Arts, Games and Sensors Harnessed to Enhance Well-being

Andrew Sirkka (ed.)

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1 Introduction and acknowledgements

Well-being Enhancing Technology (WET) research group at Satakunta University of Applied Sciences (SAMK) is a multidisciplinary team targeting at developing a person's health and well-being by means of technology applications rather than the care itself. Ever since the WET research group was established in 2012, the multidisciplinary approach in research team activities are embedded both in traditional Data System Sciences as well as Automation and Electrical Engineering. The core fields of expertise are mobile, gaming and automation technologies (e.g. identifier technologies, machine vision, sensor and measuring, systemic entities) and usability and user research.

Design for Somebody is the background philosophy in WET, meaning that an individual's need is placed as the centrepiece in development processes. Development processes are conducted in close collaboration with beneficiary parties and organisations. By doing so, the research group intends to take a role as interpreter between individuals and service suppliers as well as to assist modify services and linked technologies to become user-based in optimum level.

The purpose of this publication is to discuss and report some of the main activities and perspectives related to the WET development and research at Satakunta University of Applied Sciences (SAMK) in 2014.

As the editor, I would like to express my very great appreciation to each member of WET research group for valuable and constructive contribution to this publication and to the WET-development and research in general. Your enthusiasm to tackle challenges and your innovative spirit has been the driving force making it possible to achieve all the results, part of which is proudly presented in this publication.

I would also like to thank all the authors in this publication. Without your effort and contribution this publication could not be accomplished.

Special thanks to all our partners, colleagues and students in Finland and overseas for your contribution to the processes and results described and reported in this publication.

Andrew Sirkka
Editor

2 Arts and technology play well together

Andrew Sirkka & Antti Koivisto

Fine arts and music have already a long history of being used in therapeutic purposes within health care. Music therapy and music medicine are acknowledged and defined fields of practice. The effects of arts and music on the brain have been studied and applied especially in mental health, occupational and physical therapy of people of all age groups. (Park 2003; Yinger & Gooding 2014.)

Fine arts are proven to assist in handling emotions, learning verbal expressions and behavioural challenges (Moon 2011; Oppenheim et al 2002). Clinical implications of participation in creative activities like painting and music therapy are encouraging in specific child and adolescent population and in disorders diagnosed in childhood, substance abuse, anxiety and eating disorders. (Caddy et al. 2012; Park 2003.)

In recent years, new technologies have emerged, such as constraint-induced therapy, biofeedback therapy and robot-aided therapy. The literature suggests that there is evidence supporting the use of technology to reduce functional impairments. Robotic techniques with precise recording of movements and application of forces are used as a tool for motor rehabilitation. Repetitive movements can be very boring for a patient to do for a longer period. By visualising movements in a game format motivates patients to do physical exercise also beyond hospital stay. Digitalised games offer new tools also for professionals to measure the frequency of activities, width of extensions and muscle power used. (Loureiro et. al 2011; Thomson et al 2015; Tsoupikova et al 2013.)

Today's key word is cost-effectiveness. Incorporating art both in care and care professionals' education programmes has a solid basis in recent research findings. As to care, there is lots of evidence available demonstrating that using arts in care has significantly reduced use of sedative medications, associated overnight stays, and nurse time resulting in a cost savings. In health promotion using arts has proved to be an effective method all over the world. Creating art is evidenced, among other things, to increase the sense of control, distract from pain, decrease blood pressure and stress level, provide a person an outlet for emotional exploration and expression. Widely spread use of patient journals is based on the fact that storytelling improves the quality of life reducing symptoms and doctor visits in cases of various severe illnesses and long-term care. Art provides also effective alternative

means to communicate with people with challenged communication. (Christenson 2011; Kearsley & Lobb 2014.)

Art and technology experiments in KOLMIO-project

Well-being Enhancing Technology research group (WET) at Satakunta University of Applied Sciences (SAMK) participated in the final phase of a multidisciplinary KOLMIO -project which offered a forum to combine expertise from distinguished fields of practice towards the same target, enhancing well-being. The project was administered by SAMK and was funded by the Lapland Centre for Economic Development. KOLMIO took place in Helsinki area and in Satakunta Region 2012-2014 in collaboration with Finnish Artists Association, Finnish composers, Arts and culture trade union Taku, Rehabilitation Centre Kankaanpää, Onnikoti, Jyllin Kodit, PoSa, and City of Rauma. KOLMIO aimed at encouraging and increasing the use of art-related methods in health and welfare services. The project framework lied on art-related pilot projects and workshops carried out in multi-professional teams, which consist of artists, musicians, social workers and especially in Satakunta, welfare technology professionals. (Satakunnan ammattikorkeakoulu 2014.)

Well-being Enhancing Technology research group (WET) at Satakunta University of Applied Sciences (SAMK) made an experiment within KOLMIO-project to combine game technology and fine arts as a means for physical rehabilitation. The game applications were tested in collaboration with Rehabilitation Centre Kankaanpää. Several workshops for clients were arranged where the rehabilitees could practice the game. The game controller was a mobile phone or PC tablet which could be steered either by holding the device in hand or by feet using a balance board (Figure 1).

Figure 1. Mobile painting tested as physical exercise in Rehabilitation Centre Kankaanpää

Technology behind the painting game was fairly simple as presented in the figure 2. The mobile device (1) used to control the game sends constant gravitation data to the server (2) where it is interpreted and sent to the game console (3) which identifies and determines positions of the game elements. In some cases the server and the game console can be the same device (e.g. if the network is limited or unreachable). Figure 2 presents how the data is handled and transferred in the system between the different devices.

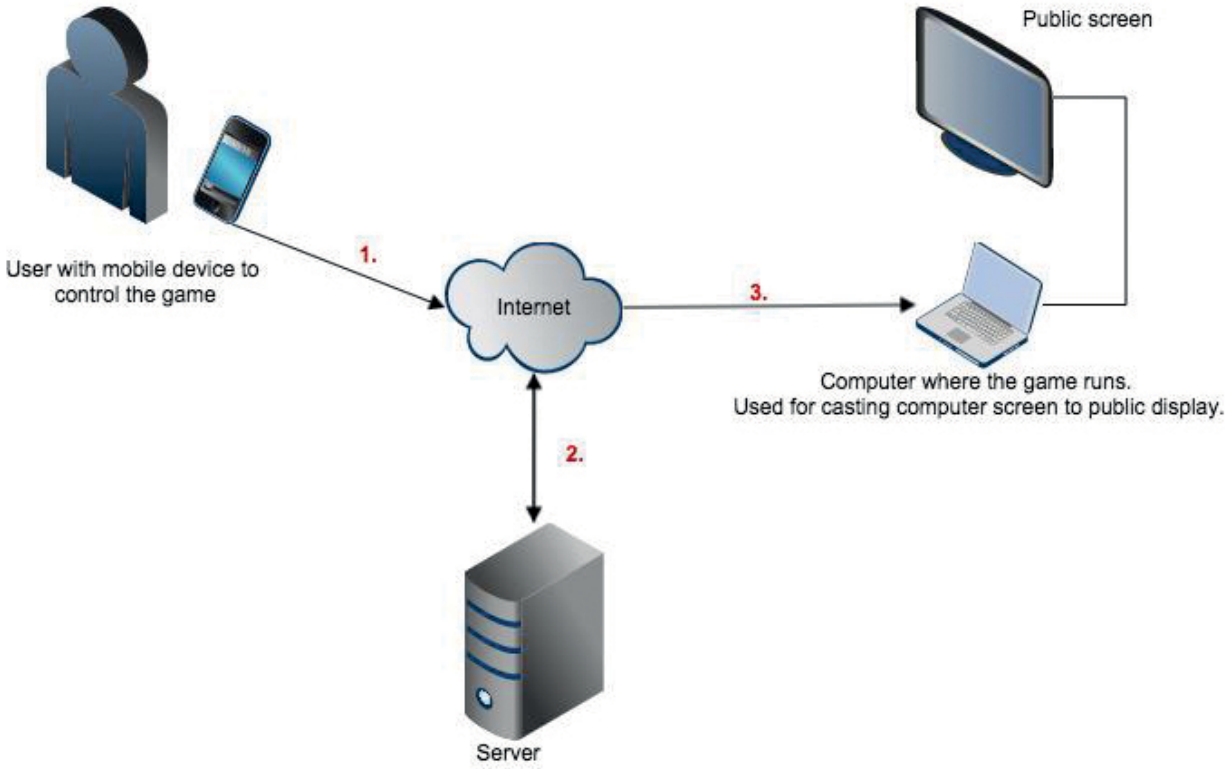

Figure 2. Technology in the painting game

When designing the games, an own application suitable for the mobile device was generated using PhoneGap framework. PhoneGap is a free and open source framework that enables use of JavaScript, HTML and CSS, instead of relying on platform-specific APIs like those used in iOS or Android. In addition, PhoneGap allows some plugins that are usually needed in order to get the most of the application.

Node.js was installed into the server. Node.js is an open source, cross-platform runtime environment for server-side and networking applications. In the Node.js server Socket.IO was installed, which is a JavaScript library for real-time web applications. IO enables real-time, bi-directional communication between web clients and the server. The game itself in the game console was done with JavaScript using HTML canvas element where game events were drawn.

All the above-mentioned libraries and frameworks were selected to keep the environment simple, sleek and light based on our previous positive experiences. The named libraries and frameworks also minimised the programming languages necessary to create the environment.

It was very encouraging to notice how warmly our painting game was welcomed by rehabilitees. It became very obvious to us that both technology and fine arts fit well together offering novel possibilities for experiences, thrills, and individualised ways of expressing oneself. Both fields of practice have lots to offer in terms of improving accessibility and innovative approaches especially for people with special needs.

Product development exhibited in expositions

The public got possibilities to test balance board painting in various Expositions in 2014. One of the biggest events was “Hyvä Ikä” [Good Age] Exposition, Tampere, 25–26 September 2014, where WET from SAMK participated in as part of CoastAL consortium activities with Turku University of Applied Sciences (TuAMK). Both universities of applied sciences share the interest of generating user-friendly serious games for therapeutic use in healthcare settings. CoastAL consortium has opened wider possibilities for collaboration in the field of well-being enhancing technology development. The CoastAL stand with presented game technology got huge attention from the public. The common feedback was that balance board painting was fun and motivating. The artistic results were printed to take home as a long-term reminder of this positive experience. (Figure 3.)

Figure 3. Public active in game experiments on Exposition events

Other games presented in various expositions were designed to activate and improve motor and cognitive skills (Figure 4). The idea of this simple and fun Cat-Mouse game is to control the mouse's direction and speed by just tilting the Tablet PC in order to collect as many cheese chunks as possible in one minute. One has to avoid being caught by any of the cats that might appear and start chasing after the mouse. The game records the player's scores based on how many chunks of cheese one managed to collect within the given time frame.

The Trail Making -game is a modified version of the standardised pen and paper Trail Making Test that is used in diagnosing memory impairments. The player can select the difficulty level to play between 5 and 40 characters on the screen. The player is requested simply to tap the numbers or numbers and letters that appear on the Tablet PC screen in the correct order. The game registers the tapping time and the number of mistakes made (Figure 4).

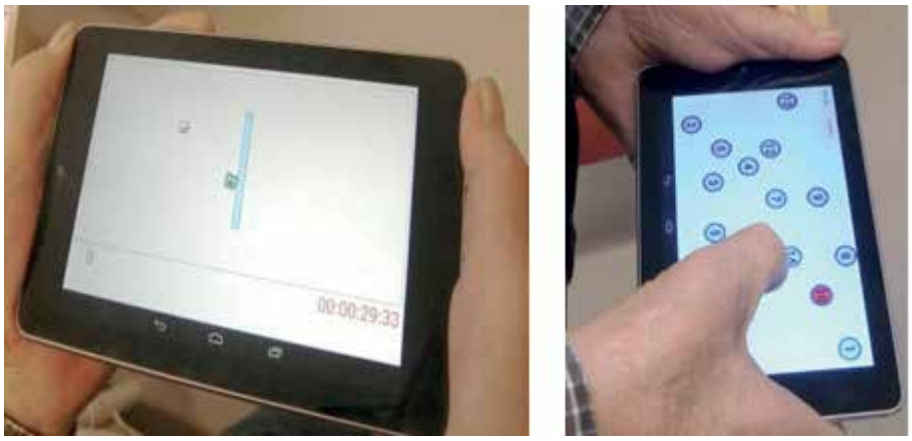

Figure 4. Cat-Mouse and Trail Making game scenes on tablet PC

Another aspect in amalgamating arts and technology is the visualisation of games. Collaboration with Dundalk Institute of Technology (DkIT) in Ireland has offered a good boost and vantage point in regard with what is going on in the field of gamification. Especially active dialogue with the teachers and students in the Department of Computing and Mathematics has been mutually rewarding. Various games for people with learning disabilities, seasonal affective disorders, depression, and physical limitations have been generated and tested together with encouraging results. Even some of the games generated have gain awards in competitions and even commercialised already.

The DkIT students were requested to research principles of colour psychology, clinical figures of selected health problems, and principles of user-friendly applications to be applied in their game development projects. The game development projects have gone through regular expert panels where the game development has been commented from various

perspectives and improvement has been discussed in order to achieve the final goal. A group of DkIT students also visited Satakunta in June 2014 participating in the regional Summer Event for people with learning disabilities organised by Group Home of Kaunummen Koti Ltd. Group Homes are small, residential facilities located within a community and designed to serve people with chronic disabilities. The students demonstrated games that were specially generated for people with learning disabilities. The event was a huge success in all aspects (Figure 5).

Figure 5. Exploring Interactive Gameplay for Well-being Enhancement (Finn 2014)

As part of the WET experiments in amalgamating arts and technology, people with learning disabilities draw their personal game figures that were placed into the games to be specially adapted to their individual likings (Figure 6).

Figure 6. Artistic visualisations in games

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3 Games to improve cognitive skills

3.1 Memory disorders challenge the care

Andrew Sirkka

Memory disorders are the most significant group of diseases requiring health and social services support and intervention. Memory disorders present physical, psychological and cognitive challenges. Despite impairments of physical functions, cognitive challenges appear as impaired abilities of observation, attention, working memory, processing speed, dual tasking, coordination, and visuospatial conceptualisation. The rehabilitation resources available are limited, and cognitive rehabilitation even lacks updated means and tools (Spector et al. 2003).

Memory disorders become more common along with the aging of the population and lead to progression of disabilities, the need for constant assistance and ultimately to dependency on institutionalised care (Peretz et al. 2011). Good care of degenerative memory diseases consists of providing appropriate medication and timely support services including physical activity and individualised rehabilitation (Rosenberg et al. 2011). Physical activity and cognitive rehabilitation are proven to slow the progression of the memory disease (Bottino et al. 2005; Giordano et al. 2010).

Majority of people with dementia are cared for at home or home like environments (Verbeek 2011). Self-supported activation and use of easy-to-use technology could therefore offer some solution to the problem where a person is empowered to take charge of restoring and maintaining their own health status by means of controlled rehabilitation events. That is why Well-being Enhancing Technology research group (WET) at SAMK invested in generating games combining physical movement with cognitive impetus. The games were developed in such a way that playing would require coordination of hands and brain by light physical exercise. This approach was taken based on numerous studies showing that both physical exercise and game play have a positive effect on older adults. According to a recent report, moderate, regular exercise may be just as helpful in combating serious depression in older people as antidepressant medication. (Gao & Mandryk 2012; Khoo & Cheok 2006; Sirkka et al. 2012; Koivisto et al. 2013; Wilson et al. 2002.)

Findings from scientific research studies indicate the positive outcomes of playing video games like changes in an individual's alertness, pleasure, dominance, dexterity and the

state of experienced well-being in general. It is also evidenced that acute cognitive benefits, such as temporary improvements in concentration, can result even from as few as ten minutes of regular exercise. (Sirkka et al. 2014.)

Usability was taken into special account in our game designs taking in to account that the games were meant for people who are not necessarily experienced in using technology (older people, nursing staff, people with special needs etc.). The games were designed on a tablet PC and the player identification was automated with the help of near field communication (NFC; NFCIP-1 2013). The goal in the game trials was to investigate, whether the games would have any positive effect on the cognitive skills or simply on the mood of the player.

Another challenge for care and rehabilitation services would be increasing memory problems among working-age population. In Finland alone, about 7000–10 000 people under the age of 65 are suffering from certain degree of memory impairment. While memory problems at work might be revealed at an early stage, they can be easily confused with symptoms of burnout or depression. It is estimated that brain load has increased in working life alongside with development of information technology. Interestingly, technology development can also benefit in the care and rehabilitation of memory impairments.

WET participated in Work Goes Happy Occupational Health Fair in 11 November 2014 at Logomo, Turku, in collaboration with Southwest Finland Memory Association (see figure 1). Memory Association has seen be a lot of potential in the games to restore the capacities in different types of challenged memory and rehabilitative activities.

Figure 1. Memory game demonstrations at an Occupational Health Exposition

Thesis studies at SAMK made for WET research indicate also some actual challenges in the care of memory impaired people. Ylikoski (2014) studied memory nurses' experiences of the use of memory assisting technology. The interviews of five memory nurse specialists in the region (N=5) results in indicating that quite a variety of simple reminder type of assistive

technology is commonly used. An obvious need for deeper knowledge and training regarding the latest easy-to-use or even automated technology to assist memory appears to be there. In addition, information exchange between distinguished organisations dealing with the care of memory impaired should be improved and systematised.

Forsten (2013) studied the home care staff's capacities in early identification of memory impairments. Home care services have a great potential to identify the memory impairments of the old adults and to instruct them for further examinations. However, the study indicated several challenges and development needs in the home care service systems.

In order to maintain the ability for older people and also people with memory impairments to live at home for as long as possible, it is important to respond to the professional needs of home care staff. The professional needs of home care staff that came up in this study were deeper knowledge about memory impairments, memory diseases and their relations to other diseases. In addition, shortage on knowledge about medical treatments, non-medical treatments, and the importance of rehabilitation were mentioned.

Added to knowledge based needs, some developmental needs related to skills, attitudes and values emerged, like collaboration, interaction and ethical skills when working together with professionals of another field of practice. The home care system had some structural impediments, like delayed admissions, lack of observation skills, attitudinal problems, poor interdisciplinary collaboration and communication. Another service system constraint is increased work-related stress among the staff due to decrease of work force in home care sector.

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3.2 Cognitive mobile games for memory impaired adults: An Irish comparative case study

Enda Finn, Andrew Sirkka, Sari Merilampi, Mirka Leino & Antti Koivisto

This article provides a summary of an ongoing applied research project being carried out between Satakunta University of Applied Sciences (SAMK) and Dundalk Institute of Technology (DkIT) in Ireland by SAMK's Well-being Enhancing Technology research group (WET) and DKIT's Department of Computing & Maths. Games to support Memory Rehabilitation (GaMeR) for older adults have already been evaluated in a trial in Finland in 2013 (Merilampi et al. 2014). A comparative trial of this serious game application has recently carried out in The Birches, a specialist day care centre caring for people affected by dementia, in Dundalk Ireland (The Birches 2015). This work also builds on experience gained in previous comparative trials in Finland and Ireland into serious games for primary school maths education (Kiili at al. 2014).

Approach taken to the comparative trial

Following on from the Finnish trial and given the collaborative nature of the international research cooperation, WET researchers were motivated to find a suitable, comparative care setting. An important issue to immediately highlight is that "suitable" did not have to mean identical or even ideal. Furthermore, it was clear from the outset that attempting a straight "comparison" would more likely involve comparing and contrasting between the two trials even where the differences might be quite significant or even excessive.

Through DkIT's Netwell Research Centre, it was initially hoped to access a target group of older people, with slight memory impairments in assisted living environments (Netwell Centre 2015). However, due to logistical issues and existing research commitments, this cohort was not readily available. Netwell had also worked closely with The Birches and hence the idea of running a comparative trial based there was first explored in late 2013. Even from the initial discussions it was clear that although there were broad similarities (for instance working with memory impaired adults; using Tablet PC based games as a means

of positive engagement and activation) there were also significant differences. The Birches provide a day care facility of between one and four days per week for adults with moderate to severe dementia whereas in Finland care was fulltime residential (24/7), for older adults with mild, age related dementia.

Following further project and logistics planning, ethical approval was sought from DkIT's Research Ethics Committee. This was granted in June 2014. There then followed the important steps of training of care staff (for the GaMeR app), seeking of client consent and setting up the trial (like commissioning of Tablet PC based GaMeR app, registering the anonymous client ID badges, conducting initial MMSE memory tests). The trial proper was finally ready to run in September 2014. Such relatively slow progress has been a feature of this applied research project, especially considering the voluntary status of the day care setting, the limited availability of busy staff and also the international cooperative nature of the work involved.

In the Finnish trial, there were total of 16 participants split into a test group (n=9) and a control group (n=7). Both groups were measured using a standard MMSE test at the beginning and at the end of the trial. The control group did not participate in the game trial. By contrast in the Irish trial, there were just a test group (of n=12) with no control group. The test group was likewise measured at the beginning and end of the trial. Furthermore, the Finnish trial operated on the basis of game interactions twice per day, every day for the 3 months of the trial whereas in the Irish trial game interactions operated (at best) only once per day for each day of attendance at the day care centre by client over a four month period. Attendance varied from client to client from between one and four days with the average being two days per week. In both trials, clients were assisted (and encouraged) to play the games. (Merilampi et al. 2014.)

In the Finnish trial, clients were more independent and more able to play on their own. Observation was made by care staff but only as part of the normal care model. In the Irish trial there were a small number of clients who played more independently, however due to more of the clients having moderate to severe dementia they needed additional support and encouragement from care staff. In fact for some it was the case that each interaction with the games was like the first interaction, requiring repeated retraining for the client. Participation on a given day was also effected by the client's mood. If they didn't feel like playing on a particular day then they didn't play! In both trials, each game interaction was recorded (time, score, and an optional comment from carer), against a client's own unique ID badge which kept their actual identity anonymous. (Merilampi et al. 2014).

Outcomes and initial findings

The Irish trial is, in terms of game interactions, now complete. The final stage of evaluation (via a care staff questionnaire) is as yet incomplete. Furthermore, the trial period had to be extended to include December 2014 due to major logistical issues around reorganisation of the day care service in October 2014. Such are the realities of hard pressed voluntary care services. There were also occasional technical glitches reading a client ID badge from a Tablet PC device meaning the particular game interaction and score was not recorded. Despite these difficulties and setbacks and the unavoidable fact of the Irish trial data set being smaller and more sparse compared to the Finnish dataset, initial findings are encouraging and some significant outcomes have been noticed.

For example, a simple regression analysis two thirds of the way through the trial made it clear that the TMT game was too easy at the basic level (5 number and/or letter combination). It showed that clients were more capable and could be encouraged to stretch themselves to play at higher levels (10, 15 etc.). Care staff told us that they are particularly interested in change in a client, any change even a small change in game performance could be seen as significant. Furthermore, it is especially important to be able provide clients with positive feedback, on something they are actually good at and from this, to encourage more social interaction and engagement with an appropriate degree of competition.

Such engagement and participation by clients with interactive games that are new, modern and technology based highlights an ability to learn, even where in more severe dementia cases what is learned is not remembered and therefore has to be relearned. It's not solely about remembering. One of the most positive effects of game interaction is that clients are engaging, even if just in the moment and are benefiting from the associated cognitive, physical and even emotional involvement.

Another important insight which was offered is that since the first diagnosis of dementia for a client, it has been all about measurement, typically of a declining memory function or capacity. Client's already know something is wrong and can sense it is regressive and hence they will tend to be very negatively disposed towards further measurement that might simply reinforce what they fear about themselves. It can therefore potentially be something very motivating where they might experience a positive outcome to a game or sense that there is some degree of improvement.

Game design, especially games designed for older less technology savvy users is very challenging. This trial took this challenge even further. The games needed to provide a

positive, reinforcing experience right from the off. Often games are designed around exposing deficits in a player's skill or capability. Win or lose -logic tends to be oriented towards losing as a means of learning how best to "outsmart" your opponent in the game moving your mouse character quickly and skilfully so as to grab more cheese before the clever cats get you.

Taking the reverse view of typical game design reflects a deeper challenge around dementia care between the "medical model" and the "social model". The medical model tends to focus on dementia as a disease with negative and inevitable effects of decline and loss of function or capacity, whereas the "social model" looks at the long term not in terms of loss but in terms of maintaining and supporting capability and using what you still have in the most engaging and stimulating way. So the game mechanics, challenges and game flow need to provide a more positive and rewarding "can do" experience in order to encourage engagement. In short, it needs to be less of a test and more of a playful experience.

One rather interesting cultural aside to this trial was the observation, that, in the Finnish trial, the cat and mouse game was seen as more engaging and fun whereas the Trial Making game was more "work" rather than "play". However, in the in the Irish trial many of the clients were less interested in the cat and mouse game, seeing it as perhaps "childish" and "time wasting" whereas the Trial Making game was viewed as more challenging and rewarding.

Another outcome was the realisation, through careful observation that in the case of clients with severe dementia, to achieve even five minutes of engaging gameplay, it takes at least fifteen minutes of set-up, explanation and encouragement on the part of the carer every time the games are played! This is very time consuming and demanding on the carer and requires skill and patience. This was a key difference from the Finnish trial where for most all of the clients, once they became familiar with the game interactions they were able to play by themselves over the following days and weeks.

Indeed all game interaction with clients with severe dementia is a two person interaction; both client and carer are playing the game cooperatively. This wasn't factored into the game design and even if it had been, such dual interaction presents many more challenges for designers. As part of this actual, observed behaviour researchers were asked also to consider the potential for using such games as both a training tool for carers and potentially as a diagnosis tool in client case review. One advantage of engaging game play is that it hides or distracts from more explicit measurement of memory function.

Finally it should be noted that care staff saw it as very important that a cohort of clients with moderate and even severe dementia could in fact take part in such a trial and that they clearly demonstrated as a result that they had something very worthwhile to contribute. The experience of engaging, stimulating and challenging interaction was at least in part evidence of a well-being enhancing technology, even if just in that moment! To quote one carer who quipped, “You either use it or you lose it!”

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3.3 Activation and rehabilitation games for people with special needs

Antti Koivisto, Sari Merilampi & Andrew Sirkka

People with special needs are too often seen as a minor and marginalised group that have no use or even interest for game technology. However, modern user-friendly technology applications have shown huge capacity in intensifying care and rehabilitation services. Active ageing, self-supported care, and other ideological putting emphasis on the quality of life aspects, have assisted in taking enormous steps forward towards individualised and tailored care services (Leinonen et al. 2012; McCallum 2012; Confalonieri et al. 2012).

The sense of having possibilities to be mentally, physically and socially active is an important part of well-being in all ages. People with special needs, like cognitive impairment or physical limitations, often feel unnecessarily disabled due to beliefs and limitations prevailing in the social environment, including care professionals. To break the unnecessary impediments, new means and methods are required. Entertainment and therapy content are the elements put together into the mobile games investigated in this study to make games become a tool for rehabilitation adoptable for anyone. (Leinonen et al. 2012.)

Several studies show that both physical exercise and game play have positive effects on people, including older adults or people with learning disabilities, combating serious depression or even Alzheimer's disease (Fairchild & Scogin 2010; Geda et al. 2010; Spector et al. 2003; McCough et al.2011; Merilampi et al. 2014). Also there is evidence indicating that playing video games can lead to positive changes in an individual's pleasure, vigilance, dominance, and in overall state of experienced well-being. Simple and easy-to-play video games are well accepted and found to create positive feelings and enjoyment even among older adults (Khoo & Cheok 2006; Koivisto et al. 2013; Sirkka et al. 2012; Snowden et al. 2011). Already few minutes of gaming exercise on daily basis has cognitive benefits improving performance in attention and concentration (Gao & Mandryk 2012). All this knowledge has been the source of inspiration for SAMK's Well-being Enhancing Technology research group (WET) in generating games that combine physical movement with cognitive impetus and testing them in several target groups.

Design principles in the games

Instead of investing in Design for All, the WET research group is generating applications following the philosophy of Design for Somebody. Since our target groups consisted of people with special needs (like diagnosed memory impairment, older old adults and people with learning disabilities), a special attention is paid on the game design. Due to the impaired perception and sensation skills in the target groups, the following accessibility principles were deployed in the game design: large target button elements, simplified and only necessary graphics, minimal amount of animation, colours used conservatively with high contrast, simple one-view display at the time, and placing important information in the middle of the screen (Díaz-Bossini & Moreno 2014). Apart from the above mentioned accessibility principles, the games are designed to use obvious logics without additional introductions how to play. This is seen especially important by people with learning disabilities even when assisted by staff in the gameplay. (Sirkka et al. 2014.)

In general, the games should correlate with the physical condition of the player as well as their skills to achieve the so-called “flow feeling”. Games are designed to generate a positive effect in players and are most successful and engaging when they facilitate the flow experience. The ‘flow’ describes a state of complete absorption or engagement in an activity and refers to the optimal experience (Csikszentmihalyi 1990). During the optimal experience, a person is in a psychological state where he or she is so involved with the goal-driven activity that nothing else seems to matter. The activity producing such experiences is so pleasant that a person may be willing to do something for its own sake, without being concerned about what to get out of it. Theoretically, the flow consists of nine dimensions, but immediate feedback, sense of control, loss of self-consciousness, clear goals and the challenge-skill balance dimension in particular provide a meaningful approach with which to embody engaging elements into exergames used in activation. (Kiili 2005; Kiili et al. 2012; Kiili et al. 2013; Koivisto et al. 2013; Merilampi et al. 2014; Wilson et al. 2002).

In summary, the focus in our game designing is set on the accessibility factors, minimal amount of required equipment in order to play, and to make the games appealing enough to generate the “flow feeling” to make gameplay activating, easy and fun to play but at the same time being a “serious game” with certain goal and purpose applicable in rehabilitation. These requirements led us to select components like mobile phone, internet connection and TV- or tablet PC display.

Divergences in subjective experiences of various user groups

Despite of many similarities in our target groups, also some clearly defined target group centred requirements emerged. People with learning disabilities were more heterogeneous group than the groups of older adults (variety in ages and capabilities). Based on the feedback, adjustable difficulty levels, animations and sounds seem to be very important especially for the younger players. On the contrary, older adults disliked unnecessary elements in the game, and against all our expectations, the simple game setting was not experienced childish at all; rather did the simple logics and elements clarify the mission of the game. This indicates that well-known concepts and characters are helping people with special needs to grasp the idea in gameplay. Similarly, typical age-related impairments in senses should be notified when designing and adjusting the games for older adults.

The competition and players' scores displayed on screen appeared to motivate the older adults to play and achieve higher scores. The group of people with learning disabilities seem to be less competitive focusing only on each player's own performance.

User experiences on rehabilitative elements in games

All user groups experienced games as potential skill improvement and rehabilitation tools despite the differences in participants' health, cognitive and physical conditions. Some participants had motor skill limitations in all target groups. The challenge related to physical limitations in game designing is to find the ways to adapt the game control according to the player's abilities. Mobile phone as game controller could easily be integrated in different kinds of assistive technology or training equipment, or attached on different parts of the body. The use of a balance board in game controlling broadened the user groups to people unable to use their hands. The players testing the balance board games were seated during game for safety reasons.

For older adults with memory impairment the rehabilitative element was more cognitive than physical. However, also tilting the tablet or playing with balance board by feet required some light exercise.

To summarise, the motivational aspects required in self-regulated rehabilitation are provided in gaming. Games can be adjusted and modified according to personal capabilities, interests and other requirements. The results of our trials indicate strongly that gamification has a real potential in rehabilitation. The overall feedback rates of various target groups (N=107)

our games have been tested so far (Figure 1). Apart from the players participating in game trials, the feedback data was also gathered by interviewing the staff. The staff interviews contained assessment of therapeutic usability of the games as well as observation notes of the staff over and after the gameplay events.

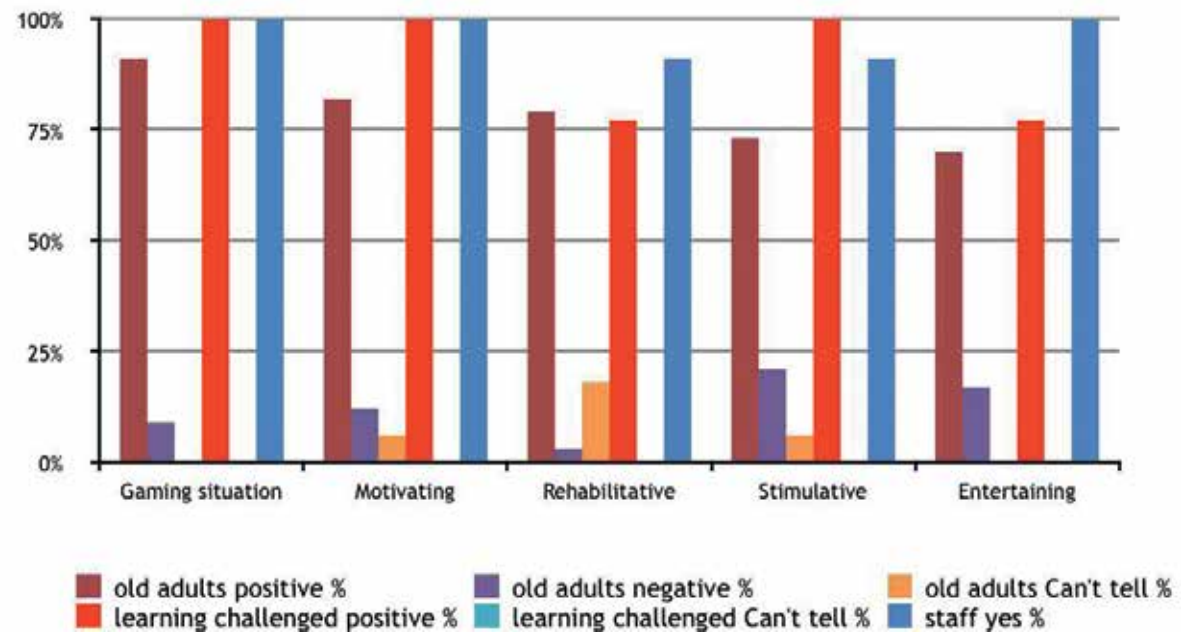

Figure 1. Summary of the feedback gathered from various target groups (N=107)

New technology obviously provides cost-effective, individualised, reasonable and mindful ways to activate and motivate people to be self-supportive, mobile and vigilant. Especially in long-term care facilities should encourage residents to maintain their cognitive, motor and social skills by deploying new and easy-to-use technology to provide meaningful things to do, individually and in groups.

As seen in the figure 1, the positive experiences make the difference in overall well-being. Easy-to-use technology is available and more and more evidence confirm that it is useful for and accepted by older people as well as people with special needs. In these trials, the games were welcomed as potential self-rehabilitation tools that can be adjusted according to personal skills and limitations. They also give meaningful activities to those in care saving time and efforts from professional carers who very often feel guilty of not being able to socialise with clients as much as needed and wanted.

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4. Sensors as well-being indicators

4.1 Communication with sensible things – Makes Sense!

Andrew Sirkka, Sari Merilampi, Mirka Leino & Johan Sidén

This article reports a one-year sensor technology project MakesSense! which was a new collaborative research initiative between Mittuniversitetet, Sweden (MIUN; Sensible Things that Communicate – STC) and Satakunta university of applied sciences, Finland (SAMK; Well-being Enhancing Technology – WET). The research case was based on the core competences of the two research teams in last part of the year 2013, and the project implementation took place in 2014 as a Botnia-Atlantica EU-project. The two research teams together create a strong multidisciplinary welfare technology team to collaborate and achieve synergy benefitting both parties also creating a basis for possible longer-term research collaboration with new research outcomes, business opportunities and joint education possibilities.

The goal of this one-year project in 2014 was to generate tools to increase and measure self-activation by means of developing mobile sensor platform as a basis for novel and advanced services applicable in health and care sector. In this project, the first sensor prototype was developed to measure for example body hydration levels by employing mobile phone to provide data of the affectivity and safety of a person's exercise. The prototype utilises Near Field Communication (NFC) and it was designed to be modified for other sensing purposes (e.g. to measure skin moisture, body temperature). The project also formed a basis for larger research project in which also long range (ultra-high frequency radio frequency identification, UHF RFID) sensing systems were employed for health care purposes. Another research trial executed in this project was to analyse the capability of near infrared imaging (NIR) and long wave infrared imaging (IR, thermal imaging) in measuring perspiration.

Project background

Finland and Sweden are facing similar challenges as to financial situation and demographic changes. Due to demographic and economic reasons it is crucial that aging population maintain their functional capacity longer than before in a level required in autonomous living. In addition, the modern welfare society has generated new health challenges, like

obesity and inactivity. All this challenges to additional input in 1) facilitating, encouraging and enabling people to increase their own role in self-care, as well as 2) enabling and motivating people on physical and cognitive exercises and activities. However, there will always be need for services from a care giver. In global situation with reducing economic resources it is essential to use care resources reasonably.

Although the situation might seem challenging, the two countries, Finland and Sweden, share similar potential in meeting these challenges with the help of high quality research and technology expertise. Pooling resources as to technology and care expertise would multiply possibilities and flexibility enabling more individualised care. New technology can be used as a tool to facilitate and motivate people in self-initiated rehabilitation and follow-up of one's own health parameters to encourage in more active life styles.

Mittuniversitetet (MIUN) and Satakunta University of Applied Sciences (SAMK) own technology expertise on those key areas that are useful in health sector (mobile phone and game industry, automation technology, care technology). Combining resources of the two universities concerned offer a new forum for innovative approaches with wider competence-base to meet the current challenges. In addition, Sundsvall and Pori are twin cities. MIUN provides higher education and runs research activities in Sundsvall the same way as SAMK in Pori. MIUN and SAMK have signed a partnership contract sharing the same fields of interest.

Collaboration between the two research teams was initiated in terms of preliminary negotiations on the common fields of interest and researcher exchange supported by a scholarship from Svenska Kulturfonden i Björneborg (Mikaelsgården 2014). Both collaborative teams have executed research projects related to health and well-being, care technology, activation and sensing. Previous relevant projects at SAMK could be named as follows: User-centred building environment (KÄKI); Wireless technologies assisting autonomous living (WTAL); Gaming in memory rehabilitation (GaMeR); Joint project Elcanet, Family support in elderly care policies. Similarly, MIUN and STC have a long experience from developing and evaluating geriatric diapers with integrated printed electronics to tell when the diaper is saturated. In a 3-year project funded by the research council FORMAS ("Fuktsensoretiketter", Eng. "Moisture labels") MIUN and Linköping University together performed research on wireless low-cost humidity reading with RFID- and NFC technologies for building constructions, creating a great deal of base knowledge for this proposed project. Based on the research lines and attained expertise, this project would benefit both parties by combining forces and expertise to seek new innovations applicable in the fields of healthcare and welfare.

Project implementation

The Project consisted of five (5) work packages: WP1 partner visits, WP2 Sensing with NFC readout, WP3Sensing with NIR/IR camera system, WP4 Sensing perspiration, and WP5 Reporting & Evaluation of project outcomes and planning for the future. The Project Steering Committee was nominated involving representatives of both universities concerned and a representative of Botnia-Atlantica Programme (Gabriel Högberg/ Botnia-Atlantica Program, Bengt Oelmann and Johan Sidén/ MIUN, Petteri Pulkkinen, Sari Merilampi, Mirka Leino and Andrew Sirkka/ SAMK). Total amount of three Steering Committee meetings were held over the Project period (27.2.2014; 19.8.2014; 15.10.2014).

Sensing with NFC read-out

The second work package in the project set the focus on evaluation of different integrated circuits suitable for resistance-based measurement of human perspiration, and circuits powered by and communicated with through NFC-equipped smart phones. The original plan was to use the chip SL13A from IDS Microchip, which had previously been experimented with at MIUN. The SL13A was therefore thoroughly experimented with, both as passive sensor tag (no battery) and as active sensor tag (with battery) with the overall objective of developing an RFID sensor for perspiration measurements. There were, however, many obstacles discovered in using this kind of chip. (Dobkin 2008; Finkenzeller 2003.)

One obstacle discovered was a difficulty to create reliable circuitry for voltage division with a resistive sensor as the chip provides approximately 3.4 Volt output voltage demanding the sensed value to be within 0.3 to 0.6 Volt. Without a full knowledge of what conductivity to expect from human perspiration one has to prepare a solution where series and parallel resistors should be easy to replace. Another obstacle was detected as the SL13A was provided in QFN packages only, which is a package with no leads from the circuits but only very small flat connections underneath the circuit package. These characteristics make it extremely hard to work manually. In active mode, where a battery was used for logging sensor data over time, bugs were detected in the circuit and the internal timer that was used to tell when sensor values should be sampled was far from accurate. Nevertheless, prototypes for perspiration analysis were fabricated. (Kurokawa 1965; Nikitin & Rao 2008.)

Due to the above mentioned obstacles, an alternative solution in form of the M24LR NFC chip-series from ST Microelectronics was later chosen for perspiration measurements. The M24LR chips cannot measure any external sensors on their own but can provide a rectified

DC-voltage from the incoming RF-signal of a nearby phone that together with the chips I2C-bus was used to power and communicate with an extra microcontroller. Such two-chip solution, with one NFC-chip and one microcontroller, provide a very wide freedom in sensor design as compared to the limited resources provided by the NFC chip SL13A. First prototypes have been fabricated at MIUN and even though they would still benefit of some extra stability optimization they work relatively well as a general measurement system for healthcare applications where cost-effective wireless passive sensors are desired.

The sensor elements have been based on parallel conductors distributed over the measurement area. Tests were made with prints containing conductive ink, milled aluminium foil and sewed conductive threads on fabrics.

Material suitable for wearable sensors (sensing elements for the NFC sensor tags) and upon which conductive traces and sensors could be printed were also investigated. Analyses of printability, water absorption, 0.3% saline and 0.5% glucose, resistance change and wearability were conducted. Based on the preliminary results of these tests a few materials have been selected for further tests with real sweat: hospital sheet, 2 technical fabrics, one track suite fabric, artificial skin, a plaster material and a long thin ribbon with parallel metallic wires sewed into it. A relatively simple database was been setup to receive sensor data from phones that reads the NFC sensors. The database is mainly based upon PHP and MySQL. (Chen & Lu 2005; Kim et al 2009; Pantepoulos & Bourbakis 2008; Salvo et al. 2010).

In addition, UHF RFID tags provided by MIUN has been measured with advanced RFID measurement equipment. These tags comprise of pairs of standard RFID tags where one of the tags is covered with a moisture absorbing material such as paper or fabrics and the other is left open. Monitoring the RF properties of the respective tags' antennas provide information about the moisture content at the tags location. Such unit with two tags are therefore referred to as Twin Tag. (Voyantic 2014.)

The tags provided by MIUN for characterization at SAMK comprised sole tags with and without covering absorbing paper and three Twin Tags with different distances in between the two tags in order to evaluate the most promising setup for measuring perspiration.

A thorough amount of measurement data was sent to MIUN where analyses were performed. It was concluded that there were not that much differences for separating the two tags why a setup with the tags placed relatively narrow to each other (distanced about 5 mm) should be used for any on-body measurements. Such setup provides the most comfortable solution and is least likely to be geometrically bent when placed on the body.

Sensing with NIR and IR camera systems

Near Infrared (NIR) imaging and/or Long Wave Infrared (IR) imaging, also known as thermal imaging in sensing moisture differences in different kind of fabrics and materials was the core of WP3. The tests were conducted as series of imaging with different dry and moistened materials. The materials used in these tests were tracksuit fabric, bandage/plaster, hospital sheet, artificial skin, technical fabric and paper (Table 1).

Table1. Descriptions of the materials used with NFC sensor patterns.

MATERIAL	DESCRIPTION
1 Hydrocolloid dressing (”Artificial skin”)	Dressing containing one or more hydrocolloid components such as pectin, gelatin or sodium carboxymethylcellulose. It can be used for ’hard-to-dress’ areas. The dressing features a wide outer foam border that does not require additional taping. Bordered dressing is indicated for chronic wounds- pressure ulcers (Stage I-IV), leg ulcers, acute or traumatic wounds with minor abrasions, lacerations, partial thickness burns and donor sites.
2 Adhesive bandage	Adhesive bandage was made of a porous, elastic non-woven polyester fabric coated with a skin friendly, water based, and solvent-free polyacrylate adhesive for secure and gentle fixation.
3 Disposable surgical drape	Drape is paper based, highly absorbent, nonwoven, two-sided polyethylene - tissue layered 100% impermeable fabric used widely in surgery
4. Tracksuit fabric	Commercial fabric typically used in tracksuits. 100% polyamide.
5. ”Technical fabric, black”	Commercial technical fabric with plastic plating under textile. Breathable, waterproof, impervious to wind. 100% polyester.
6.”Technical fabric, blue”	Commercial TECHNO-sport knit fabric. 100% polyester.
7. Stretchable PVC	Stretchable and flexible PVC plastic foil which can be heat-pressed on textiles

Firstly, all the material was NIR/IR -imaged dry. Secondly, they were moistened with approximately 3 drops of water. Three minutes after the moistening the fabrics were imaged again. Different materials absorbed water differently which could be seen in both NIR and IR images. When water did not absorb nearly at all it stayed on the material like artificial skin. Then it could be seen as wet as water itself. In other words it did give false information about the material inner moisture (Figure 1).

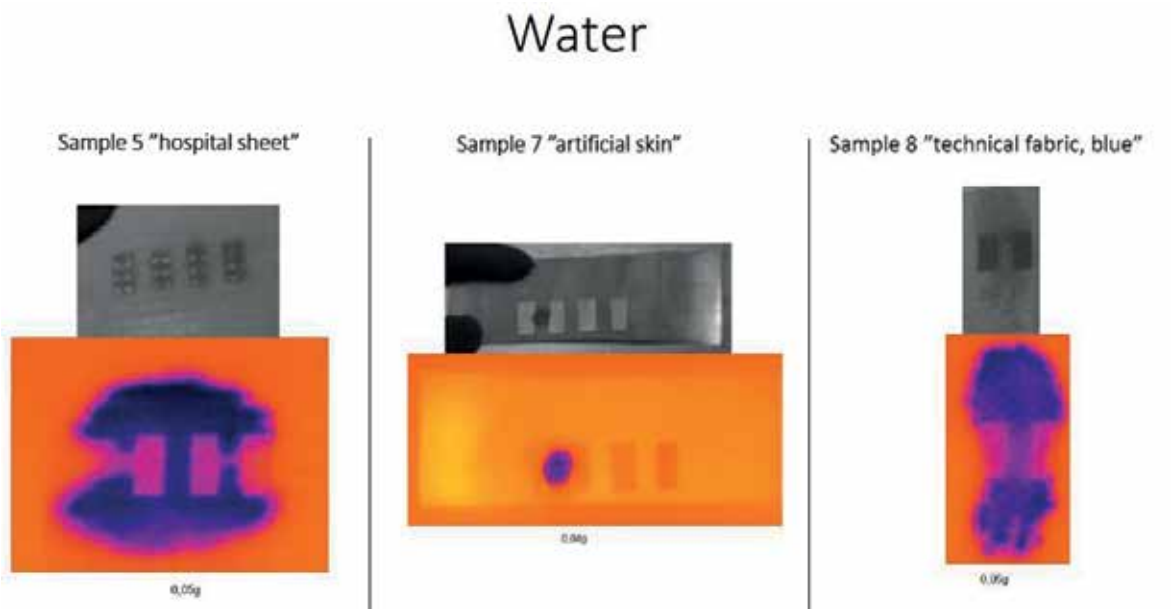

Figure 1. Examples of NIR images (B/W) and IR images (colourful) of different moistened materials. The darker the NIR image is the moister the material is. The darker the IR image is the moister the material is as the moist leads the energy and heat more effectively.

The second test was conducted using the same fabrics and material but with different moistening liquids. This time moistening was done with 0.3% saline demonstrating sweat and with 5% sugar solution as a reference for the resistance measuring. All the same fabrics and materials were again NIR and IR imaged as dry and then three minutes after moistening with three drops of saline or sugar solution. Same tests were also conducted as fabrics and materials were moistened with both saline and sugar solution. The moisture and its spreading could easily be seen with both NIR and IR imaging. Water, saline or sugar solution did not make any difference in moisture detection. In other words if the material is moistened with same amount of water, saline or sugar solution the moisture detection with NIR or IR imaging gives roughly the same result (Figure 2).

Figure 2. NIR and IR images of materials moistened with saline and sugar solution together.

The third test was to find out if and how clearly the moisture percentage can be detected. The materials were entirely soaked and the moisture percentage was calculated according to the weight difference. Wet materials were NIR and IR imaged. Then the materials were squeezed a bit and the moisture percentages were again defined by the scales and the differences were NIR and IR imaged. The drying squeeze and NIR and IR imaging was made once again. These tests demonstrated that also the moisture percentage can be defined with NIR and IR imaging. In this case NIR imaging was found to be more accurate (Figure 3).

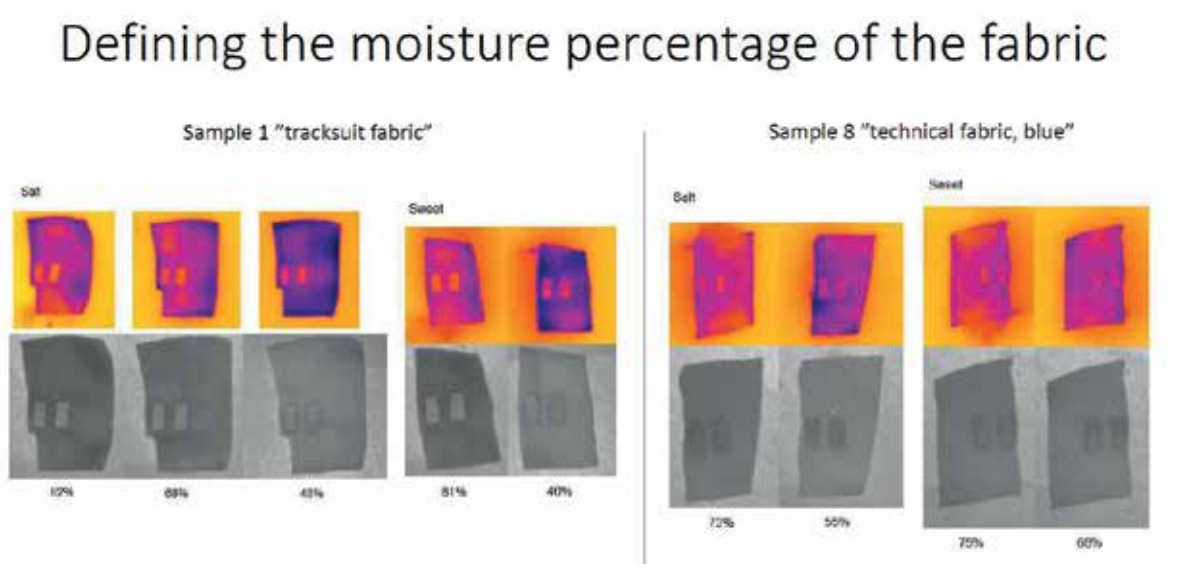

Figure 3. Example results of defining the moisture percentage of the fabrics.

Sensing perspiration

The main goal of **NIR and IR imaging** was to find out if these imaging technologies could be used in sensing perspiration. The experiments were performed with NIR imaging and thermal imaging during cycling exercises in SAMK. The cyclist was cycling and the different perspiration levels were imaged with NIR and IR cameras (Figure 4).

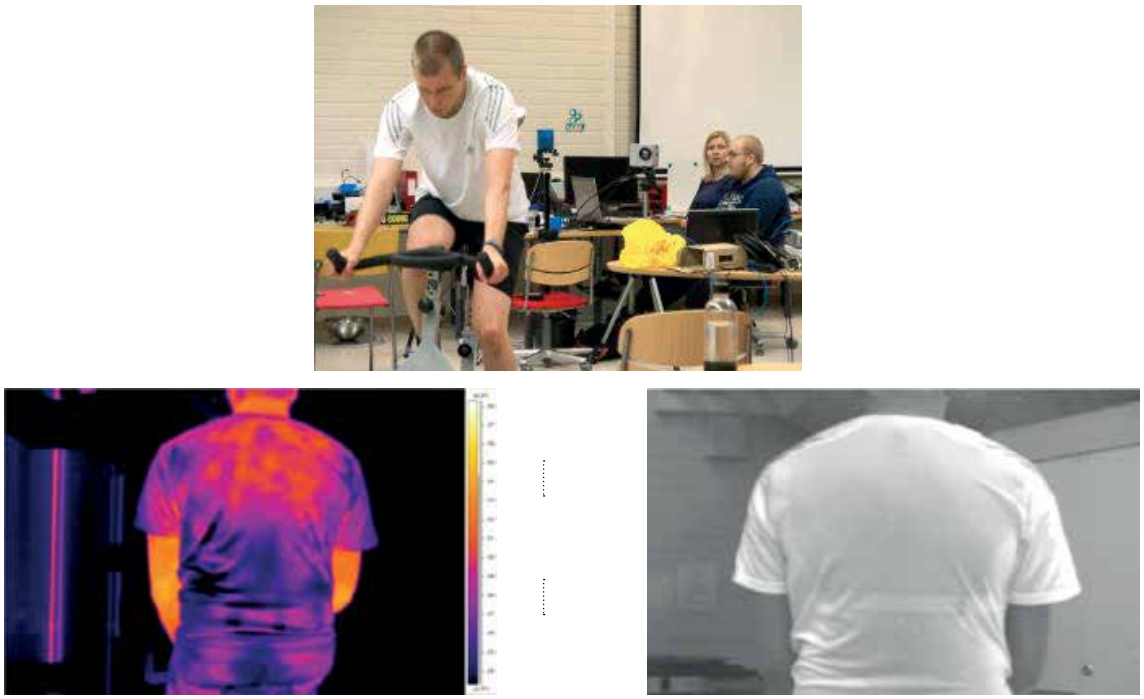

Figure 4. Cycling experiment (upper figure) with results measured by IR- (lower left) and NIR- (lower right) imaging.

The tests were conducted in two-minute cycles. The first imaging was done after 5 minutes and in two-minute sequences. After each cycling session, the back of the cyclist was imaged through his shirt. The more the cyclist was sweating the warmer the shirt was seen in IR image and respectively the darker the NIR image was seen. The experiment took 41 minutes altogether.

The main conclusion of this experiment was that it is possible to distinguish different sweating levels through a person's clothing with long wave infrared and near infrared machine vision technologies. At the moment it requires expensive cameras and very complex analysing though.

First test related to **use of NFC sensor tag** for measuring perspiration were done to evaluate the resistance (order of magnitude) of the sample sensing elements made of selected wearable materials (test from WP2) after applying real sweat on them (Darwish & Hassanien 2011; Kim 2009). The aim was to give more information about the resistance which is then to be measured with the NFC read-out electronics. More sophisticated sensor patterns were then designed by MIUN and produced in SAMK. 5 different kinds of sensor patterns were printed on 7 different materials (Figure 5). The printing was made in three layers and the patterns were dried in room temperature overnight. The samples were used as part of the NFC-sensor tag (by SAMK and MIUN).

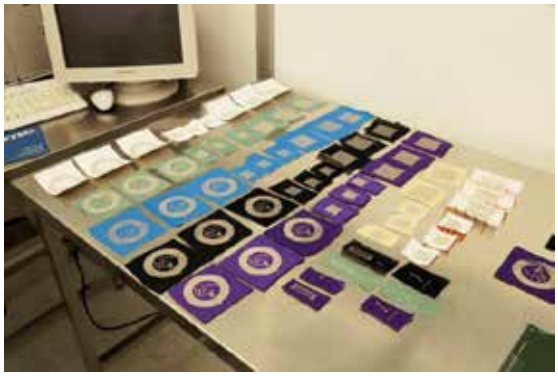

Figure 5. Printed NFC sensor patterns on different materials from the left stretchable PVC, disposable surgical drape, ”technical fabric, blue”, ”technical fabric, black”, tracksuit fabric, hydrocolloid dressing (”artificial skin”) and adhesive bandage.

For measuring perspiration, the NFC sensors were first evaluated with 250 mm long fabrics with metallic wires sewed into them in a parallel manner to be used as distributed resistive sensor elements. This setup with sewed metallic wires was used before evaluating fabrics that had received prints of conductive ink as it is much more robust and thus limits the number of unknown errors and can be used for comparative purposes. The conductive ribbon was taped vertically on the central upper back on a person sitting on an exercise bike where electrical resistance was measured both through an NFC tag and a verifying Ohm-meter. Starting from a value in the order of 500 kΩ for a “cold” person the resistance quickly went down to a few kΩ when the person had cycled relatively hard for 5 minutes. The resistance continued to decrease as the exercise continued and after 25 minutes of biking exercise it was observed that the resistance had not changed significantly during the last minutes and the measurement setup was thus deemed to be saturated at about 600 Ohm.

For verification of the saturation, the sensor strip was removed and subsequently rubbed and pressed against the person's forehead, bearing a significant amount of sweat. The now very sweaty fabric measured a resistance of 270 Ω.

In a comparison to normal tap water, a 250 mm long conductive fabric was pressed towards a wet towel where saturation was reach at about 2.5 kΩ, about ten times higher than the corresponding value with perspiration. When later immersed into a glass of water the resistance was about 2kΩ. As a final comparison between perspiration and water, the sensor provided a resistance of 30 Ohm when immersed into 37°C water saturated with sodium chloride (NaCl).

Based on the above observations, perspiration is obviously much more conductive than water, and it is concluded that this kind of setup could indeed be used for indicating the amount of sweat on a person's body.

Tests were subsequently performed to measure respectively water, salt water and perspiration by evaluating the resistance of the more sophisticated sensor patterns that were designed by MIUN and produced at SAMK in the work package 2 (WP2). These sensing elements made of six different selected wearable materials of different kinds of fabrics, plaster material, artificial skin and similar and had received screen-printed inter-digital patterns with conductive ink. The interdigital pattern proved have sensitivity to moist, roughly, in the same order as the first evaluated strips with sewed metallic wires as parallel conductors. That is, starting above 10 kΩ for lower amounts of pure H2O moist and decreasing to below 1 kΩ for a higher degree of perspiration. Most of the evaluated materials had problems in either not providing continuous conductive paths (breaks in the) or short-circuits (artificial skin) and not letting moist through the material but need the conductive pattern to be pressed against the skin. A few of the material however provided very good results (like the disposable surgical drape) that was thus mainly used in the evaluation and provided a sheet resistance of the printed conductors of < 100 mΩ/square.

The values read by respectively the ohm-meter and the NFC-tag only differed marginally why it is also verified that a low-cost tag can be used to provide sensor data by holding a smart phone towards the tag.

Even though this measurement setup proved to work relatively well for detecting the level perspiration, the NFC readout would probably be more accurate if the now very large dynamic range was decreased to only cover for example 30Ω to 3kΩ instead of up to the order of MΩ.

SAMK has also performed tests for textile UHF RFID tags which are not originally meant for sensing purposes. The effect of sweat on the functioning of screen printed and conductive fabric UHF RFID tags were analysed in experiments. The two tag types were: type 1: tag antennas manufactured from silver plated stretchable fabric made of nylon (76%) and elastic fibres (24%) (the commercial elastic fibre fabric has low surface resistivity: less than 0.5 Ω/sq (upstretched); type 2: tags manufactured in SAMK by screen printing polymer thick film (PTF) silver ink on stretchable fabric substrate. After printing, the samples were cured at 120 °C for 15 minutes.

The transmitted threshold power ("wake-up power") of the tags was measured before and after real human sweat was applied on the samples. The screen printed tags were more severely affected by sweat than conductive fabric tags (which also means more suitable for sensing). The main reason for different behaviour is believed to be impedance matching which is differently affected. In conductive fabric tags the sweat is absorbed only in the conductive antenna pattern whereas in screen printed tags there is fabric in the t-match structure in the middle of the antenna as well as under the conductive antenna pattern in which the sweat also absorbs and thus affects the impedance matching due to changed material parameters in that part of the fabric (power reflection coefficient is affected). Also the radiation efficiency may change due to sweat inside the fabric substrate of screen printed tags (dielectric losses increase). The spreading of sweat has an effect on how much the response is affected. In conductive fabric antennas the sweat can only affect the conductivity of the fabric. Sweat seams to slightly lower the threshold power of the fabric tag (radiation efficiency may be improved due to smaller conductor losses). At least we can conclude sweat not to make the performance worse.

Also the read range of the tags was measured. Even in the worst case, the tags were remotely readable (>2m measurement distance).

As a conclusion, this kind of textile tags (especially screen printed tags) could be used in theory for sensing perspiration. Significant benefit of using this method is that there is no need for any specific read-out electronic (just standard RFID reader) and the tags can be wirelessly measured. There is still a lot of work to be done since at this point the measurement results are not very accurate and we can only tell whether there is sweat or not. Especially calibration of this kind of measurement method needs extra attention.

The Twin Tag UHF RFID tags mentioned in WP2 was also tried with real sweat in a comparison to water. Comparing the absorbing paper above a tag receiving 0.44 gram (10 "drops") of H2O to receiving 0.29 gram of sweat showed that the tag needed 2.5 dB more wake-up

power for the perspiration than for the slightly higher amount of H2O. The corresponding backscatter power showed a difference of 1 dB. Thus it is shown that the setup is more sensitive for perspiration than for pure water, which can be attributed to the fact that sweat contains more salt, making it more lossy dielectric than water.

Just as with the evaluated conductive fabrics, to be used on a person (not done in these experiments) the tag's sensor material must be placed so that perspiration is allowed to enter the material. Another potential difficulty is that the RFID tags' antennas must be close to the body, where radio the UHF radio waves will also be affected by the high level of liquids found in the body, just under the skin.

The overall evaluated sensitivity and readout methods for respectively the NFC and UHF setups in these experiments tells that there was not that high difference between water and perspiration with the UHF method as with NFC resistive measurement.

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4.2 Tackling the challenges of well-being with machine vision

Mirka Leino, Pauli Valo, Joonas Kortelainen & Kari Laine

Machine vision technologies have developed hugely in the past ten years. Most of the applications and therefore most of the research have been headed for industrial use. These days, prices of cameras and other items have decreased making machine vision applications much easier to employ in everyday use. Machine vision has many advantages when compared to traditional methods of diagnostics or physical therapy. Machine vision is non-invasive technology where you don't need any needles for instance. By machine vision it is possible to image wide areas simultaneously making the procedures quick and repeatable even if missed precisely correct points. Machine vision can be used to monitor health and well-being, like physical and physiological changes in a human body. Because of the industrial base of the applications, new innovative adaptations are needed to make them applicable for enhancing well-being.

Satakunta University of Applied Sciences (SAMK) has focused on machine vision research nearly for 20 years. At first the research was mainly executed for industrial purposes while the past eight years different kinds of applications for diagnostics and welfare have become more and more desired. Both automation technology and well-being enhancing research groups at SAMK are very interested in machine vision applications and many joint research projects have been made.

1. Special machine vision technologies

In this article, the deeper attention is paid in describing various special machine vision technologies, such as 3D imaging, IR imaging and spectral imaging. The potentials of machine vision in well-being enhancement are discussed in the later part of the article.

1a. 3D Imaging

With 3D imaging we mean those technologies that form 3D models of real items with different kind of imaging techniques. 3D imaging has developed a lot over the past few years. This chapter introduces several techniques available to do 3D imaging.

Laser scanning is imaging technique where laser line moves on the target or the target moves under a laser line. At the same time the camera images the different shapes of the laser line as the line shape changes according to the target (Figure 1). (Batchelor 2012a.)

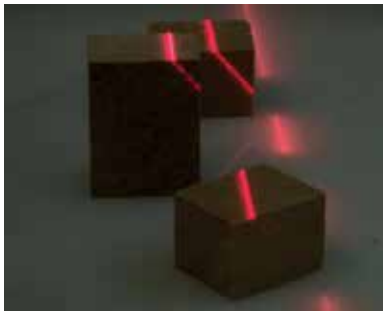

Figure 1. 3D imaging with laser scanning

Stereo imaging uses two or more cameras which image the same target from a bit different angles. The 3D image is created by combining the images taken from different angles. (Marshall 1994.)

Kinect based imaging is a technology that has been developed for Microsoft Xbox game console. The Kinect camera actually consists of two separate cameras; the traditional type of camera taking images in visible light wave length and the other imaging in near infrared wave lengths. At the same time, the near infrared dot pattern is reflected to the target and the near infrared camera sees the changes of the dot pattern. Target point distances can be calculated based on this information. (Kortelainen et al 2013.)

In **fringe imaging**, the target is illuminated with different lighting patterns. Based on the changes of the lighting pattern, the shape of the target items can be detected. An example of the lighting pattern is presented in figure 2. Figure 3 on the other hand presents a 3D model of a human face made with fringe based imaging system. (Batchelor 2012a.)

Time of flight technology is based on measuring the time-of-flight of a light signal between camera and the subject for each point of the image, or measuring light phase shift between the transmitted and received light. (Kortelainen et al 2013.)

Figure 2. Fringe lighting pattern on the target.

Figure 3. 3D model of a human made with fringe based scanning imaging system.

3D imaging technologies have mainly been developed for industrial use but are also applicable in games, like Kinect technology used in Xbox game console. Commercial applications of these technologies are reasonably inexpensive and therefore more applicable in health and well-being sectors, too.

1b. InfraRed (IR) Imaging

Various special machine vision systems are focus areas in SAMK machine vision research. One of those systems is infrared imaging. The research concentrates in longwave infrared imaging also known as thermal imaging, and in near infrared (NIR) imaging. Thermal imaging is traditionally used in finding hot or cold spots in processes or items. Thermal imaging in SAMK research has been used especially in automated quality control, in heating process optimisations, search and examination of welding or casting faults (Figure 4), and in identifying contact resistance in electrical connections (Figure 5). Near infrared imaging again has been used mainly in moisture detection and seeing through some material invisible to the naked eye like kerosene based liquids (Figure 6).

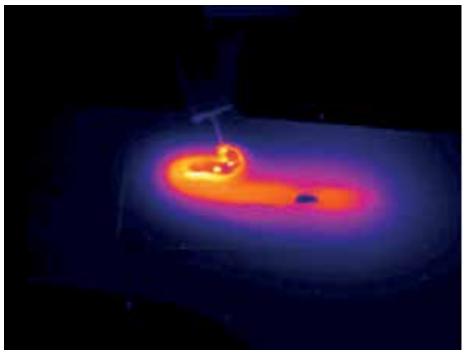

Figure 4. Faults in welding seen with thermal imaging.

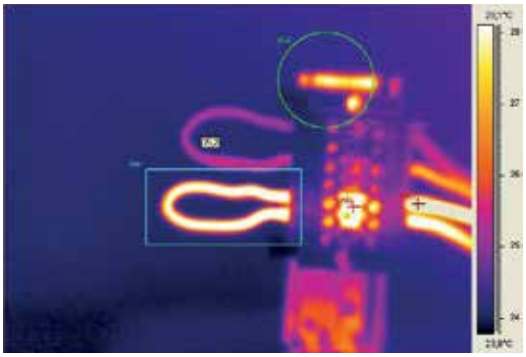

Figure 5. Identifying contact resistance in electrical connections with thermal imaging.

Figure 6. Near infrared imaging used in moisture detection and in seeing through kerosene based liquid.

1c. Near Infrared Spectral Imaging

Another special machine vision technology researched and applied at SAMK is near infrared spectral (NIRS) imaging, which is an innovative combination of spectroscopy, machine vision and signal processing. With near infrared spectral imaging, the spectrum of the material in certain point of an object can be detected from every pixel of the image. In visible light wavelengths the spectrum tells the real colour of the target object but in the near infrared wavelengths the spectrum is comparable to a finger print identifying exactly the material concerned. The spectrum identifies and visualises each distinguished material the target contains, which is why it is useful in identification and sorting of substances. An example of plastic identification is presented in figure 7. (De la Ossaa et al 2014)

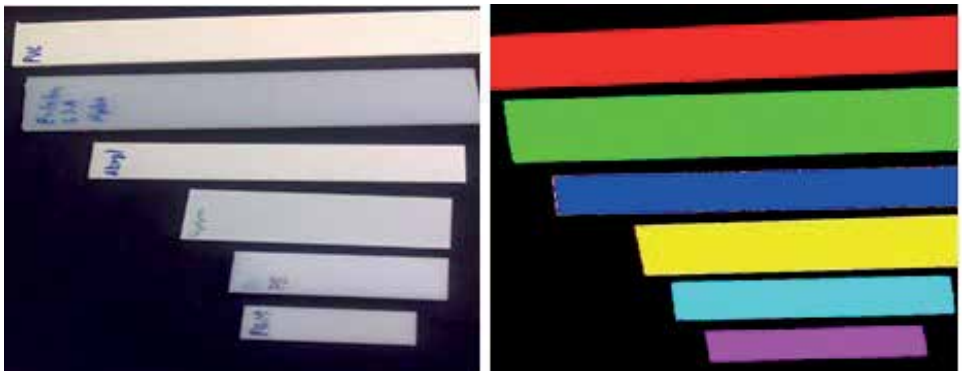

Figure 7. Plastics identified with near infrared imaging

2. Potential of machine vision technologies for enhancing well-being

In this chapter, a couple of machine vision applications are introduced as deployed in well-being enhancing technology development at SAMK. Machine vision is fairly novel technology in the field of health and well-being and therefore commercially usable applications still require a lot of fine-tuning and refining.

2a. Kinect based imaging in enhancing well-being

Cheap Kinect camera for Xbox 360 is designed for game playing but can also be used as personal trainer. Microsoft released the SDK for application developers offering a chance to prepare personalised application software. Kinect could be taught to give instructions based on observing the movements while exercising. Useful and personalised instructions to exercise correctly are seen motivating to increase physical exercise.

Another example of SAMK RDI-laboratory-based 3D imaging applications made for enhancing well-being is a Kinect-based human user interface. With this application the user may save personal movements to be used in particular functions like switching on or off the electrical devices at home. By lifting right arm the lights switch on, and by lifting left arm the light goes off again, giving an example (Figure 8). This human user interface is usable as assistive technology or as motivator in physical exercise. To teach the Kinect application new movements is very easy. In addition, the additional control electronics with interfaces to control intended systems are easy to install.

Figure 8. Kinect application recognises the user lifting his left arm and turns the lights off.

2b. Infrared imaging in welfare technology applications

In SAMK research, the selected special infrared imaging technologies as mentioned earlier have also been used in welfare technology applications. Near infrared imaging is applied and studied in perspiration detection, and thermal imaging in detecting muscle temperature.

Figure 9 presents findings of another very interesting study, where different cold therapy methods were tested and their effects in muscles were examined by thermal imaging. Three students used one cooling method each applied on the calves of their left legs. First student was using cold gel, the second one cold spray, and the third one used cold pack. Right side calves were imaged as the control reference.

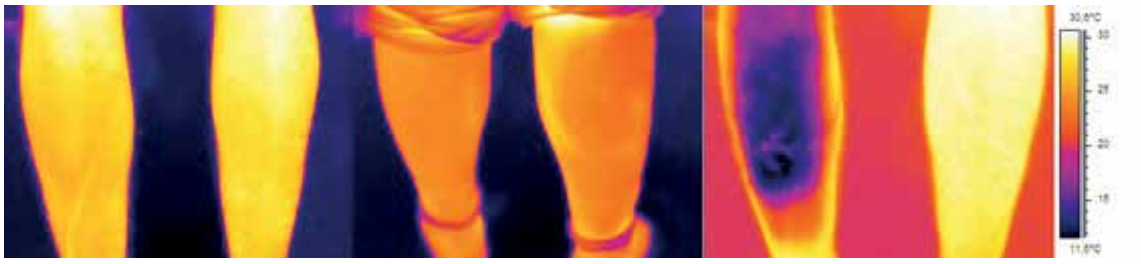

Figure 9. Three different pairs of calves where each left calf cooled down with a different muscle cooling method. From the left: cold gel; cold spray; cold pack.

The effects of various cooling methods can be seen very clearly through thermal imaging (Figure 9). The legs were imaged 15 minutes after the cooling method was applied. The

findings indicate that cold gel and the cold spray had no cooling effects at all. Only the temperature in the calf handled with a cold pack had cooled down measurably, even if in all cases the persons felt cooling sensations in their calves. To explain the sensed effects, gel and spray only irritated nerve sensors on the skin to send messages to the brain that the muscle is cooling down. This study only confirmed the measurable temperature affects to the muscle tissue without detecting any other possible physiological tissue reactions that could not be measured by imaging.

2c. Near Infrared Spectral Imaging (NIRS) in diagnostics

The usability of near infrared spectral imaging (NIRS) in diagnostics has also been researched at SAMK. The blood flow changes detected in inflamed tissues or skin grafts were researched through NIRS imaging. Figure 10 presents how severely inflamed tissues are seen on a person's left hand. Similar inflamed parts as a blood flow change are seen red in spectral image on the right hand where only some bruise could be detected by naked eyes.

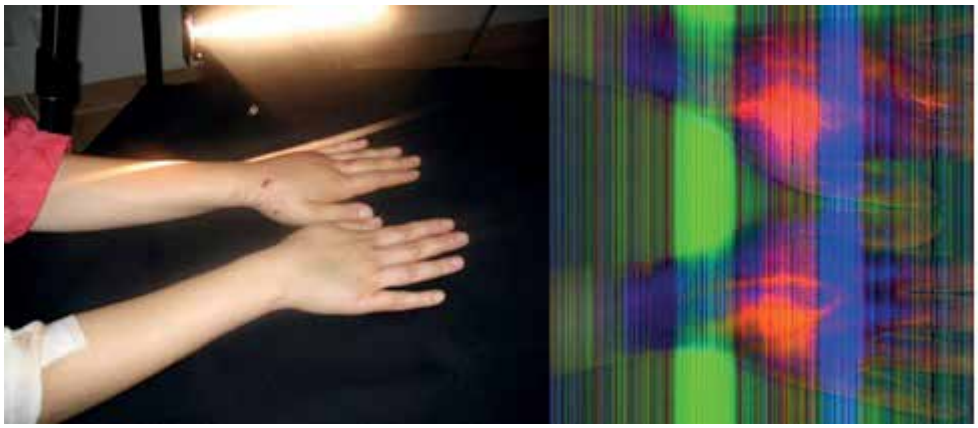

Figure 10. Septic hand (left hand) and a beginning bruise in the right hand seen with NIR spectral imaging.

Figure 11 presents a skin graft. The green colour in NIR spectral image represents deteriorated blood flow and blue normal blood flow. Analysed by near infrared spectral image these qualifications indicate that one part of the skin graft is healed better than other.

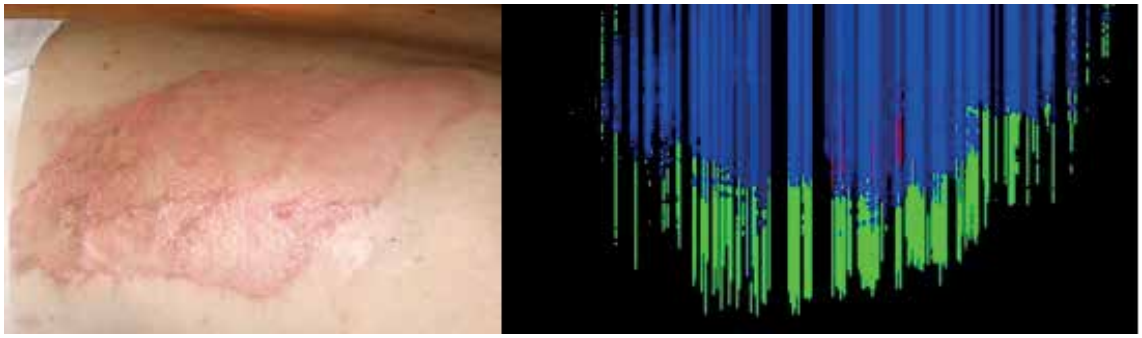

Figure 11. Skin graft in nature and in NIR

Conclusions

Base on the research findings and demonstrations presented in this article, the Well-being Enhancing Technologies research group (WET) at Satakunta University of Applied Sciences would state that machine vision technologies designed for industrial or game technology use can be configured also for other purposes, like enhancing well-being. Instead of asking which actions can we automate, the question should be: what kind of actions do we want to automate?

However, further research is needed in many areas, like:

- How could machine vision be used in recognising human body movements?
- Refining new 3D imaging technologies that offer a huge range of possibilities to recognise human body movements and thereby controlling different devices.
- How could thermal imaging and near infrared imaging be used in observing human body reactions.

To develop and apply novel technologies requires multidisciplinary research and collaboration. SAMK tends to be one significant party in building up methods, systems and teams for this kind of collaboration and innovation.

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5 Master degree programme on welfare technology – part of RDI activities at SAMK

5.1 Master degree programme as part of research and innovation activities at SAMK

Andrew Sirkka

Universities of applied sciences (UAS) are part of the Finnish innovation system alongside with science universities, ministries and industry (Tieteellisten seurain valtuuskunta 2012-2014). The future scenario is that universities (including UAS), research institutes and companies create effective efficient business models and incentive nozzles for sealing cooperation in order to improve utilisation of research results to support new structures, procedures and mechanisms (Ministry of Education and Culture 2014). Especially service-oriented technologies and management have gained attention in the past few years, promising a way to create the basis for agility for companies and organisations to deliver new, more flexible business processes that harness the value of the services approach from a customer's perspective (Demirkan et al. 2008; Ministry of Employment and the Economy 2015).

Satakunta University of Applied Sciences (SAMK) has been running a master degree programme on Welfare Technology since 2000. The programme started in close relation with The Satakunta Macropilot Project (1999–2001) testing the regional application of information technology (IT) in social welfare and health care. The project aimed at supporting a seamless linking of services by various providers to respond optimally to client needs. The project was a part of a wider welfare cluster collaboration implementing the IT strategy of the Ministry of Social Affairs and Health in Finland. (Ohtonen 2002.)

Since the year 2000, the programme has developed in terms of contents, approaches and orientations towards serving wider public interested in expediting amalgamation of services and technologies benefitting the customers and professionals in health and care sectors. In 2014 the programme curriculum is constructed upon the following pillar themes: smart technology, accessibility and user-centeredness, leadership and management, and research and development methodology.

International aspects are highly appreciated and much implemented all over the programme. International experts have an important role in teaching which is why the studies are partly done in English. Another concrete international content is the annually organised UAS Master Symposium for public where master students present there master thesis and other working life linked development projects. The international approach intensified alongside with the membership in the Consortium of European Master Care & Technology coordinated by Zuyd Hogeschool in the Netherlands. The Consortium aims at launching out the first European master degree programme on Care & Technology in September 2015. (Sirkka 2013.)

As to the Welfare Technology master degree programme at SAMK, like in most of so called Polytechnic master programmes (ylempi AMK) in Finland, the students are supported to closely collaborate with their background working life connections in terms of their master thesis projects. However, the programme pillar themes are strongly steering the contents in the development projects or research done. Therefore master theses are intensely linked to the needs and structure of the regional development meaning that polytechnics develop innovative products, services and methods to meet the needs of their regions. (Ministry of Education and Culture 2015.)

The students of Welfare Technology master degree programme at SAMK have performed a good number of research and development as master thesis projects in collaboration with working life partners in the regions of Western and South-Western Finland. The themes cover a wide range of services and technologies from innovations in the fields of education and safety, research on social and physical accessibility issues to innovations in assistive, telehealth and mobile technologies applicable in numerous services related to populations' health and well-being (Table 1). The master theses are published in the national Theseus data base (http://theseus.fi/handle/10024/154).

Table 1. The most recent Master Theses published in Theseus data base

AUTHOR; YEAR	TITLE IN FINNISH	TITLE IN ENGLISH
Pajula, Matti 2014	Fyysisen esteettömyyden kartoitus Tampereen seudun ammattiopiston Koivistontien toimipisteessä	The assessment of physical accessibility in Tampere vocational college´s Koivistontie unit
Vuori-Viitala, Sari 2014	Tekniset ja sosiaaliset ratkaisut kotihoidon piirissä olevien vanhusten yksinäisyyteen	Technical and social solutions for senior people who live alone and are assisted by home care
Piitulainen, Sanna 2014	”Mä olen semmonen kun mä nyt oon. Ihan ihminen siinä kun sinä ja muutkin.” Sosiaalinen esteettömyys kehitys-vammaisen kansalaisen kokemana	”I am what I am. A human being like you nd the rest of us.” Social accessibility as a experienced by adults with mental disabilities
Liukkonen, Jussi 2014	Kodinautomaatiolla turvallisuutta ikääntyvälle ja muistisairaalle	More Safety with Home Automation for Elder and Person with Memory Disease
Virtanen-Ylinen, Tuija 2014	Kehitysvammaisten palvelusäätiö – tekniikka tulevaisuuden palvelu-asumisessa	The Service Foundation for People with an Intellectual Disability Technology in Service Housing of the Future
Vina, Saku 2014	Läsnätyön mahdollistavat tekniikat Turun ammattikorkeakoulussa	Mobile Work Enabling Technologies in Turku University of Applied Sciences
Pakkanen, Terhi 2014	”Pieniä jokapäiväisiä asioita” – Kuntouttava työote päivystyspoliklinikalla hoitohenkilökunnan kokemana	”Small, Daily Things” – The Methods of Rehabilitative Working Approach in Acute and Emergency Nursing
Uusitalo, Tuomas 2014	Kehittämisehdotus Satakunnan sairaanhoitopiirin hoitotason ensihoito-henkilöstön täydennyskoulutuksesta	A Motion for Developing Further Education on Advanced Level Pre-Hospital Emergency Care in Satakunta Hospital District
Hautaviita, Hanna 2014	Telehealth-laitteiden käytettävyys ikäihmisten arjessa	Usability of the Telehealth Equipment in the Old People’s Daily Life
Rantanen, Ritva 2014	Sosiaalinen esteettömyys alakoulu-ikäisten lasten näkökulmasta – verkko-opetuspaketin kehittäminen kaikille.fi-sivustolle	Social Accessibility from the Point of View of Primary School Children – Developing a Learning Environment for Kaikille.fi Webpages
Lensu, Päivi 2013	Hyvinvointiteknologian pilottikokemusten hyödyntäminen vanhuspalveluiden toiminnassa	Utilisation of Technology in the Elderly Care
Forsten, Maire 2013	Muistihäiriöiden varhaisen tunnista-misen kehittäminen	Development Needs in Early Identification of Memory Disorders
Klemetti-Talvinen, Outi 2013	Aikuiskouluttajan arjen esteettömyys ja siihen liittyvä hiljainen tietämys	Accessibility, Obstacle - Free Working and Related Tacit Knowledge in Adult Educator’s Work
Viitakoski, Elias 2013	Triageapuvälineen kehittäminen päivystyspoliklinikalle	Development of an Electronic Triage Tool For Acute and Emergency Department
Leppäniemi, Antti 2013	Minilennokkien käytön perusteita viranomaistehtävissä sekä Orbiter 2B-järjestelmän esittely	Mini-UAS Use Criteria for Authority Missions and Orbiter II B -MUAS Introduction
Saarinen, Heino 2013	Esteettömyys ammattiopinnoissa	Accessibility In Vocational Studies
Niemi, Ahti 2013	(Connecting Ageing People)	Connecting Ageing People

In SAMK, welfare technology master degree programme has been developed towards more international education. The consortium of European Master Care & Technology (M-CT) has partners from the Netherlands (Zuyd, Fontys and Saxion), Finland (SAMK and TAMK), Austria (Johannes Keppler Univerity; JKU) and Portugal (Universidade de Beira Interior; UBI) covering a broad area of expertise and facilities in the care and technology domains. Students will visit all these facilities during the curriculum. Zuyd University of Applied Sciences is chosen as the secretariat for this program.

Essential to the optimal interaction between care and technology is the availability of professionals – with a background in either technology or care domain – who are able to build the bridge between these domains. By developing an educational environment in which students work and learn together, conditions are created to build a professional network that will allow for future cooperation and knowledge exchange as well. Principles of distant education with joint degree possibilities by a European consortium are used to reach this goal. Based on the ambition and vision to realise innovations at the intersection of care and technology, an independent market study was performed in the Netherlands for the purpose of backing up the macro-functionality of the education.

The major conclusions of this report indicate a (very) positive attitude towards the European M-CT master. The conditions under which the master programme is organised (international aspect, 2 years study length and cost involved) are acceptable once a fitting rate of return is presented. The start of the programme is planned in September 2015. (Sirkka 2014; Willems 2014.)

5.2 Exploring well-being enhancement in age friendly cities in Louth, Ireland

Yrjö Löytömäki, Toni Marila, Meri Olenius, Tommi Lehtinen & Andrew Sirkka

World Health Organisation (WHO) generated criteria for age-friendly cities in collaboration with aged persons and professionals representing 33 cities in 2007. An age-friendly city promotes active aging by optimising possibilities to sustain health, participate and contribute as well as live in safe environment. Age-friendly cities are expected to adopt the infrastructure and services acceptable at optimum level for the aged population. (WHO 2007.)

WHO (2007) lists up areas that are of crucial importance in implementation of age-friendly city criteria: 1) Outdoor Spaces and Public Buildings, 2) Transportation, 3) Housing, 4) Respect and Social Inclusion, 5) Social Participation, 6) Communication and Information, 7) Civic Participation and Employment, and 8) Community Support and Health Services. The list is based on the evidence regarding the aspects and challenges due to the increase of aged population and urbanization. This WHO project has provided the impetus for myriad local actions aimed at improving the age-friendliness of cities around the world. These actions were based on suggestions made by older citizens themselves and those who provide services and support to them. The project exemplifies a model for highlighting a critical issue, the aging of the world's cities, and pointing to specific steps that business, agencies, healthcare and social service providers, urban planners, and policy makers can take to make cities better places for people of all ages and abilities. (Neal and DeLaTorre 2009; Kennedy 2010.)

County of Louth in Ireland is actively participating in Age-Friendly Initiative. The aim of the Louth Age Friendly County is to make the county with all agencies working together to promote and maintain best possible health and well-being of older people, and to make the County itself a great place to grow old. The aged population with their special needs are put in the centre of all development of the region including the service attitude and atmosphere in business life (Kennedy 2010; Louth Age Friendly County 2015). Research on aging and WHO strategy for age-friendly society have played a huge role in changing attitudes towards aging and the aged population in past decade (O'Hanlon & Brookover 2002; McGee et al. 2008).

Drogheda & District Support 4 Older People (DDS4OP) proves that the aged can be a resource

A group of three researchers and four students of welfare technology master degree programme at SAMK visited Drogheda & District Support 4 Older People (DDS4OP) in November 2014. DDS4OP plays an active role in Louth Age Friendly County Initiative in supporting older population in Drogheda district. Right when entering the facilities, our delegation was embraced with warm welcome by quite a number of active, enthusiastic and resourceful older people willing to share their visions and experiences of this voluntary organisation. Far too often the European politicians tend to speak about aging population as a problem, challenge or burden. They should visit DDS4OP and see what a priceless resource aged people are in the society.

Motivated, committed and skilled volunteers are running a good variety of social activities and much needed assisting services from computer and language classes to free calling service and listing trusted traders available for care & repairs. “Unbelievable, fabulous, inspiring” and “this is what we need all over Europe” were constantly aired expressions of the delegation during the 2-hour visit in the organisation. Why is this not done everywhere?

Figure 1. Director Dave Turner in front of the DDS4OP headquarters in Hay Market, Drogheda

Perhaps the most innovative of their services is called “Good Morning Drogheda” which is aimed largely at older people living alone. Via this service clients can receive regular phone calls to check that everything is OK, or simply for a bit of human contact to offset feelings of isolation and vulnerability. Clients can choose the frequency and time of the calls.

Confidential notes are taken so that the operator can get to know the client and be able to offer assistance and gentle reminders about doctor's appointments etc.

Figure 2. Meeting with DDS4OP staff

Another service that is proving popular is a care and repair service which involves volunteers, mostly retired men but also a couple of ladies, carrying out repairs and other jobs such as, cutting grass, installing handrails, decorating. If a job is too big for them the DDS4OP has a list of trusted traders they can call on.

Senior citizens are keen to learn the skills of the internet age. DDS4OP's popular computer lessons are given on a one to one basis to provide older people with the skills to access information online, like send emails, to use skype, use internet banking services.

It was indeed inspiring to hear the feedback and results of DDS4OP services assisting and supporting hundreds of older people in their daily lives in the district. What an asset for the local authority to pay attention to! How happy one would be to see the tax money channelled to fund that kind of organisations serving their community with such a high quality, warmth and commitment. Instead of worrying about money this kind of organisation should have guaranteed regular income. Instead of feeding bureaucracy, voluntary organisations use every penny right to its ultimate purpose – to support those in need.

No doubt DDS4OP is one of those organisations that should be awarded as a good example of older people being an asset and resource in the society.

Visiting the Great Northern Haven, Dundalk

The Netwell Centre is developing novel ideas to enhance the quality of life and well-being of older people and those who care for them, through more integrated community-oriented services, more sustainable home and neighbourhood design, and more age-friendly technologies. Various research and development projects produce important knowledge that is crucial in further development of assisted living technologies to commercial products. The Great Northern Haven is one of the Netwell Centre's awarded projects. (Netwell Centre 2013.)

The Great Northern Haven is a compound of 16 high-tech apartments designed for the aged. Each apartment is equipped with a hundred various types of sensors providing data about activities in the apartment. This data is used for research purposes on the tenant's consent. Apart of sensors, the apartments are equipped with technology that assists the tenants to control the doors, windows, curtains etc. by remote control.

Figure 3. The Great Northern Haven in Dundalk

The data gathered from the apartments enable assistive services. The long-term data profiles the tenants' normal activities. Whenever some exceptions occur, the changes could be seen and assistive service agents could contact the person(s) to check-up the situation. In case of doors or windows left open unintendedly, the sensors launch an alarm to catch the tenants' or care givers' attention.

Figure 4. Various technologies installed in the apartments at the Great Northern Haven

The study visit offered a great vantage point to attain new insights into care and technology applications and even wider in different cultural and professional aspects related to individual and societal challenges in Europe. To see concrete examples of WHO's Age Friendly City/ County projects was an eye opening possibility. Comprehension of the importance of user-friendliness not only in care & technology applications but also wider in the society gave a lot to think and boosted the students' professional growth.

In order to provide wider vantage point to observe ongoing projects, the study visit was scheduled to coincide with the "GaMeR" memory rehabilitation trial at The Birches Alzheimer Care centre in Dundalk. In addition, students participated in expert evaluation seminars of highly innovative serious games projects that were developed by the final year degree students (B.Sc. Hons) in Computing and Game Development at DkIT. Game development projects have been part of WET research group collaboration at SAMK.

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