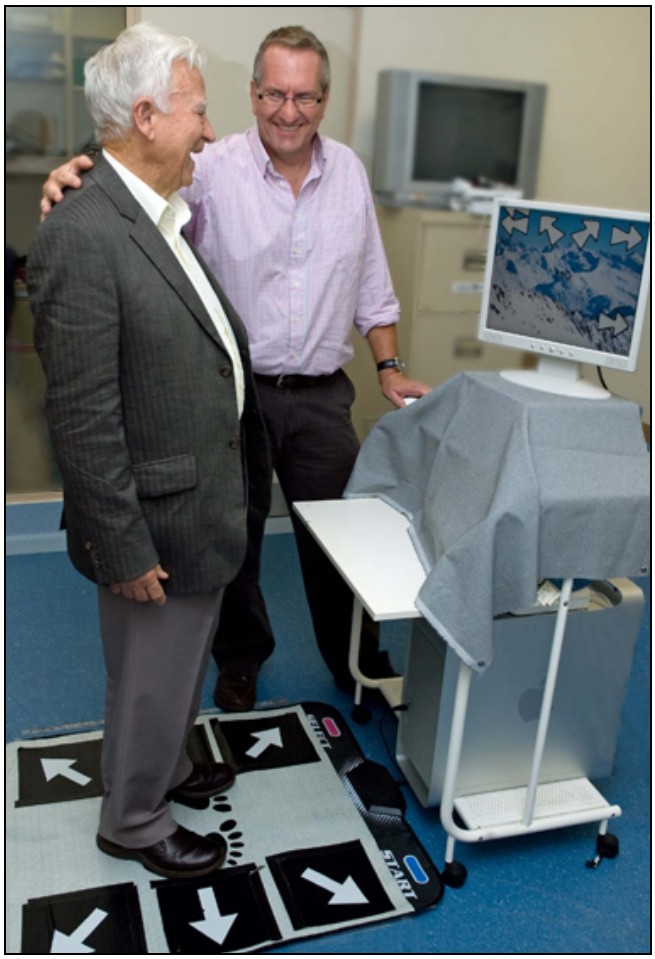

**Figure 1** - Dr Stuart Smith and NeuRA volunteer, Mr Kieran Young, with a modified Dance Dance Revolution step training system.

Dance Dance Revolution involves "players" stepping onto panels of a flexible sensor mat in time with a visual stimulus presented on a television screen. The game can be programmed such that photos of grandchildren, favourite pets or any image of interest can appear on the screen. In addition, any music of the person's choice can be played in time with the stepping patterns. By engaging older people in the design of their own step training system, we hope to further promote adherence to their training.

Results from our initial investigations (Smith et al 2011) have shown that older adults really enjoy playing DDR-style video games. Furthermore, we've shown in a recent pilot study (manuscript in preparation) that stepping performance can be improved in older adults, even those relatively frail adults found in rehabilitation wards of hospitals. Of the 44 patients in the pilot study, 19 (43%) were able to successfully complete the initial level of DDR difficulty and progress to higher, more complex levels of interaction with the game. In addition to increasing physical activity and engaging in older adults in step training, we are also exploring the possibility that performance on gameplay can provide us with an indication of the older players' risk of having a fall in the future (Schoene et al 2011). If used on a regular basis by older adults in their own homes, we will be able to track changes in fall risk over time and respond as a consequence, playing video games may therefore be a novel approach to facilitating continued independent living in older adults.

The system we have developed provides older adults with a "set top box" computer attached to their television. Videogames can be selected and played through a user friendly interface that does not require the player to learn complex computer commands, use a keyboard or mouse nor will it require constant updating of virus definitions like most PCs. Data from games or clinical tests deployed on the home-based system can be sent back to researchers at Neuroscience Research Australia via an internet connection for longitudinal monitoring of fall risk. If an increased level of fall risk is identified, a video consultation session with a remote falls prevention clinician could be initiated and an appropriate intervention plan developed and put in place. We have integrated a telepresence-quality videoconferencing solution (VidyoDesktop™ ) into our set-top box system which enables a low latency HD-quality video for natural communications between remote clinical and research staff and study participants who may live in regional, rural or remote areas.

## MAKING USE OF THE NATIONAL BROADBAND NETWORK

To address delivery of such health services (such as video consultations) to people living in regional Australia, the Federal Government plans to roll out a high-speed broadband network. This national infrastructure project will provide significant opportunities to transform the delivery of fall prevention services such as the delivery of formal, supervised rehabilitation and training sessions from a remote location and simultaneously capture the data stream from the videogame solutions developed by ViGILANT. In the next phase of ViGILANT we will explore use of the Microsoft Kinect camera technology to engage remotely located older adults with trainers in metropolitan Sydney in real-time fall prevention exercise classes. The Kinect is a "controller-free gaming and entertainment experience" by Microsoft for the Xbox 360 video game platform, and will soon be supported by PCs via Windows 8. It enables users to control and interact with the game console without the need to touch a game controller, through a user interface using gestures and spoken commands. Kinect enables full-body depth-based 3D motion capture, facial recognition and voice recognition capabilities. As such it offers full-body motion tracking as compared to previous generation hand-motion (Wii) or remote control technologies. According to information supplied to retailers, the Kinect is capable of simultaneously tracking up to six people, including two active players for biomechanical motion analysis with a feature extraction of 20 joints per player. This means that a centrally located therapist or trainer will be able, in real-time, monitor and analyse the movement profiles of a remotely located patient and provide instantaneous feedback and guidance to the patient. To engage remotely located participants in exercise-based videogame play with each other and with trainers based in metropolitan Sydney, it will be necessary to have high speed, low latency broadband connections available of the kind offered by the NBN. A key conclusion of a recent report by NICTA into the use of NBN for delivery of telemedicine states "*The NBN will provide a unique opportunity to catalyse change in the way health care is delivered"* (Hanlen and Robertson 2010). ViGILANT's innovative use of broadband-enabled videogames for delivery of telehealth services is well positioned to capitalise upon this opportunity.

## INNOVATIVE DELIVERY OF HEALTH INFORMATION TO OLDER ADULTS

Recommendation 119 of the Hospital and Health Reform Commission report (Bennet 2009), states "Ensuring access to a national broadband network (or alternative technology, such as satellite) for all Australians, particularly for those living in isolated communities, will be critical to the uptake of person-controlled electronic health records as well as to realise potential access to electronic health information and medical advice". A feature of ViGILANT videogame solutions will be integrated, easy to use feedback mechanisms for older adults to track game-based correlates of health and function via their home television set. Longitudinal monitoring of videogame-based markers of health status, combined with clinical decision support systems, could be used to effectively alert older adults to a change in their risk of falling and provide encouraging feedback for continued adherence to rehabilitation exercises at home. The broadband-enabled videogame solutions developed by ViGILANT will make possible delivery of health information to older adults, their families or support networks.

## SOCIAL CONNECTIVITY AND INDEPENDENCE

The social encouragement provided by videogames developed by ViGILANT may also be leveraged to build greater social connectivity with older adults. For example, a grandfather could compete in a videogame against his grand daughter when she visits him or he could play against other older adults living in Dubbo, Darwin or even Dublin. Inadequate social connectivity is associated with an increase in mortality, morbidity and psychological distress, older people who report a lack of social contact have been shown to be more likely to die than those with higher social support (Holt-Lunstad et al 2010). In their submission to the Productivity Commission report (Productivity Commission 2011), The Benevolent Society said, "*In older age social exclusion can result in poor quality of life, avoidable illness and disability, higher rates of hospitalisation, premature institutionalisation and premature death. ... Most older people want to live as independently as possible, continuing to do the things they enjoy and staying connected to their community*" [p80]. The videogames developed by ViGILANT can therefore also be used to address important issues of social connectivity in older adults.

## A NEW INDUSTRY FOR AUSTRALIA

Worldwide there is an increasing use of videogame technology for addressing health issues. Australia is well placed to be at the forefront of this revolution, both in terms of fundamental research and its commercialisation. Whilst the Australian videogame development industry is world class, in recent years the industry has experienced the closure of many major local development houses with subsequent retrenchment of highly skilled employees. Of compelling interest to many industry observers is the opportunity that exists for individuals possessing high-end skills within the interactive media industries to apply their knowledge into 'non-entertainment' industry sectors such as health. ViGILANT offers a new avenue for creation of a "Games for Health" industry in Australia, which will have significant export potential.

## SUMMARY

Independent living supported by smart technologies offers the potential for substantial savings in community and residential aged care and in reduced admissions to hospitals, by providing early alerts to changing health patterns and by minimising falls and other accidents in the home. Many technologies for elderly-friendly housing depend on information and communication technologies to address social communications, personal health monitoring, telehealth, shopping and education. The program of work outlined by ViGILANT aims to

develop innovative videogame technologies that make use of the National Broadband Network to achieve these goals.

## REFERENCES.


Anderson, CA; Bushman, BJ. 2001. Effects of violent video games on aggressive behavior, aggressive cognition, aggressive affect, physiological arousal, and prosocial behavior: a meta-analytic review of the scientific literature. P*sychological Science: A Journal of the American Psychological Society* / APS 12 (5): 353-359.

Barnett, A; Cerin, E; Baranowski, T. 2011. Active video games for youth: a systematic review. *Journal of Physical Activity and Health* 8: 724-737.

Basilakis, J; Lovell, NH; Redmond, SJ; Celler, BG. 2010. Design of a decision-support architecture for management of remotely monitored patients. *IEEE Trans Information Technology in Biomedicine* 14 (5): 1216-1226.

Beale, IL; Kato, PM; Marin-Bowling, VM; Guthrie, N; Cole, SW. 2007. Improvement in cancer-related knowledge following use of a psychoeducational video game for adolescents and young adults with cancer. *The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine* 41 (3): 263-270.

Bennett, C. 2009. A healthier future for all Australians. National Health and Hospitals Reform Commission final report.

Bergeron, BP. 2008. Learning & retention in adaptive serious games. *Studies in Health Technology and Informatics* 132: 26-30.

Bhangu, A; Lwin, M; Dias, R. 2009. Wimbledon or bust: Nintendo Wii related rupture of the extensor pollicis longus tendon. *The Journal of Hand Surgery, European Volume* 34 (3): 399-400.

Blackburn, S; Brownsell, S; Hawley, MS. 2011 A systematic review of digital interactive television systems and their applications in the health and social care fields. *Journal of Telemedicine and telecare*, Published online on 11 March 2011, doi: 10.1258/jtt.2010.100610

Bouwhuis, DG. 2003. Design for person-environment interaction in older age: a Gerontechnological perspective. *Gerontechnology* 2 (3): 232-246.

Christiansen, C; Abreu, B; Ottenbacher, K; Huffman, K; Masel, B; Culpepper, R. 1998. Task performance in virtual environments used for cognitive rehabilitation after traumatic brain injury. *Archives of Physical Medicine and Rehabilitation* 79 (8): 888-892.

Chuang, Y. 2006. Massively multiplayer online role-playing game-induced seizures: a neglected health problem in Internet addiction. *Cyberpsychology & Behavior: The Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society* 9 (4): 451-456.

Clark, M; Shah, A; Sharma, U. 2011. Systematic review of studies on telemonitoring of patients with congestive heart failure: a meta analysis. *Journal of Telemedicine and Telecare* 17: 7-14.

Delbaere, K; Cropmbez, G; van Haastregt, JC; Vlaeyen, JW. 2009. Falls and catastrophic thoughts about falls predict mobility restriction in community-dwelling older people: A structural equation modelling approach. *Aging Mental Health* 13 (2): 587-592.

Demris, G; Charness, N; Krupinski, E; Ben-Arieh, D; Washington, K; Wu, J; Farberow, B. (2010). The role of human factors in telehealth. *Telemedicine and e-health* 16 (4): 446-453.

Duque, G; Fung, S; Mallet, L; Posel, N; Fleiszer, D. 2008. Learning while having fun: the use of video gaming to teach geriatric house calls to medical students. *Journal of the American Geriatrics Society* 56 (7): 1328-1332.

Eley, KA. 2010. A Wii fracture. *New England Journal of Medicine* 362: 473-474.

Gamberini, L; Alcaniz, M; Barresi, G; Fabregat, M; Prontu, L; Seraglia, B. 2008. Playing for a real bonus: videogames to empower elderly people. *Journal of Cybertherapy and Rehabilitation* 1 (1): 37-47.

Gentile, DA; Anderson, CA; Yukawa, S; Ihori, N; Saleem, M; Ming, LK; Shibuya, A; Liau, AK; Khoo, A; Bushman, BJ; Rowell Huesmann, L; Sakamoto, A. 2009. The effects of prosocial video games on prosocial behaviors: international evidence from correlational, longitudinal, and experimental studies. *Personality and Social Psychology Bulletin* 35 (6): 752-763.

Golomb, MR; Warden, SJ; Fess, E; Rabin, B; Yonkman, J; Shirley, B; Burdea, GC. 2011. Maintained hand function and forearm bone health 14 months after an in-home virtual-reality videogame hand telerehabilitation intervention in an adolescent with hemiplegic cerebral palsy. *Journal of Child Neurology* 26 (3): 389-393.

Gil-Gomez, JA; Llorens, R; Alcaniz, M; Colomer, C. 2011. Effectiveness of a Wii balance board-based system (eBaViR) for balance rehabilitation: a pilot randomized clinical trial in patients with acquired brain injury. *Journal of Neuroengineering and Rehabilitation*, 8:30.

Graf, D.L; Pratt, LV; Hester, CN; Short, KR. 2009. Playing active video games increases energy expenditure in children. *Pediatrics* 124 (2): 534-540.

Grealy, MA; Johnson, DA; Rushton, SK. 1999. Improving cognitive function after brain injury: the use of exercise and virtual reality. *Archives of Physical Medicine and Rehabilitation* 80 (6): 661-667.

Grüsser, SM; Thalemann, R; Griffiths, MD. 2007. Excessive computer game playing: evidence for addiction and aggression? *Cyberpsychology & Behavior: The Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society* 10 (2): 290-292.

Guderian, B; Borreson, LA; Sletten, LE; Cable, K; Stecker, TP; Probst, MA; Dalleck, LC. 2010. The cardiovascular and metabolic responses to Wii Fit video game playing in middle-aged and older adults. *Journal of Sports Medicine and Physical Fitness* 50 (4): 436-442.

Gwinup, G; Haw, T; Elias, A. 1983. Cardiovascular changes in video-game players. Cause for concern? *Postgraduate Medicine* 74 (6): 245-248.

Hanlen, L; Robertson, P. 2010. Telemedicine in the context of the National Broadband Network: Report for the Department of Broadband, Communications and the Digital Economy. National ICT Australia.

Hardy, LL; Dobbins, TA; Denney-Wilson, EA; Okely, AD; Booth, ML. 2009. Sedentariness, small-screen recreation, and fitness in youth. American Journal of Preventive Medicine, 36 (2): 120-125.

Hoffman, HG; Doctor, JN; Patterson, DR; Carrougher, GJ; Furness, TA 3rd. 2000. Virtual reality as an adjunctive pain control during burn wound care in adolescent patients. *Pain* 85 (1-2): 305-309.

Holden, MK. 2005. Virtual environments for motor rehabilitation: review. *Cyberpsychology and Behavior* 8 (3): 187-211.

Holden, M; Todorov, E. 2002. Use of Virtual Environments in Motor Learning and Rehabilitation. In *Handbook of Virtual Environments: Design, Implementation, and Applications*. Lawrence Elbraum Associates.

Holt-Lunstad, J; Smith, TB; Layton, JB. 2010. Social relationships and mortality risk: A meta-analytic review. *PLoS Med* 7 (7): e1000316. doi: 10.1371/journal.pmed.1000316

Intergenerational Report 2010. Australian Government, 2011. ISBN 978-0-642-74576-7. Accessed 17 March 2011. Available from: http://www.treasury.gov.au/igr/igr2010/.

Jack, D; Boian, R; Merians, AS; Tremaine, M; Burdea, GC; Adamovich, SV; Recce, M; Poizner, H. 2001. Virtual reality-enhanced stroke rehabilitation. *IEEE Transactions on Neural Systems and Rehabilitation Engineering: A Publication of the IEEE Engineering in Medicine and Biology Society* 9 (3): 308-318.

Kizony, R; Raz, L; Katz, N; Weingarden, H; Weiss, PL. 2005. Video-capture virtual reality system for patients with paraplegic spinal cord injury. *Journal of Rehabilitation Research and Development* 42 (5): 595-608.

Koch, S. 2005. Home telehealth-Current state and future trends. *International Journal of Medical Informatics* 75 (8): 565-576.

Leeson, GW; Harper, S; Levin, S. 2003. Independent Living in Later Life: Literature Review, London: UK Department of Work and Pensions, In-House Report No. 137, August 2003.

Lieberman, DA. 2001. Management of chronic pediatric diseases with interactive health games: theory and research findings. *The Journal of Ambulatory Care Management* 24 (1): 26-38.

Lord, SR; Ward, JA; Williams, P; Anstey, KJ. 1994. Physiological factors associated with falls in older community-dwelling women. *Journal of the American Geriatric Society* 42: 1110-1117.

Lord, SL; Fitzpatrick, RC. 2001. Choice stepping reaction time: A composite measure of falls risk in older people. *Journal of Gerontology: Medical Sciences* 56A (10): M627-632

Martikainen, S; Ikavalko, P; Korpela, M. 2010. Participatory interaction design in user requirement specification in healthcare. *Studies in health technology and Informatics* 160 (pt1): 304-308

McIlroy, WE; Maki, BE. 1996. Age-related changes in compensatory stepping response to unpredictable perturbations. *Journal of Gerontology: Medical Sciences* 51A: M289-296

Maki, BE; Edmonstone, MA; et al. 2000. Age-related differences in laterally directed compensatory stepping behavior. *Journals of Gerontology Series A: Biol Sci Med Sci* 55: M270-M277

Maloney, AE; Bethea, TC; Kelsey, KS; Marks, JT; Paez, S; Rosenberg, AM; Catellier, DJ; Hamer, RM; Sikich, L. 2008. A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time. *Obesity (Silver Spring, Md.)* 16 (9): 2074-2080.

Mattke S; Klautzer, L; Mengistu, T; Garnett, J; Hu, J; Wu, H. 2010. Health and Well-being in the home: A global analysis of needs, expectations, and priorities for home health care technology. Rand Corporation. Accessed 17 March 2011 Available from: http://www.rand.org/pubs/occasional_papers/OP323.html.

Merians, AS; Poizner, H; Boian, R; Burdea, G; Adamovich, S. 2006. Sensorimotor training in a virtual reality environment: does it improve functional recovery poststroke? *Neurorehabilitation and Neural Repair* 20 (2): 252-267.

Miller K; Rodger, S; Kipping, B; Kimble, RM. 2011. A novel technology approach to pain management in children with burns: A prospective randomized controlled trial. *Burns* 37: 395-405.

Moffatt, JJ; Eley, DS. 2009. The reported benefits of telehealth for rural Australians. *Australian Health Review* 34 (3): 276–281

Mouawad, MR; Doust, CG; Max, MD; McNulty, PA. 2011. Wii-based movement therapy to promote improved upper extremity function post-stroke: a pilot study. *Journal of Rehabilitation Medicine* 43 (6): 527-533.

Nash, E.B. et al., 2000. A Review of Presence and Performance in Virtual Environments. *International Journal of Human-Computer Interaction* 12 (1): 1.

Noel, HC; Vogel, DC; Erdos, JJ; Cornwall, D; Levin, F. 2004. Home tele- health reduces healthcare costs, *Telemedicine Journal and e-Health* 10: 170– 183.

Peek, AC; Ibrahim ,T; Abunasra, H; Waller, D; Natarajan, R. 2008. White-out from a Wii: traumatic haemothorax sustained playing Nintendo Wii. *Annals of the Royal College of Surgeons of England* 90 (6): W9-10.

Peng, W. 2009. Design and evaluation of a computer game to promote a healthy diet for young adults. *Health Communication* 24 (2): 115-127.

Productivity Commission. 2011. *Caring for Older Australians*, Draft Inquiry Report, Canberra

Robinson, RJ; Barron, DA; Grainger, AJ; Venkatesh, R. 2008. Wii knee. *Emergency Radiology* 15(4): 255-257.

Rosser, JC; Lynch, PJ; Cuddihy, L; Gentile, DA; Klonsky, J; Merrell, R. 2007. The impact of video games on training surgeons in the 21st century. *Archives of Surgery (Chicago, Ill.: 1960)* 142 (2): 181-186; discusssion 186.

Sambrook, PN; Cameron, ID; Chen, JS; Cumming, RG; Lord, SR; March, LM; Schwarz, J; Seibel, MJ; Simpson, JM. 2007. Influence of fall related factors and bone strength on fracture risk in the frail elderly. *Osteoporosis International* 18 (5): 603-610.

Sanchez-Vives, M.V; Slater, M. 2005. From presence to consciousness through virtual reality. *Nature Reviews. Neuroscience* 6 (4): 332-339.

Schoene, D; Lord, SR; Verhoef, P; Smith, ST. 2011. A Novel Video Game–Based Device for Measuring Stepping Performance and Fall Risk in Older People. *Archives of Physical Medicine and Rehabilitation* 92 (6): 947-53.

Smith, ST; Sherrington, C; Schoene, D; Studenski, S; Lord, SR. (2011) A novel Dance Dance Revolution system for in-home training of stepping ability in older adults. *British Journal of Sports Medicine* 45 (5): 441-445

Suter, P; Suter, WN; Johnston, D. (2011). Theory-basd telehealth and patient empowerment. *Population health management* 14 (2): 1-6.

Vincent, C; Deaudelin, I; Robichaud, L; Rousseau, J; Viscogliosi, C; Talbot, LR; Desrosiers, J; BRAD group. 2007. Rehabilitation needs for older adults with stroke living at home: perceptions of four populations. *BMC Geriatrics* 7: 20.

Warburton, DER; Bredin, SS; Horita, LT; Zboga,r D; Scott, JM; Esch, BT; Rhodes, RE. 2007. The health benefits of interactive video game exercise. *Applied Physiology, Nutrition, and Metabolism* 32 (4): 655-663.

Watson, W; Clapperton, A; Mitchell, R. 2010. The incidence and cost of falls injury among older people in New South Wales 2006/2007. Sydney: NSW Department of Health, 2010.

Windich-Biermeier, A; et al. 2007. Effects of distraction on pain, fear, and distress during venous port access and venipuncture in children and adolescents with cancer. *Journal of Pediatric Oncology Nursing: Official Journal of the Association of Pediatric Oncology Nurses* 24 (1): 8-19.

**Cite this article as: Smith, Stuart T. 2011. 'Videogames for independent living: A novel approach to telehealth'. *Telecommunications Journal of Australia* 61 (3): 40.1-40.14. Available from: http://tja.org.au.**