Partners:

Join-In

Senior Citizens Overcoming Barriers by Joining Fun Activities

AAL Joint Programme: Project No. 031121

Deliverable: 5.1 - Public version

Requirements and State of the Art in Exergames for the Elderly, Low-Cost Motion Tracking and Respective HCI for Elderly

Date of deliverable: 30-11-11 / Version: 1

Lead contractor for this deliverable:
NST

Contributors:
NST, Norut, ITC, PAS, DMM, HMGU

Dissemination Level:
Public

Project Duration: Nov. 2010 – Feb.2014

Project co-founded by

SPONSORED BY THE Federal Ministry of Education and Research

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Join-In Project Report D<Nr> <Title>, <Year>. Retrieved <The date on which you retrieved the information> from <URL>.

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About Join-In

Join-In aims at providing the methodology and the technologies for elderly persons to participate in social activities and have fun via digital media.

Loneliness in the elderly is a major problem in elderly care. Studies in Britain show that more than half of the people over the age of 75 live by themselves. Many of these suffer from loneliness and social isolation[1]. Activities offered by social services do, however, often not reach those most in need. Challenges for the elderly include: social deprivation, low self-esteem or physical inability. Social isolation and health are closely related and may lead to a variety of physical disorders and even depression. Studies have shown the correlation between loneliness and poor health. Especially the effects on immune system, the cardiovascular system and the onset of Alzheimer's disease could be shown[2][3][4].

The Join-In project aims at counteracting loneliness in the elderly by providing a concept, the methodology and technologies for elderly persons to participate in social activities.

Fig.1 Join-In Platform

[1] Office of National Statistics: Older people,. Living arrangements. At: http://www.statistics.gov.uk/cci/nugget.asp?id=1264

[2] CARMA – Care for the Aged at Risk of Marginalization (QLK6-CT-2002-03421) - Recommendations and Guidelines to Policy Makers. (2005). http://www.egga.ee/RecommendationsFinalwCoverTOC.pdf Last accessed:2/10

[3] Sorkin D, Rook KS, Lu JL: Loneliness, lack of emotional support, lack of companionship, and the likelihood of having a heart condition in an elderly sample. Ann Behav Med. 2002 Fall; 24(4):290-8

[4] Tomaka J, Thompson S, Palacios R: The relation of social isolation, loneliness, and social support to disease outcomes among the elderly. JAging Health.2006 Jun; 18(3):359-84

Join-In is setting up a social platform for the elderly; it allows communication by TV, Tablet and PC. A multi-player serious game for the elderly is being developed. The interest in gaming is high in seniors: In a survey performed in Germany with 1200 participants, age above 61, two out of three PC users stated that they enjoy playing games regularly on the internet[5]. Studies[6] could demonstrate the increase of cognitive skills, reaction times, self-esteem and the sense of well-being in the elderly when playing computer games. Another positive effect is that gaming is multigenerational and enables the elder generation socialising with the younger one, e.g. grandchildren. The concept includes exercising either by exergames or by moderated exercises as physical activity -besides supporting good health- counteracts the feeling of loneliness, while loneliness leads to less physical activity[7]. Recent results indicate that exergames create physical benefits and counteract loneliness[8.] Join-In encourages contacts with peers in the region and with family and friends living further afield - if necessary facilitated by an assistant.

Active participation is vital if the individual is to profit from the Join-In developments. Yet motivation for participation among the elderly is a challenge. One of the problems is the heterogeneity of the elderly, among other things regarding interests and health. Join-In is developing a methodology for elderly persons to participate in social activities. This is based on a thorough user requirement analysis. User groups are set up in Germany, Hungary, Ireland and Norway. The lead user group is based in Munich. Based on the results of the user requirement analysis and the analysis of relevant studies and related work a methodology for setting up a social networking platform which will encourage and enable involving homebound senior persons in social networking activities being developed. Digital inclusion and factors hampering its acceptance -such as accessibility, motivation, lack of skills and confidence- will be tackled and form part of the methodology. The involvement of user groups in four different countries will help us to achieve a European solution which will also be useful in other countries.

The Join-In project web-page:

http://www.join-in-for-all.eu

[5] OE24.at. Deutsche Studie - Sechs von zehn Senioren spielen am Computer. http://www.oe24.at/zeitung/digital/article318942.ece. Last accessed: 2/10

[6] Basak C, Boot WR, Voss MW, Kramer AF: Can training in a real-time strategy video game attenuate cognitive decline in older adults? Psychol Aging. 2008 Dec; 23(4): 765-77).OE24.at

[7] Hawkley LC, Thisted RA, Cacioppo JT: Loneliness predicts reduced physical activity: Cross-sectional & longitudinal analyses. Health Psychol. 2009 May; 28(3):354-63

[8] http://www.theatlantic.com/technology/archive/2011/02/physical-video-games-may-help-the-elderly-psychologically/71184

1 Introduction

The aim of WP 5 is to define and develop the exergames in Join-In. These exergames will be based on low-cost technologies for implementing the games and for capturing user movements (game controllers, web-cameras, open source software). The exergames will also be adapted to the capabilities of the different Join-In user environments in question (see Deliverable D4.1).

In this report we present the identification and analysis of the requirements for the exergames in Join-In. In order to identify requirements some existing commercial exergames have been tested and evaluated with user groups in several countries. Before-after scenarios have also been made.

The report also addresses related work on exergaming for the elderly and identifies low-cost motion tracking systems and their suitability in exergames for our user group, and discusses motivational aspects in exergaming, including socialising, for the elderly.

The work described in this report for WP5 has been performed in close cooperation with activities in WP2.

1.1 Exergames

An exergame is a term used for video games that are also a form of exercise[9]. In an exergame movements are usually tracked using a set of sensors, embedded in the device, in handheld controllers, floor mats or by using video cameras with which the user controls an avatar on an output device - usually a TV screen. When exercising you gain personal scores that will be stored in the game in order to compare them to other scores achieved at a later point in time or by other players. Sometimes, the user is given motivational feedback like “Well done” or “You have to try harder” by the game.

The Join-In exergames for the elderly should be social, e.g. allow for casual and pleasant communication in speech and singing, be motivating, as well as fun, with exercises and movements both beneficial and tailored to the health of the target group and the individual (Figure 1).

[9] http://en.wikipedia.org/wiki/Exergaming

Figure 1 Join-In games and exergames

In Join-In we will also exploit the concepts of gamification, which is the use of game design techniques and mechanics to solve problems and engage audiences[10]. This is done by making everyday situations into a game (in Join-In physical activity/exercising in daily life). For example, walking outdoor with Nordic Walking sticks could credit the walker with points in a game that later can be exergamed online with peers, since an application area for Join-In is to motivate elderly to exercise regularly and increase their physical activity in daily life.

1.2 The Join-In architecture

The Join-In user environment consists of a hardware platform, the software running on the platform, and the user controllers (Figure 2). The system environment provides different services to the games and applications of Join-In. The choice of user and system environment depends on the actual Join-In games and exergames.

[10] http://en.wikipedia.org/wiki/Gamification

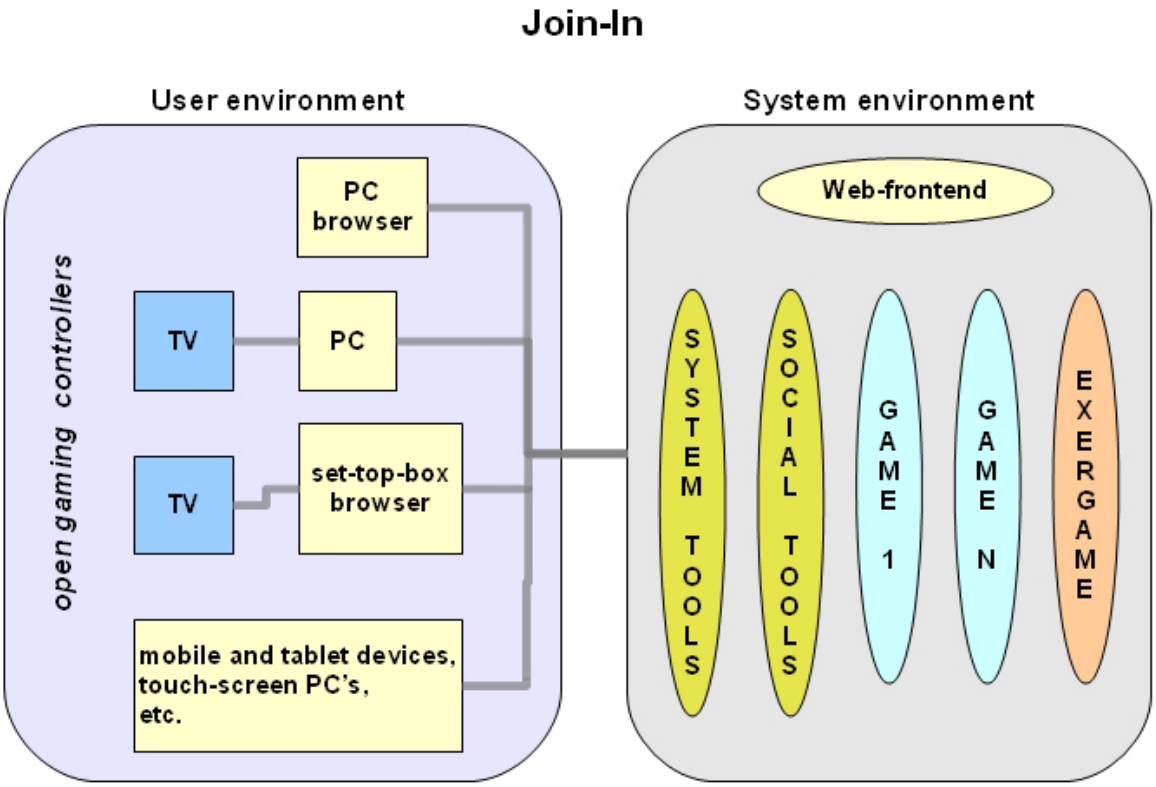

Figure 2 An overview of the user and system environments of Join-In

As described in Deliverable 4.1 Platform, neither of the major video game consoles of today, Microsoft Xbox, Sony Playstation or Nintendo Wii, are likely candidates for Join-In, due to their closed and proprietary environments. The exergames for these video game consoles are also not tailored to the needs of the elderly, as they are made for younger user groups. However, some of the individual game activities in the commercial exergames can be suitable for the elderly, and their specially designed game controllers may also be exploited in Join-In. This was for example the case for the Blobo ball and its games. All this is further elaborated upon in chapter 7.

1.3 The rest of the deliverable

The rest of this deliverable is organized as follows; chapter 2 gives an introduction to the aging process and the benefits of physical activity for the elderly. Chapter 3 gives a brief introduction to the exergames history, exergames made for the elderly and user interaction in exergames for the elderly. In chapter 4, motivational aspects are discussed including flow, the social dimension, goal setting and handicap. Chapter 5 presents the results of the exergame testing and evaluation in the different country sites in the project as well as related work on exergaming and eldery. In chapter 6 a review of existing exergames is presented. Chapter 7 discusses low-cost game controllers that are candidates for Join-In, in chapter 8 some candidate exergames for Join-In are presented, in chapter 9, the requirements for the Join-In exergames and their priorities are presented, and finally, in chapter 10 a summary is given. Several appendices are also included.

2 Exercising for the elderly

2.1 The aging process

Billis, Konstantinidis, Mouzakidis, Tsolaki, Pappas and Bamidis[11] point out that old seniors commonly lack physical fitness and often suffer from severe mobility problems in their upper and lower extremities. They also state that elders often lack motivation for physical activities and stay at home instead of visiting day care centres and organized training activities.

In addition elderly face several other changes concerning senses and motor skills[11]. Elderly also face several cognitive challenges, such as slower information processing and learning[12.] Falls are the most common reason for medical intervention amongst the elderly[13], and prevention is important. Physical exercise is both important in prevention and in rehabilitation.

The target group is heterogeneous when it comes to physical and cognitive abilities[14]. This means that the games we make should have different modes. For instance feedback could be given both in the form of text and sound, games should both be playable while standing and seated, etc. Also the games should maybe be playable with different input equipment - for instance the same game could be playable with a stationary bike, a balance board or two handheld/arm-strapped remotes.

Properties that we often find in the elderly population[14]:

Cognitive impairments:

- Decrement in episodic memory
- Variance in working memory performance
- Reduced attention span

Decline in motor skills:

- Decrements in fine motor skills
- Changes in posture
- Changes in balance
- Motor learning of new skills is also negatively affected by age
- Physical impairments include decrements in sensory processes which affect the interaction with the environment
- Problems from chronic illness
- Loss of sensomotoric skills

[11] A.S.Billis, E.I. Konstantinidis, C. Mouzakidis, M.N. Tsolaki, C. Pappas, P.D. Bamidis, "A game-like interface for training eniors' dynamic balance and coordination" in IFMBE Proceedings, 2010, Volume 29, Part 4, 691-694, DOI: 10.1007/978-3-642-13039-7_174

[12] O.K. Burmeister, "Websites for Seniors: Cognitive Accessibility" in International Journal of Emerging Technologies and Society Vol. 8, No. 2, 2010, pp: 99 – 113

[13] E.D. de Bruin, D. Schoene, G. Pichierri, S.T. Smith, "Use of virtual reality technique for the training of motor control of the elderly, Z Gerontol Geriat 2010, 43:229–23, DOI 10.1007/s00391-010-0124-7, Springer Verlag 2010

[14] **R**hythm Exergaming – Become the musician or dancer and be guided by the music while the exergame records your dance steps or your musical timing. (Rock Band, Guitar Hero, We Cheer, DDR & iDANCE)

- Visual impairments
- Impairments in auditory perception

We also know that the elderly need more time on tasks, and there should only be one (or a limited set of) action at the time. However, even though we become slower with age, we keep the ability to learn[15].

2.2 Elderly and physical activity

Physical activity is important for the elderly; it delays the aging process, reverses decline in condition, and it reduces risk for diseases. Other benefits include better mood, self-image and confidence[16].

The prevalence of chronic conditions increases with age[17] [18], in addition to the decline of vision, hearing etc. In Join-In we also take this into consideration, and incorporate exercises that could be beneficial also for elderly with chronic conditions, such as lung and heart diseases, e.g. diseases many elderly suffer from and where exercising and physical activity are important. An exercise regime that is recommended for all should also be a starting point for elderly, but with a focus on specific constraints due to the conditions of the individual.

Useful exercises for the elderly include: Balance, muscle strength, endurance and flexibility of upper extremities. Preferably the exercising should be performed more than once a week, but a bit of exercise is better than no exercise.

[15] P F Hjort, Tidskrift for den Norske lægeforening Fysisk aktivitet og eldres helse – Gå på! http://www.tidsskriftet.no/?seks_id=190191
[16] P F Hjort, Tidskrift for den Norske lægeforening Fysisk aktivitet og eldres helse – Gå på! http://www.tidsskriftet.no/?seks_id=190191
[17] V Kannisto, J Lauritsen, A Roger et al. Reduction in mortality at advanced ages: several decades of evidence from 27 countries. Pop Devel Rev 1994; 20: 793-810.
[18] Statens institutt for folkehelse (2010) Folkehelserapporten 2010 Helsetilstanden i Norge. Rapport 2010:2. Nasjonalt folkehelseinstitutt: Oslo

3 Exergames

3.1 Exergame history

Originally, the focus of exergames was on motivating children and younger adults to move more, partly because of the obese epidemic. The overweight and obesity epidemic has increased the interest for games requiring the users to exercise instead of sitting in front of a PC. Brox et al[19] state that in Norway more than 10% of 13-year-old teenagers are overweight, and in the USA more than one third of the population is obese Recently the American Heart Association endorsed the Wii Nintendo exergames with the "healthy product" label as they have done before with healthy food.

There are many studies showing that exergames result in real exercising for children[19]. "Dance Dance revolution" has been tried both on overweight and non-overweight children and adolescents and for both groups the level of exercising gave above the minimum recommended heart rate intensity for developing and maintaining cardio respiratory fitness. Adding an active video game component (car race) to standard stationary biking led to a modest increase in energy expenditure in overweight children. Playing at least some exergames give enough energy expenditure to be considered exercise also for young adults. Dancing exergames, such as "Dance Dance Revolution" where the players have to follow dancing steps on a special mat, are popular amongst the young. Another example of games for children using the Wii mat is "Active Life Outdoor Challenge" that "offers several fast-paced events in both a fun and challenging way". "Froggers Hop, Skip & Jumpin' Fun" from Konami is another example where a control mat is used. "SmartCycle" is yet another game aimed at children. Gamers are on a stationary bike while playing a learning video game about spelling, counting, shapes, etc. Many of these games are using extrinsic design methods – i.e. game points are earned by doing things that are not related to the main aim (exercising). In addition many of the games are using competition between players.

In recent years, exergames for elderly and older adults have received attention. However, there are not many exergames we are aware of made particularly with an elderly audience in mind.

The Eyetoy Playstation 2 exergames for the home market came in 2003[20]. They use a camera to track movements, and have games for improved cardiovascular fitness, improved speed, physical strength and flexibility, and for improved breathing, posture and relaxation.

[19] Brox E, Fernandez-Luque L, Tøllefsen T. Healthy Gaming – Video Game Design to promote Health. Applied Clinical Informatics Vol. 2: Issue 2 2011; DOI http://dx.doi.org/10.4338/ACI-2010-10-R-0060

[20] http://en.wikipedia.org/wiki/EyeToy

The first rhythm exergame ‘Dance Aerobics’ was released on the ‘Nintendo Entertainment System’ (NES) in 1987. The game used a peripheral dance mat called the ‘Power Pad’ game by stepping on arrows on the mat.

Figure 3 Playstation and Xbox

Today the major game consoles on the market are Playstation 3, Xbox 360 and Nintendo Wii. They use a variety of input devices (different handheld remotes, balance board, mat and bike) and provide a range of different exergames:

- Playstation 3 (Figure 3)
  - Playstation Move (camera and hand held controller)
  - Dance, sport and exercise games
- XBox 360 (Figure 3)
  - Kinect (based on body movement)
  - Exercise, dance, movement games
- Nintendo Wii (Figure 4)
  - Handheld consol(Wii remote), Balance board (Wii fit), Exercise Bike
  - Sport and exercise games

Figure 4 The Wii

The Wii remote is a pointer device with an accelerometer which is designed to look like a television remote. The Wii balance board is designed like a body scale which can measure the user’s weight as well application and distribution of pressure using pressure sensors. The Kinect is a full body motion tracking camera which is a completely button free

controller. The device tracks and records a user's movements which are then usually mapped to an in game avatar.

The exergames listed above have different difficulty levels and are aimed at a wide range of ages, but have not been made particularly with the elderly in mind. However, recently due to the attention exergames for the elderly have received, several studies have been performed with testing existing exergames with elderly, especially different kinds of Wii games. This is further elaborated upon in chapter 5.5 in this deliverable.

3.2 Exergames for the elderly

A good exergame for elderly must satisfy requirements in several dimensions:

1. Games in general: a good exergame should also be a good game
2. Age: A game for elderly should take different age related constraints into consideration
3. Exercises: The games should give good and balanced exercises
4. Exergames in particular: they should be safe to use, movements should be automatic letting the player concentrate on the games, etc.

An exergames for the elderly should offer good and balanced exercises that meet the needs for training of the type we choose, whether it be balance, strength, flexibility or endurance;

- Use of both arms (many current exergames only use one arm, such as bowling and tennis) if arms are used
- Use of both legs if legs are used
- Controlled movements (no jumping, no need for quick reactions that can lead to falls or strained muscles).
- Follow advices from physiotherapists, also directed at different chronic ailments such as COPD (chronic obstructive pulmonary disease), heart problems, etc.

Currently we are only aware of one exergame particularly made with the elderly population in mind: Dancetown Fitness System[21]. On their homepage the developers state that "it is a slow motion version of Dance Dance Revolution". The players are supposed to follow a footwork displayed on a computer screen. The game system comes with a frame to prevent the players from falling. It is possible to level up into a steady paced dancing for those mastering the "oldies" level. It can be played alone, in a group with a director or as a competition against others.

[21] http://www.popcitymedia.com/innovationnews/dancetown1212.aspx

Figure 1 The Dancetown Fitness System from their homepage

Many of the existing exergames are also playable for elderly, but not all give good exercise. For instance the senior group in Germany loves to play Wii bowling, but this game only requires the use of one arm, and does thus not give balanced exercise. Some of the Wii balance board games on the other hand, give good balance training and are embraced by the Norwegian focus group, but there can be a risk of falling off since the board is rather small.

3.3 Human computer interaction for the elderly

A user interface encompasses both software and hardware. Due to the elderly users of Join-In, which typically are less familiar with computers than the younger generations, we are focusing on well known technologies on the hardware side, such as the TV as interface, as well as devices such as Tablets (with touch screens) in addition to the PC. See Deliverable 4.1 for a further description of these devices. Even though the next generation of elderly will be more used to computers, physical impairment such as reduced eyesight or hearing, and increased shivering that increases with age, will make computer usage harder for all affected by such factors, - for example double clicking on a computer mouse for those with limited fine motor skills. Also diseases such as dementia are posing problems regardless of whether you have been a former computer user or not. In the choice of controllers and motion sensors for the Join-In exergames, the elderly dimension is also taken into consideration. See Chapter 7 for a further discussion of suitable game controllers and motion sensors for the target Join-In users, and Appendix B for an extensive list of open game controllers.

Also, the software of the user interface has to be suitable for the elderly. As described in Chapter 2, we keep the ability to learn with age, but we learn and process information slower. Speed is therefore something that has to be taken into consideration in the design of the user interface of an exergame for elderly. The amount of information on the screen simultaneously, and the amount of tasks to handle at the same time, should be reduced compared to a system made for a younger audience. Keeping the interfaces simple and

easy to use are important, so that the users can handle the Join-In exergames at home on their own (many elderly live alone), without technical assistance.

In general, multimodal interfaces, which provide the users with multiple modes of interfacing with a system[22] are a way to achieve increased accessibility and usability independent of the abilities of the users.

[22] http://en.wikipedia.org/wiki/Multimodal_interaction

4 Motivational aspects

For games to be motivational and persuasive they must be accepted by the target group. Persuasive technology can be defined as a set of technologies that attempts to change attitudes and behaviour of people through persuasion and social influence, but without making use of coercion and deception[23]. Those changes should be voluntarily accepted by the subjects. Persuasive technology could have a great potential to motivate and encourage old-aged people to change their sedentary lifestyle and become more physically active. Good exergames can be viewed as persuasive technology that motivates the players to exercise. Some strategies that can be used are:

- Display information to encourage people to be more active – this could for instance be information showing how well they are doing
- Record and display the users' past behaviour so that they can compare with their current behaviour
- Use positive reinforcement to improve behaviours
- Make an attractive and friendly user interface
- Provide information at opportune moments (so as not to disturb gameplay, for instance)
- Use social influence

There is some research on seniors and exergames giving an indication on what kind of games this target group likes and can benefit from using. Most research on seniors and exergames have been performed on Nintendo Wii, but there are also some other examples.

4.1 The flow concept

One of the basic properties of a good game is the ability to reach a state called "flow". This is a state of total engagement in an activity, used in the video game domain[24] [25]. It is identified by the following characteristics[26] [27]:

1. Required and enabled concentration and focusing - a high degree of concentration on a limited field of attention (a person engaged in the activity will have the opportunity to focus and to delve deeply into it)
2. Challenges that are neither too easy nor too difficult - balance between perceived skills and perceived challenge
3. Development of individual skills and mastery

[23] B.J. Fogg. "Persuasive Technology. Using Computers to Change What We Think and Do", Magazine Ubiquity, Volume 2002 Issue December, December 1 - December 31, 2002, doi>10.1145/763955.763957

[24] http://en.wikipedia.org/wiki/Flow_%28psychology%29#Gaming

[25] Considerations for the design of exergames", J Sinclair, P Hingston, M Mask, Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia ACM New York, NY, USA ©2007 ISBN: 978-1-59593-912-8

[26] Control Exergaming – Your whole body becomes the controller as your movements are motion captured into the game (Eyetoy:Kinetic/Groove/Antigrav, Wii Sports, Your Shape, Project Natal Trazer 2)

[27] Exergaming Machines – Using real fitness equipment, the fun of the games takes your mind of the exercise. (Gamercize, Gamebike, Fitclub, GameCycle, BrainBike & Expresso Bikes)

4. A sense of control over personal actions within the game
5. Clear goals for succeeding at the game
6. Reception of specific feedback on individual success
7. Unambiguous feedback (successes and failures in the course of the activity are apparent, so that behaviour can be adjusted as needed)
8. Effortless immersion within the game, to the exclusion of time awareness - the merging of action and awareness
9. Social interaction opportunities
10. Autotelic experience (the activity is intrinsically rewarding - it is undertaken for its own sake)

These points should be taken into consideration when developing user requirements also for exergames. We will comment on some of the points:

- If we look at point one, required concentration, this means that the players should either concentrate on the game or the exercising. A treadmill for instance requires so much attention, that the player will not be able to concentrate on the game-play. Walking or biking on the other hand is done automatically, and the players can delve into the game.
- When it comes to point two, challenges, we both have to consider how hard the exercises are and how difficult the game-play is. The game must not be so difficult that the players give up, because then they stop exercising.
- Point six refers to feedback. We can add that the feedback should also be positive or at least encouraging, since the target group is very sensitive to feeling embarrassed if they fail.

4.2 The social dimension

Social facilitation suggests that people get more involved while performing an activity when other people are participating too or if they are being observed[28]. For example, some studies show that people exercise more effectively when they do it with others[29]. A study of methods to promote physical activity among healthy inactive persons and cardiovascular or COPD patients and, found that group training is effective, especially under conditions that professional monitor training and that training is in progress at least three or six months. Another review of nine compilations, covering over 120 studies, maintains that exercise along with others seem to increase activity among adults[30] [31]. In the project *Jogging over a distance*[32], jogging partners who are not in the same location use an audio system to be in contact in order to socialize and to motivate each other.

[28] G. Roberts, K. Spink, C. L. Pemberton. Learning Experiences in Sport Psychology , 2nd edition, 1999, ISBN: 0-88011-932-2
[29] F. Mueller, S. O'Brien, A. Thorogood. "Jogging over a distance: supporting a "jogging together" experience although being apart.", CHI 2007. Publisher: Stanford Captology Media ISBN-10: 78097950251 and ISBN-13: 978-0-9795025-2-1
[30] M.-L. Hellénius, V. Alton, L. Ekerluns, S. Eksell, M. Emtner et. a.l (2007) 'Metoder för att främja fysisk aktivitet En systematisk litteraturöversikt'. Rapport 293. Stockholm: Statens beredning för medicinsk utvärdering (SBU).
[31] V. Underland, E. Nilsen, and A. Fretheim (2010) Effekter av tiltak utenfor helsetjenesten for å øke fysisk aktivitet hos voksne. Rapport 2010:19. Oslo: Kunnskapssenteret.
[32] L. Festinger. "A theory of social comparison processes.", Sage social science collection, doi: 10.1177/001872675400700202 Human Relations May 1954 vol. 7 no. 2 117-140

Several studies conclude that playing Wii or exergames together is perceived as fun and social[33, 55, 56], but we have no studies of playing exergames together via the internet. We do however have some evidence that the senior population does not find co-playing quite as rewarding as the young. For instance Gajadhar et al[34] tried out woodpong both co-located and remotely, and found that online co-play was deemed less rewarding than physical co-playing or when they thought they were playing against a computer. These players were playing with strangers, and we think that playing online together with someone you already know is different.

We know that the social factor might be important, and think that making social exergames will give better persuasive exergames than those without a social part, but that it is important that the players are confident with the technology and that the risk of feeling embarrassed is low. The seniors could for instance play exergames together with persons from a group they already have met and exercise together with. They could also play with grandchildren or friends / acquaintances they don't meet so often. The exergame could give them an opportunity to experience some fun together.

A group can also stimulate the participants to put extra effort into exercising compared to exercising alone, and it can also influence the sustainability of exercising over time. But, even if the group can be a motivating factor for exercising, introducing competition within the group can be a two edged sward – and is not necessarily positive[35 36]. Gender may also be an issue when it comes to the socialising aspect. In the German user group, for example, where women are in the majority, they prefer the socialising (aspect of) games to the competing aspects. In Norway they want both: they want to be able to form teams that can compete with each other.

4.3 Fun

The games and exergames in Join-In are to be fun to play. But what makes computer games and exergames in particular fun? As pointed out by Sinclair et al [37] in their considerations for exergame design, Malone[38] identified *challenge*, *curiosity*, and *fantasy* as three factors influencing this. However, in Malones research, the participants were children and young adults.

[33] Y. Jung, J. L. Koay, J.S. Ng, G. L. C. Wong, M. L. Kwan, "Games for a better life: Effects of playing Wii games on the well-being of seniors in a long-term care", IE '09 Proceedings of the Sixth Australasian Conference on Interactive Entertainment, doi> 10.1145/1746050.1746055

[34] B. J. Gajadhar, H.H. Nap, Y. A. W. de Kort, W A Ijselsteijn, "Out of sight out of mind: co-player effects on seniors' player experience", Proceedings of the 3rd International Conference on Fun and Games 2010, doi>10.1145/1823818.1823826

[35] E. Johnsen, T.Burkow, L. Vognild: Digitalt pasientfellesskap som sosial ressurs og tilfredse pasienter som sosiologisk problem (Digital patient community as a social resource and satisfied patients sociological problem), s. 163-189 i *"Digitale pasienter"*, Tjora og Sandaunet (ed.), Oslo, Gyldendal Akademisk, 2010. ISBN:978820539909

[36] E. Johnsen, T. Burkow, L. Vognild: Den sosiale gruppa som motivasjon til fysisk trening (The social group as motivation to exercise), forthcoming in *"Helsesosiologi"*, Aksel Tjora (ed.), Oslo, Gyldendal Akademisk, 2012.

[37] Considerations for the design of exergames", J Sinclair, P Hingston, M Mask, Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia ACM New York, NY, USA ©2007 ISBN: 978-1-59593-912-8

[38] T.W. Malone What makes things fun to learn? heuristics for designing instructional computer games, In '80 Proceedings of the 3rd ACM SIGSMALL symposium and the first SIGPC symposium on Small systems, Palo Alto, Calefornia, Unitred States.

4.4 Goal setting and handicap

For exercising to have a health effect, it is important to exercise more than once a week. Making exergames that are social and fun could be one way to encourage this, but also to incorporate the concept of goals, individual or common for a group, could be a means to motivate to exercise.

If goals are incorporated, they should not be "*to do your best*" – but the goal level should be specified, as Locke and Latham states: *"when people are asked to do their best, they do not do so",* and feedback on progress is also important for achieving goals[39]. Ubitif garden[40] and IS-ACTIVE[41] are two examples, not on exergames, but on systems using weekly goals for motivation to physical activity in daily life.

Many studies indicate that individuals are more inclined to fulfil their goals if they form implementation intentions - that is, if they consider the conditions under which they will execute the intended behaviours[42].

The concept of handicap is a way to avoid unfair competition since the best, with respect to his abilities, should win. Introducing handicap in exergames could be a way for people with different physical capabilities to play exergames together. This could be especially valuable for the elderly population, which is a heterogeneous group when it comes to, among others, health related issues and physical impairment.

4.5 Health benefits

Health is an important aspect for our target group, and exergames that provide health benefits could be important for the motivation. The exercises included in Join-In should be good and balanced, whether it is balance, strength, flexibility or endurance, as discussed in section 3.2

Intensity is another aspect related to health benefits. Intensity is defined by the U.S. Department of Health and Human Services as how hard a person works to do an activity[43]. The intensity of the Join-In exergames should preferably start at a low level, with the option to increase the intensity. Exergames that start with a vigorous intensity will not be accessible for all Join-In users, since the target audience is elderly users.

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39 Locke, E.A. & Latham, G.P. 2002. "Building a Practically Useful Theory of Goal Setting and Task Motivation: A 35- Year Odyssey," American Psychologist, 57(9), 705-17.

40 Goal-setting considerations for persuasive technologies that encourage physical activity, Consolvo S, Klasnja P, McDonald DW, LandayJA Proceedings of the 4th International Conference on Persuasive Technology, ACM, NY USA, 2009

41 http://www.is-active.eu/wp-content/uploads/2011/08/D5.1-User-interaction-and-feedback.pdf

42 Oettingen, Hoig, & Gollwitzer, 2000

43 U.S. Department of Health and Human Services (HHS) 2008

4.6 Other aspects

4.6.1 Familiarity

The elderly are least likely to use the internet and play digital games out of all the age groups investigated Even though the elderly play digital games less than other aged groups, this cannot be attributed to their lack of interest[44]. With this in mind it is important that any willingness by the elderly to play exergames be met with familiarity if possible. According to Hammitt, familiarity that is gained through prior knowledge and past experience can be vital to how people react to an environmental scene. Past experience helps people develop cognitive models of their environment, which can aid them in the perception of future environments[45]. Research by Zhang and Ghorbani suggests that there are five factors which effect familiarity: prior experiences, repeated exposure, study duration, level of processing and forgetting rate.

4.6.2 Approachability and accessibility

Approachability can be described as "how easy it is for a novice player to be able to start playing the exergame without facing setbacks that will discourage the player from continuing"[46]. It is vital that the games developed are easy to approach by the target Join-In audience. If users find the exergame difficult during initial setup and the first play of the exergame they may not play again. Accessibility is a similar term to approachability. Accessibility is defined as "the factor by which the user of an artefact can go from no knowledge of the artefact to adequate knowledge to be able to use the artefact to satisfaction"[47]. Desurvire and Wiberg describe accessibility as how usable a system is by as many people as possible, usually the term relates to usability in relation to disabilities[48].

4.6.3 Usability

The International Organisation for Standardisation (ISO) defines usability in relation to software as "the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments"[49]. An efficient and effective interface will be important for elderly users.

4.6.4 Adjustability

Adjustability is the ability of a game to change the difficulty of an experience. Maintaining a level of difficulty that is consistent with the player's ability is an important aspect.

According to Westra et al. adjustability can be broken down into two distinct categories [50]:

Pre-defined: This method implements a more traditional option of choosing "easy", "medium" and "hard" levels, and applies static difficulties to each chosen option[51]. Westra

[44] Ijsselsteijn, W., Nap, H. H., de Kort, Y., and Poels, K. (2007) Digital Game Design for Elderly Users
[45] Hammitt, R.E. (1979). Measuring familiarity for natural environments through visual images.
[46] Molin, J. (2010) A practical model of game approachability testing of computer games.
[47] Preece, J. and Rogers, Y. and Sharp, H. (2007) Interaction design: beyond human-computerinteraction
[48] Desurvire, H. Wiberg.C. (2008).User Experience Design for Inexperienced Gamers: GAP – Game Approachability Principles
[49] ISO 9241-11 1998
[50] Westra, J., van Hasselt, H., Dignum, V., Dignum, F. (2008). On-line Adapting Games using Agent Organizations.

et al. state that this static model may lead to less than optimal uptake of the game in the case where players do not fit well with the expected stereotypes.

- Dynamic Balancing: This method implements the ability to adjust the game itself during play without the need of an expert guiding this process. Research by Andrade et al. states that there are three important aspects that must be considered when performing dynamic balancing. First, the game must identify the player's skill level as quickly as possible and adapt accordingly. Second, the game must track, as closely and quickly as possible, the player's evolution and regression in performance. Third, the game behaviour must remain believable throughout[52].

Missura and Gartner also suggest that games which provide in-game adaptive difficulty based on player performance tend to result in players enjoying them more than games that ask the user to select the typical levels of "easy", "medium" and "hard".

4.7 Summary motivational aspects

Several motivational aspects have to be taken into consideration when making exergames for elderly. One of the basic properties of a good video game is the ability to reach a state called flow, e.g. a state of total engagement in an activity. Another aspect is the challenge of making games that are fun. Challenge, curiosity, and fantasy are three factors influencing how fun a game is perceived. Also, several studies conclude that playing exergames together with others is perceived as fun. Other techniques that can influence the motivation to play an exergame include the use of goal setting, handicap, positive feedback, and also the visualisation techniques in question. Other aspects that may have an impact on motivation to use an exergames encompass familiarity, approachability/accessibility, usability and adjustability.

Research shows that people get more involved and perform an activity better if it's done in the presents of others or if they are being observed.

The social influence is therefore forceful, and doing exercising in a social group has the potential to be motivating, fun, effective and sustainable. Motivating people to exercise together with others could also contribute to the prevention of social isolation and loneliness.

[51] Missura, O. Gärtner, T. (2009). Player Modeling for Intelligent Difficulty Adjustment*.
[52] Andrade G., Ramalho G., GomesA. S., and CorrubleV., (2006).Dynamic game balancing: An evaluation of user satisfaction

5 Exergame testing with elderly

Commercial exergames have been tested by senior users in Join-In. Our results are presented and related to existing work on exergames and elderly.

5.1 Exergame testing Join-In

As described in Deliverable 2.1, user groups have been set up in Germany, Ireland, Hungary and Norway. Tests of existing exergames in the requirement phase have been performed with elderly participants from:

- Germany:
  - The Serial focus group: Key persons such as reverends, home care personnel, social advisors, dance instructors and club organisers. Age of the participants between 55 – 75 years old
  - The senior club. Age of the participants between 66 - 85 years old
- Hungary
  - User groups from five centers in five regions of Hungary. Two in the main urban area of the Hungarian capital, two in towns in the countryside, and one in a rural area in the south-western part of Hungary.
- Norway:
  - Heracleum senior centre. Age of the participants between 72 – 85 years old
  - The Norwegian lung and heart patient organisation (LHL) and from a pulmonary rehabilitation outpatient clinic. Age of the participants between 66 – 90
  - Working seniors. Age 55 +
- Ireland:
  - The active retiree group located in New Ross. Age of the participants between 55 - 85

A selection of Exergames (Wii, Kinect and an early version of a persuasive game) has been tested with more than 40 elderly aged 55 to 90 years old, the majority of them being retired. The elderly were recruited from the different organizations indicated above. Many of them had little or no experience with computers and computer gaming, and some were even reluctant towards new technologies. However, the concept of exergaming was well perceived by the participants, who found it inspiring and enjoyable. Cultural differences and previous experiences seem to influence the perception of the exergames, such as preferences for particular games (e.g. boxing, slalom, golf etc.). The participants gave valuable input for the design and development of exergames for elderly; such as speed, intensity, who to play with, language, how it was to handle the remote control, brightness of colours and more.

5.2 Related work exergames testing with elderly

In addition to perform tests in the project, we have also studied published research regarding elderly and exergames. Existing studies in the field support and add to our results. In this section we sum up some of our findings.

The Nintendo Wii comes with a range of games like the Wii fit balance board and the Wii sports games with handheld "Wii motes". Several studies have been conducted with elderly playing different kind of Wii games[53,54, 55, 56,] and particularly bowling has been considered suitable since the game is self-paced; i.e. players can take the time they need when it is their turn. However Wollersheim et al[55] let the senior female players choose between a range of Wii games, and found that the individual choices comprised games like tennis, boxing and sword fighting. They also found that playing Wii sports was difficult, but that said the players responded that it had a positive social effect between those participating, and they also liked the fact that the games forced them to be physically active and to do new things. Shubert[57] also found that many seniors were interested in playing Wii if it could benefit their health. A study in Singapore[56] tells that Wii had a high acceptance among elderly, but it does not tell which Wii games were played.

Jung, Koay, Ng, Wong and Kwan[54] concludes that playing Wii has a positive impact on the social well-being of the elderly compared with a group that only played traditional board games. Billies et al[53] state that balance and strength training are a suitable kind of physical exercises for elderly, and they have tried out Wii balance board.

Figure 2 Left: A player using Wii balance board and with a Wii mote (remote control) in hand, right: A dance pad used in Dance Dance Revolution – the player gets instruction on the screen about where to step

[53] A.S.Billis, E.I. Konstantinidis, C. Mouzakidis, M.N. Tsolaki, C. Pappas, P.D. Bamidis, "A game-like interface for training eniors' dynamic balance and coordination" in IFMBE Proceedings, 2010, Volume 29, Part 4, 691-694, DOI: 10.1007/978-3-642-13039-7_174

[54] Y. Jung, J. L. Koay, J.S. Ng, G. L. C. Wong, M. L. Kwan, "Games for a better life: Effects of playing Wii games on the well-being of seniors in a long-term care", IE '09 Proceedings of the Sixth Australasian Conference on Interactive Entertainment, doi> 10.1145/1746050.1746055

[55] D. Wollersheim, M. Merkes, N. Shields, P. Liamputtong, L. Wallis, F. Raynolds, L. Koh, "Physical and Psycosocial effects of Wii Video game use among older women.

[56] Y.Theng, A.B. Dahlan, M. L. Akmal, T. Z. Myint,, "An exploratory study on senior citizens perceptions of the Nintendo Wii: the case of Singapore", i-CREATe '09 Proceedings of the 3rd International Convention on Rehabilitation Engineering & Assistive Technology, ACM New York, NY, USA ©2009, doi>10.1145/1592700.1592712

[57] T. E. Shubert, "The use of commercial health video games to promote physical activity in older adults", Annals of long-term care, 20.05.2010, p 27-32.

As Theng et al points out, Wii is not designed for elderly, and many games are found to be too fast or give a too negative feedback. There is also a certain risk of falling off the rather narrow balance board in Wii fit.

Touchtown's Dancetown Fitness System® is a game specifically designed for elderly using a dance mat, and Theng et al thinks that both this and the Eyetoy games using cameras to track movement maybe are better choices for elderly both because of functionality and ease of use.
De Bruin, Schoene, Pichierri and Smith[58] studied the use of virtual reality techniques for the training of motor control in the elderly, and their theory is that "By creating a strong presence in a virtual, interactive environment, distraction can be taken to greater levels while maintaining the benefits of indoor exercises which may result in a shift from negative to positive thoughts about exercise." They have been using dance pad games to train stepping.

Video camera controllers have also been tested with elderly users. For example, Eyetoy has been tried for elderly stroke patients, as referred to by Theng et al.
Mental health is of importance, also for the elderly. Rosenberg et al have found that exergames also can be used as intervention for subsyndromal depression[59], a condition often seen in elderly.

Regular exercise helps COPD patients by increasing overall muscle tone and improving cardiopulmonary fitness, and testing shows that also COPD patients [60] can benefit from exercising with Wii games. The study aimed to find out the level of intensity of the Wii Fit exercises in patients with COPD, and five patients with stable COPD were asked to run in place, do some upper arm exercises, step in place, and maneuver on an obstacle course. Each exercise was done for three to five minutes; then the researchers (re)tested the patients measuring heart rate and workload, oxygen consumption and respiratory parameters during a walking test. The video game may encourage the physical activities as it makes it more enjoyable.

[58] E.D. de Bruin, D. Schoene, G. Pichierri, S.T. Smith, "Use of virtual reality technique for the training of motor control of the elderly, Z Gerontol Geriat 2010, 43:229–23, DOI 10.1007/s00391-010-0124-7, Springer Verlag 2010

[59] D. Rosenberg, C.a. Depp, I. V. Vahia, J. Reichstadt, B. W. Palmer, J. Kerr, G. Norman, D. V. Jeste, "Exergames for subsyndromal depression in older adults: a pilot study of a novel interaction," American Journal of geriatric psyciatry, 18:3, March 2010

[60] http://www.webmd.com/lung/copd/news/20110516/wii-fit-exercises-may-help-copd-patients (read 28.11.11)
http://healthprzone.com/company/C360445-irish-medical-information/11-copd-patients-may-breathe-easier-thanks-to-the-wii (read 28.11.11)
http://www.thoracic.org/media/press-releases/conference/articles/2011/COPD_Patients_May_Breathe_Easier_Thanks_to_the_Wii.pdf (read 28.11.11)

6 Some existing exergames

This chapter presents some existing exergames including workout exergames, rhythm, control and exercises machines. More detailed description and review of these exergames are to the found in Appendix A.

6.1 Workout Exergames

Workout exergames typically have a virtual trainer, which is generally represented by an in-game human avatar. The in-game trainer explains and demonstrates the exercise the user is going to perform. Wii Fit Plus and EA Sports Active are both examples of workout exergames**.**

6.1.1 Wii Fit Plus

Wii Fit Plus is a sequel to Nintendo's Exergame Wii Fit. Wii Fit Plus like its predecessor uses the peripheral Wii balance board (Figure 5). The Wii remote is used to interact with the menu, and certain games such as jogging. The game is comprised of several mini games that range in difficulty and targeted skills. These mini games are categorised as strength training, yoga, aerobics and balance games. Wii Fit Plus contains all the original Wii Fit exercises with additional challenges added for Wii Fit Plus such as cycling, rhythmic Kung-Fu and a golf driving range.

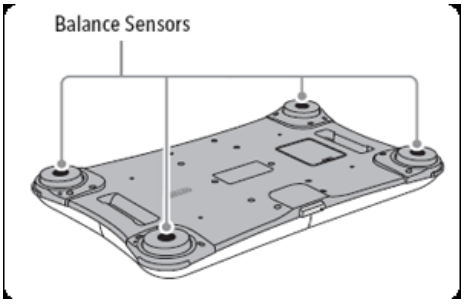


Figure 5 The layout of the Balance Board pressure sensors

All exercises in Wii Fit are demonstrated by an in game virtual trainer (Figure 6). There are two trainers selectable during initial setup. The trainer can be viewed as a mirror image or from behind while exercising. The trainer attempts to motivate and assist the user during exercises, to help the user increase the number of repetitions they can perform, thus improving the users rating. The users' rating is presented on completion of an exercise. Wii Fit also gives the players general hints and tips outside of exercises. Wii Fit Plus has a wide range of intensity from simple stances to complex yoga positions.

Figure 6 In-game Wii Fit Plus screenshot with avatar mimicking user's actions

Wii Fit Plus gives in depth instructions for all exercises. The in-game trainer gives assistance during each exercise while the "Fit Piggy" in game character give hints and tips to the user outside of exercises.

There are two difficulty settings available for each exercise, beginner and advanced. In general exercises that are unlocked later on are of higher level of difficulty, for example the starting yoga exercise, the 'half-moon', requires the user to stand with the users' arms above head level and lean left or right to stretch. A yoga exercise unlocked at a later stage, the 'shoulder stand', requires the user to lay on the ground and the users legs need to be extended and raised as high as possible and the user needs to balance using only the shoulder muscles. The difficulty of performing the 'shoulder stand' is higher than performing the 'half-moon'.

Wii Fit allows multiplayer of two users in some of its mini games. Walking/jogging can be played with two users cooperatively. Hula Hoops can be played competitively with another user.

6.1.2 EA Sports Active 2

EA Sports Active 2 is the sequel to EA Sports Active. The sequel expanded its targeted platforms from Nintendo Wii to also include the Xbox 360 and the PlayStation 3. EA Sports Active 2 offers an intense workout and is designed as a workout tool rather than a game. While other exergames feature mini games that are not explicitly for workouts EA Sports Active 2 focuses solely on exercise. Most exercises in EA Sports Active are general stretching exercises or basic activities such as walking or jogging.

Figure 7 In game EA Sports Active 2 screenshot with avatar mimicking user's action

EA Sports Active uses the Microsoft Kinect controller on the Xbox 360 and the Nintendo Wii Remote on the Nintendo Wii. On the PlayStation 3 EA Active also uses their own sensors which are strapped onto the users left and right arm as well as the left leg (Figure 8). The left arm sensor reads the user's heart rate. These sensors are also used with the Xbox 360 and Nintendo Wii in tandem with the respective controllers for those devices.

Figure 8 EA Sports Active 2 arm and leg sensors with wireless USB connector

EA Sports Active 2 allows the user to select one of two personal trainers. The trainer will guide the user through the exercises and challenges and provide support. For example, in the running exercise, the trainer will give the user advice such as "remember to keep your shoulders relaxed and your back straight" or encourages the user to increase running speed to overtake other in-game avatars. Some exercises fully track the users motion while others don't, for example during a lunge exercise if the user stops lunging the counter increments as the trainer lunges.

EA Sports Active 2 does not contain mini games such as the balance games as found in Wii Fit.

EA Sports Active contains an in-depth setup when compared to Wii Fit. Its initial setup prompts the user to customise their avatar as detailed as the character creation found in most role playing games. The in game tutorials are thorough and a video is shown with the in-game instructor explaining how to perform an exercise before that exercise begins.

EA Sports Active offers a local multiplayer option, but a second set of motion sensors for the second player is needed. The local multiplayer enables both users to compete by completing the exercises before each other or more successfully than the other. Some exercises have no competitive mode. EA Sports Active allows the user to upload their statistics to an online server which can then be compared on different leader boards.

6.2 Rhythm Exergames

The majority of rhythm exergames are dance based games. There are alternative rhythm exergames that use musical instruments; examples include ‘Guitar Hero’ and ‘Rock Band’. The genre has proven to be popular, for example Konami’s Dance Dance Revolution sold over three million copies when it was released on the PlayStation. Below, the rhythm exergame Dance Central is described:

6.2.1 Dance Central

Dance Central is a dance game for the Xbox 360 that is controlled using the Microsoft Kinect peripheral. The Kinect tracks the user’s movements and displays them onscreen using an in-game avatar. Dance Central does not require a dance mat as the Kinect performs full body tracking on the user. Dance Central features a “Workout Mode” which tracks the amount of calories burned.

Figure 9 Dance Central screenshot with in-game avatar mimicking the dance move performed by the user

The Dance Central menu options are with four options: dance, your stats, options and buy new dances. Your stats displays general statistics such as favourite track based on the track the user played most. To calibrate the Kinect the user must select the options menu. This menu has two help options, one beginner one to provide support for new and proficient users. Inside dance mode the first selection brings up a list of tracks. Selecting a track brings up a sub-menu containing: break it down which is a tutorial mode for the current song, perform it which is the one player mode, dance battle which is the 2 player mode and leader boards.

There are three difficulty settings available: easy, medium and hard. After selecting a difficulty the final menu is displayed with the following options: “play” which begins the dance. “Change venue” to switch the dance arena and ”change dancer” to switch the avatar. In addition there is a workout mode which counts calories burned and “no flash cards” which is an additional difficulty to perform the dance with no assistance. To actually perform a dance requires navigating through 5 menus.

6.3 Control Exergames

Control exergames are games that are controlled by the user’s motions. Motions can be detected in many ways such as with a motion controller or a motion tracking camera. This type of exergames contains the highest number of games since the release of the Nintendo Wii and controllers for other systems such as the PlayStation Move and the Microsoft Kinect. A wide range of games falls into this category. The game described below is Dr. Kawashima's Body and Brain Exercises.

Dr. Kawashima's Body and Brain Exercises

Dr. Kawashima's Body and Brain Exercises (also known as Body and Brain Connection) is a combinaton of an exergame and a cognitive game. It makes use of the Microsoft Kinect device to allow the user to interact with the game. A cognitive challenge is presented to the user, who must solve the challenge using a physical motion for example making the greater than or less than symbol using your arms. The game is comprised of five categories of mini games: math, reflexes, logic, memory and physical.

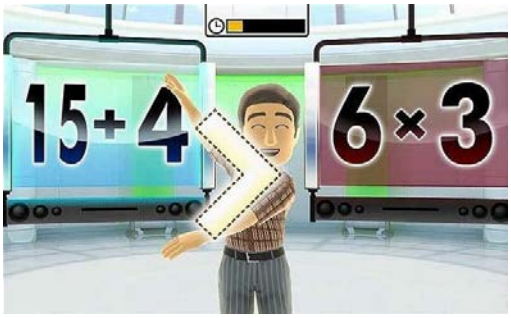


Figure 10 In-game screenshot of an avatar demonstrating the correct solution to the math problem

A digital avatar, Dr. Kawashima, gives advice to the user on how to improve at the game. The ‘brain age’ is a scoring system which asks the user to complete a set of daily challenges after the game has initialised. A new user must perform an initial setup consisting of three tests mixing cognitive and physical activities. These three activities calculate a “Brain Age” which is used as an overall score to gauge improvement. The

score is used to calculate a ‘brain age’ which ranges from twenty to eighty. This score is compared to the user’s actual age, and the goal is to reduce the brain age score. Body and Brain Connection attempts to merge activities such as ‘Wack-A-Mole’ and classic video games like ‘Pac-Man’ with low intensity physical exercise. Body and Brain Connection is generally low intensity with the exception of the ‘step mania’ mini-game. The ‘step mania’ game requires the user to memorize a pattern of lights and then walk and jump to the pattern.

There are three levels of difficulty for each exercise: beginner, intermediate and advanced. There is a local multiplayer option in Body and Brain Connection, which is a turn-based system. Each user takes a turn completing a mini-game. The mini-games in Body and Brain Connection combine both familiar and more unfamiliar elements, such as kicking a ball with number on it to solve an equation.

6.4 Exergame Machines

Exergame machines are based on exercise equipment such as stationary cycles and steppers. The two main methods of using these devices are with built in games or by connecting to existing games. The ‘Expresso Interactive Cycle’ is an example of an exergame machine which uses built in games (

Figure 11). The most popular exergame machine is the ‘Gamercize’. The ‘Gamercize’ devices are an example of machines that connect to existing video games. The devices include a stationary cycle and a stepper that can connect to platforms such as the PC, PlayStation 3 and Nintendo Wii. Compatible games include: ‘Grand Theft Auto 4’, ‘Killzone 2’ and ‘Sims 3’.

Figure 11 Demonstration of two users playing a built in game on the ‘Expresso Interactive Cycle’

7 Join-In exergames and exercise programs

7.1 Exergames

The Join-In exergames for the elderly should be social, motivating, and fun with exercises and movements beneficial and tailored to their health, that is have a physical and/or mental benefit.

In Join-In, we envision several games and applications using gaming elements for motivation to exercising and physical activity in daily life. Possible physical activities to incorporate in exergames or for gamification are:

- Walking (Indoor, Outdoor - with or without Nordic walking sticks)
- Exercising and dancing (Indoor)
- Biking (Indoor)

For outdoor activities gamification will probably be the best approach, since exergames will be harder to support when moving around. You can for example earn points for your online game by both being active outdoor walking with Nordic walking stick (gamification), and for indoor walking, jogging or biking following a “pure” exergame.

Physical activity and exercising is also important for elderly with chronic health conditions such as lung and heart diseases.

Due to varying outdoor weather conditions, and the overall climate differences between the different regions in Europe, the need for indoor versus outdoor physical activities for the elderly will probably differ from country to country. The winter season is long and often hash in the Nordic countries, so the need for motivating indoor activities are probably higher there than in other regions in Europe with mild winters.

7.2 Walking

Walking, both indoor and outdoor, is one of the most effective and easiest means of doing physical exercising. In its simplest form it requires no additional equipment or infrastructure, and its impact can be adjusted by varying the speed and intensity.

Indoor walking exercising can be done stationary, doing rounds in your house, taking the stairs, using a step, or even a treadmill. Outdoor walking exercising can have varying length, up and downhill, and even with the wind against you.

While indoor walking is easier to support with an exergame, outdoor walking may easier be supported with gamification.

See appendix C for further ideas regarding a Join-In walking exergame.

7.3 Exercising and dancing

The Join-In exergames should, in addition to incorporating exercise programs that are regarded beneficial for elderly in general, also address exercise programs that are targeting elderly with chronic conditions and disabilities. Such programs could have exercises for balance, muscle strength (in lower extremities), flexibility (in upper extremities) and endurance. A subset of such an exercise program for COPD has already been developed in another AAL-project IS-ACTIVE[61], and Join-In could benefit from incorporating this program. When including warm-up and cool-down activities an exercise program for Join-In could include the following activities:

1. Warm-up (3-5 minutes)
2. Endurance exercises (5-20 minutes)
3. Cool-down and stretching (3-5 minutes)

Such an exercise program should preferably be performed several times per week. See appendix C for further ideas regarding Join-In exercising and dancing exergame.

7.4 Biking indoor

Indoor cycling with a stationary bike is popular at local gym and fitness centers where its most popular form is *spinning*, but also health rehabilitation centers incorporate indoor exercise bikes in their exercise programs.

Stationary exercise bikes are also common in private homes. However, many regard biking alone indoor at home as boring and little motivating, so many exercise bikes are left unused and stored away. A biking exergames could be a way of overcoming this lack of motivation by making biking on a stationary bike more fun and challenging.

See appendix C for further ideas regarding Join-In indoor biking exergame.

[61] http://www.is-active.eu/wp-content/uploads/2009/06/IS-ACTIVE-Deliverable-2.1.pdf

8 Game controllers and motion sensors

An extensive list of open game controllers and motion sensors can be found in Appendix B. This chapter is focusing on some of the more suited candidates for game controllers and motion detection in the Join-In system.

Elderly users, in initial lab trials conducted during the Join-In requirement phase, have also tested some of these activity and game controllers.

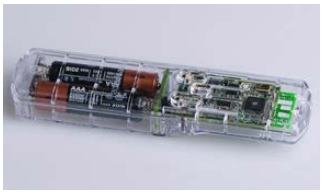
8.1 Blobo

Blobo (www.bloboshop.com) is a golf ball sized device that is packed with sensor technology and works with every modern PC. The Blobo SDK provides access to advanced sensory and environmental data, including: 6 degrees of freedom motion and orientation data; advanced analogue squeeze and tap functions; mapping real world coordinate system, based on magnetic north and gravity.

About five users in a small lab trial tested a simple exergame using the Blobo ball from 'Ball-IT Oy'. The evaluation showed that it was well accepted mostly due to the easy use of the ball. The Blobo ball is both used as an activity sensor and a game controller for the game. The trial users did however find the ball too small, but a ball seems to be a good starting point for better solutions with sensors better adapted for the elderly.

There is a native Win32 and a Unity3D-compatible Blobo SDK for Mac available (www.ball-it.com), but it's hard to get hold of this in limited quantities for a reasonable price. Additionally bloboshop shall be the sales channel for games developed for blobo.

8.2 Freespace / Hillcrest Labs



This reference design incorporates a complete six-axis Freespace® motion solution integrated with Bluetooth® RF. To simplify evaluation, the reference kit includes a remote control packaged in a small form factor. The removable module in the kit includes the Freespace Motion Engine and microprocessor together with MEMS inertial sensors, and supports prototyping with other form factors.

The FSRK-BT-1 can be used with the Freespace Motion Studio and libfreespace for performance evaluation, software development and device configuration.

Software development kits are available even as open source, and the cost is $119 for FSRK-BT-1 plus about $100 for delivery to Europe.

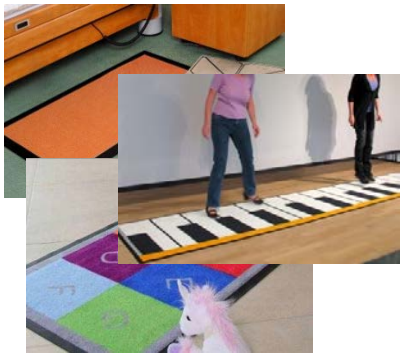
The scoop pointer remote is a ready to use motion controller with a usb-adapter and drivers for a wireless mouse. A reference kit is scheduled for end of 2011 and will cost $149.

It is the successor of the Loop Pointer with a proprietary wireless protocol.

Hillcrest Labs is licensing the technology and will provide information about module manufacturers. This means companies can either use the reference kits or design own motion controllers based on the electronic modules. This is an option for Join-In.

The usage of two or more motion controllers in one application may require further development of drivers.

8.3 Sensor Mats



Professional sensor mats from Future Shape (www.future-shape.de/en/) are the basis for different applications like fall detection, burglar alarm, light switching, heating control and the counting of persons. Every mat consists of several sensor pads. Each sensor pad has several capacitive sensor fields and one active wireless transmitter. The mat design is very flexible concerning colour, surface material and shape of sensor fields.

Currently the following interfaces are available:

- Keyboard simulation for selected keys
- MIDI interface, piano and music mat at future-shape.de
- Wireless controlled wall outlets
- RS232 serial interface with raw sensor data

Currently drivers for fall detection are available but not for general pressure, acceleration or weight evaluation. A co-operation with Future Shape would be possible, but at a price of around 800 Euros for a mat with 8 sensor pads they are quite expensive.

However, **experimental sensor** mats are easy to build based on conductive films. It is possible to build sensor mats tailored to special requirements below any surface. At: www.instructables.com/id/Stickytape-Sensors several solutions and materials are explained in detail.

Electronic components and software for interfacing are available at www.arduino.cc and www.phidgets.com. Phidgets provides capacitive sensors with extendable area beside of many other sensor types.

8.4 Other candidates

- Wireless sensor kits for exercise bikes , e.g. at www.thisisant.com
- The Wii Fit balance board
- The Microsoft Kinect

9 Requirements exergames

A good exergame for elderly must satisfy requirements in several dimensions:

1. Games in general: a good exergame should also be a good game
2. Age: A game for elderly should take different constraints into consideration
3. Exercises: The games should give good and balanced exercise
4. Exergames in particular: some general requirements are identified

The MoScoW method[62] has been used for prioritizing requirements for the Join-In exergames:

M (Must have)

S (Should have)

C (Could have)

W (Won't have)

In table below, the trial partners have given their priorities:

	Requirement (The exergames should ..**)**	Priority NST/Norut	Priority HMGU	Priority DMM-Users	Priority Irland
1	Be beneficial for their physical fitness	M /S	S	M	M
2	Be perceived as useful for the health	M/M	M/S	M	S
3	Be fun (fantasy, curiosity and challenge)	M/M	M	M	M
4	Enable communication among players (signs, audio etc.)	M/M	M/S	M	M
5	Be social	M/M	M/S	M	M
6	Allow the participants to see their progress	S/S	M	S	M
7	Give positive feedback	M/M		S	M

[62] http://en.wikipedia.org/wiki/MoSCoW_Method

8	Follow design-for-all principles (universal design)	M/M	M	M	M
9	Allow for goal settings	S/S	S/C	S	S
10	Allow for competition against yourself	C/S	C/S	S	C
11	Allow to see history and progress	M/M	S/M	M	M
12	Have adjustable speed	M/M	M	M	M
13	Have different levels of difficulty	M/M	M	M	M
14	Allow pauses	M/M	M	M	M
15	Have one centre of attention, no distractions	S/S	M	S	S
16	Be safe to use	M/M	M	M	M
17	Allow indoor biking	M/C	C	C	C
18	Allow indoor walking	M/M	M	M	M
19	Allow outdoor walking	C/C	C	C	C
20	Allow outdoor walking with Nordic walking sticks	C/C	C/S	C	C
21	Allow indoor exercising (sitting and standing)	M/M	M	M	M
22	Allow dancing (sitting and standing)	C/C	S	S	C
23	Allow multiple users to play at the same location	C/C	S	S	M
24	Allow for multiple users to play together from different locations (at home etc.)	M/M	M	M	M
25	Allow for playing together at the same time (synchronous)	M/M	M	M	M
26	Allow for playing a game together, but not simultaneously (asynchronous)	S/S	C	C	C
27	Have warm-up activities	S/S	M	S	S
28	Have cool-down activities	C/C	M	S	S
29	Have balance exercises	S/S	C/M	S	S
30	Have strength exercises	S/S	M	S	S
31	Have endurance exercises	S/S	M	S	S

32	Have flexibility exercises (upper part of the body)	S/S	M	M	S
33	Allow a coach to see progress	C/C	M	S	C
34	Be close to reality (the game surroundings)	C/W	C	S	C
35	Be beneficial for the mental fitness of elderly people	C/C	W	S	S
36	Be possible to play even with limited fine motor skills	S/M	M	S	S
37	Allow to choose between competitive and cooperative gaming	C/C	C	S	C

Non-functional requirements are to be found in D4.1.

10 Summary

In the requirement phase we have tested and evaluated several commercial exergames with users in three different countries, we have developed scenarios (see appendix C and D2.1), and studied the state of art and related work. A list of basic requirements for Join-In exergames has been identified and given priorities.

Most of the users who took part in the exergame evaluations had little or no experience with computers and computer gaming, and some of them were even reluctant towards new technologies. However, the users expressed that they found exergaming a very positive experience.

In Join-In we envision several games and application using gaming elements, for motivation to exercising and physical activity in daily life. Possible physical activities to incorporate in exergames are walking (indoor and outdoor), exercising, dancing, and biking. In Join-In we also take into account that the prevalence of physical impairment and chronic conditions increases with age, and therefore incorporate exercise activities that will be beneficial for as broad user groups as possible. Both in the selection of hardware to use (TV, PC, Tablet, motion sensors and game controllers) and the design of the applications we are committed to the capabilities and needs of our target user group - the elderly.

Appendix A Exergame Review

This section describes a set of criteria, which each video game in this appendix will be assessed against. In this section each criterion is explained, a method or tool for assessing that criterion is provided and the relevance the criterion has to the Join-In project is detailed. The review evaluation criteria have been motivation, enjoyment, intensity, approachability, usability, adjustability, social integration and familiarity, and the games have been reviewed based on literature findings, testing with users and own considerations.

Motivation

Computer Games have been identified as a tool to motivate users (Malone and Lepper 1987).Learning games have been defined as a motivational tool that adds emotional content to the instructional content of standard learning (Berger and Muller 2009). Three primary motivations for playing games were identified as: the physical challenge, the mental challenge and the social experience (Whitton 2007). The data gathered from a study of one hundred and eight students, which compared traditional computer-assisted instruction and computer-based video game instruction, revealed that learning with the aid of video games was more effective (Chuang and Chen 2009).Motivation is an important aspect of the Join-In project because elderly users of the software will need to feel motivated in order to play the games for longer, more frequently and to try and beat their scores or others scores. Motivation can be measured using Harter's Intrinsic/Extrinsic Orientation Scale (Harter 1981).This scale or a variation of it has been used in several studies such as Lepper, Iyengar and Corpus's study of Harter's Individual Differences Scale (Lepper et al. 2005).

Enjoyment

Player enjoyment has been highlighted as the single most important aspect of a video game (Sweetser and Wyeth, 2005). If a player does not enjoy the game they will not want to continue to play the game. In the Join-In project enjoyment will be a key factor. The elderly users will need to enjoy the games designed by Join-In in order to influence them to play frequently and for longer periods of time. A theory used to explain enjoyment in games is flow, defined by Csikszentmihalyi as "being completely involved in an activity for its own sake. ….Your whole being is involved, and you're using your skills to the utmost" (Csikszentmihalyi, 1997). The flow experience typically consists of the following eight elements:

- A task that can be completed.

- The ability to concentrate on a task.
- A task that has clear goals.
- A task provides immediate feedback.
- A deep but effortless involvement.
- The ability to exercise a sense of control over actions.
- A users concern for self disappears, but the sense of self emerges stronger afterwards.
- Sense of the duration of time is altered.

These elements are defined by Csikszentmihalyi, Harper and Row (Csikszentmihalyi et al. 1990). The EGameFlow scale developed by Fu et al. can be used to test enjoyment. The scale consists of eight dimensions “concentration, clear goal, feedback, challenge, autonomy, immersion, social interaction and knowledge improvement”. The results from validity and reliability tests which were administered by Fu, Su, and Yu revealed that the scale “clearly demonstrated acceptable divergent validity” and “the scale demonstrated good test-retest reliability” with a Cronbach’s alpha value of 0.942 (Fu et al.2008). Cronbach’s alpha is an objective measure of the reliability of an instrument developed by Lee Cronbach. A score of 0.9 or above has an excellent rating of internal consistency (Cronbach 1951).

Intensity

Intensity is defined by the U.S. Department of Health and Human Services as how hard a person works to do an activity (U.S. Department of Health and Human Services (HHS) 2008).The three levels of intensities examined are light, moderate and vigorous (U.S. Department of Health and Human Services (HHS) 2008).It was discovered by Tan, Aziz, Chua and Tehin in a study of 40 young adults that the game Dance Dance Revolution (DDR) met the intensity standards for cardio respiratory fitness set by the American College of Sports Medicine (ACS) (Tan et al. 2002).

In digital games a heart rate monitor can be used to perform this calculation. The intensity of games developed for the Join-In project should start at a low level, with the option to increase the intensity. Games that start with a vigorous intensity will not be accessible for all users. To meet ACSM standards it is important to allow users to work up to moderate and vigorous intensities.

Intensity can be measured using the Karvonen formula and has been applied in existing studies of video games (Trout and Zamora, 2008).

Fogel et al. performed a study investigating the effects of exergaming on physical activity among inactive children. They identified a limitation of their study as not measuring the intensity of the physical activity using a method such as the Karvonen formula during the exergaming session (Fogel et al. 2010). The target audience for the Join-In project are

elderly users. Elderly users may have special needs that must be considered before developing software, for example Chronic Obstructive Pulmonary Disease (COPD). It is important to keep the level of intensity low for this project to not exceed the user's limitations.

Approachability

Game approachability can be described as "how easy it is for a novice player to be able to start playing the game without facing setbacks that will discourage the player from continuing" (Molin 2010). The Join-In project is targeted at an elderly audience, which will consist mainly of novice players. It is vital that the games developed are easy to approach by the target audience. If users find the game difficult during initial setup and the first play of the game they may not play again. Accessibility is a similar term to approachability, which is used in human computer interaction. Accessibility is defined as "the factor by which the user of an artefact can go from no knowledge of the artefact to adequate knowledge to be able to use the artefact to satisfaction" (Preece et al. 2007). Desurvire and Wiberg describe accessibility as how usable a system is by as many people as possible, usually the term relates to usability in relation to disabilities (Desurvire and Wiberg 2008). The Game Approachability Principles (GAP) is a set of guidelines devised by Desurvire and Wiberg to help designers create high quality tutorials and learning levels to introduce casual gamers to the game (Desurvire and Wiberg 2008). Game Approachability Issue Definition (GAID) is a flowchart which aims to improve on the GAP model by identifying limitations in the design of a game (Molin 2010).

Usability

Usability in relation to software is defined by the International Organisation for Standardisation (ISO) as "the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments" (ISO 9241-11 1998). Video games, like other software provide a user interface, this interface should allow a user to interact with the game both effectively and efficiently. It is noted by Federoff that these same three aspects of usability do not apply equally to the playability of the game. Federoff identifies satisfaction as the central aspect of evaluating usability in the terms of both interface and playability (Federoff 2002). Usability like approachability is a vital factor for the Join-In project. The approachability of a game determines how new users will receive the game while the usability determines if and for how long a user will continue playing. In the case of this project an efficient and effective interface will be a necessity for elderly users. Satisfaction questionnaires can be used to assess whether the usability criteria have been met (Bevan 2008).The Software Usability Measurement Inventory (SUMI) is a method for measuring a user's satisfaction with a piece of software, which provides results used to assess perceived software quality (Kirakowski and Corbett, 1993).

SUMI is a 50 item questionnaire answered with either: agree, don't know or disagree SUMI is recognised by the ISO as a method of testing user satisfaction (ISO 9241-11).

Adjustability

The adjustability of a game is broadly described as the ability of a game to change the difficulty of an experience. In most games, adjustability is provided to allow games to be played at a level that is suitable for the expertise of the player (Missura and Gartner, 2009). Maintaining a level of difficulty that is consistent with the player's ability is an important aspect of every game for the project. If the games cannot be adjusted correctly then the users will not enjoy playing the games, and could become bored or frustrated and stop playing altogether.

According to Westra et al. adjustability can be broken down into two distinct categories (Westra et al. 2008):

- Pre-defined: This method implements a more traditional option of choosing "easy", "medium" and "hard" levels, and applies static difficulties to each chosen option (Westra et al. 2008, Missura and Gartner, 2009). Westra et al. state that this static model may lead to less than optimal uptake of the game in the case where players do not fit well with the expected stereotypes (Westra et al. 2008).

- Dynamic Balancing: This method implements the ability to adjust the game itself while during play without the need of an expert guiding this process (Westra et al. 2008). Research by Andrade et al. states that there are three important aspects that must be considered when performing dynamic balancing. First, the game must identify the player's skill level as quickly as possible and adapt accordingly. Second, the game must track, as closely and quickly as possible, the player's evolution and regression in performance. Third, the game behaviour must remain believable throughout (Andrade et al. 2006).

Missura and Gartner also suggest that games which provide in-game adaptive difficulty based on player performance tend to result in players enjoying them more than games that ask the user to select the typical levels of "easy", "medium" and "hard" (Missura and Gartner, 2009).

Dynamic balancing can be implemented using many different methods. Demasi and Cruz suggest a heuristic function called "challenge function", which maps a given game state to a value that implies how easy or difficult the game is for a user at a given time. Examples of these heuristics can be: number of successfully answered questions, time taken to complete a task, or any other metric that can be used to calculate an in-game score (Demasi and Cruz 2002). Spronck et al. suggest that through the dynamic scripting of

opponents, dynamic balancing can be achieved (Spronck et al. 2004). Although these methods are some of the more popular ways to implement dynamic balancing, there are also many other ways this can be achieved.

Andrade et al. approach to measuring the success of dynamic balancing was to associate it with player stratification. This allowed them to gather data using usability tests, opinions from the players through structured questionnaires, and user open feedback about the game. In order to take into account all the aspects that influence game balancing and user satisfaction, their testing included controlled user testing, satisfaction questionnaires and post-experience interviews as outlined in research by Maguire in “Methods to support human-centred design” (Andrade et al. 2006, Maguire 2001).

Social Integration

One of the goals of the Join-In project is to help prevent the elderly being socially isolated and establish new social circles through the online platforms. Social integration research by Cohen has shown that the lack of general resources provided by the real or perceived presence and involvement of other people, commonly referred to as “social support” plays a central role in the development of depression (Cohenet al, 1985).

Measurements of the user’s current social circles will be taken using Cohen’s Social Network Index (SNI). SNI measures both the structural size of an individual’s social network and recent contact with members of their social network (Cohen, 1997). The SNI can then be used by the Join-In project to establish overall scores for a user and thus identify how socially connected they are. This score can then later be used to see if their social connectedness has improved by playing the games via the online platform.

A study by Fleming Seay measured social integration using the following headings: social network size, perceived social support and loneliness, with each having a series of different scales to measure each heading. This method also supported the use of the SNI as measurement of social circles. It also further used The Interpersonal Support Evaluation List as measurement of perceived social support and UCLA-L as measurement of loneliness (Fleming Seay, 2006). This research method will be further investigated if a more detailed profile of the user’s social integration is necessary.

Each game will also be further evaluated using the social interaction element identified in the method GameFlow by Sweetser and Wyeth. This element has a set of criteria which can be used to evaluate each game for the online platform. The GameFlow study concluded that games which are successful generally fulfil the criteria set out in each element (Sweetser and Wyeth 2005).

Familiarity

The elderly are least likely to use the internet and play digital games out of all the age groups investigated (IJsselsteijn et al, 2007). A report suggests that even though the elderly play digital games less than other aged groups this cannot be attributed to their lack of interest (IJsselsteijn et al, 2007).

With this in mind it is important that any willingness by the elderly to use the social platform to play games be met with as much familiarity to them as possible. This familiarity will help them adopt the platform and play the games with less difficulty. According to Hammitt, familiarity that is gained through prior knowledge and past experience can be vital to how people react to an environmental scene. Past experience helps people develop cognitive models of their environment, which can aid them in the perception of future environments (Hammitt, 1979). Potential users of video games who lack familiarity with digital games may see the required skills to play as taking a long time to master (Zelnick, 2005).
Research by Zhang and Ghorbani suggests that there are five factors which effect familiarity: prior experience, repeated exposure, study duration, level of processing and forgetting rate. However even with these factors identified they insisted that measuring familiarity was a comparatively hard issue. They also noted that many different approaches to measuring familiarity have been proposed by researchers. (Zhang, J. and Ghorbani, A., 2004).

Knowing that there are many methods to measuring familiarity it is important that a method that best measures the familiarity of a game to a user be chosen. Research has shown that methods such as Natural Mapping can help improve enjoyment of games for users because of real world familiarities (Skalskiet al, 2006). Natural Mapping is the ability to replicate actions present in real life tasks to that of their digital equivalent. An example of this would be the action required to throw a bowling ball in bowling. This same action is replicated in Wii Bowling for the Nintendo Wii using the accelerometer in the Wiimote.

Workout Exergames

Workout exergames typically have a virtual trainer which is generally represented by an in-game human avatar, who will attempt to motivate the user. The in game trainer explains and demonstrates the exercise the user is going to perform. A benefit of this type of exergame is the motivational aspect given by the in game personal trainer.

The games assessed in this section are as follows: Wii Fit Plus and EA Sports Active**.**

Wii Fit Plus

Wii Fit Plus is a sequel to Nintendo's Exergame Wii Fit. Wii Fit Plus like its predecessor uses a peripheral balance board (see Figure 14). The balance board is designed like a body scale which can measure the user's weight as well application and distribution of

pressure using pressure sensors (see Figure 15). The game is comprised of several mini games all of which range in difficulty and targeted skills. These mini games are categorised as strength training, yoga, aerobics and balance games. Wii Fit Plus contains all the original Wii Fit exercises with additional challenges added for Wii Fit Plus such as cycling, rhythmic Kung-Fu and a golf driving range.

Figure 3 (*In-game Wii Fit Plus screenshot with avatar mimicking user's actions)*

Figure 4 (*Diagram of the Wii Balance Board)*

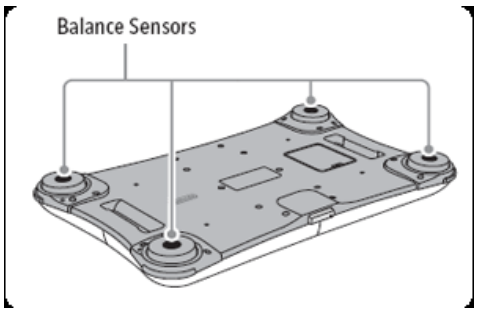


Figure 5 (*Diagram displaying the layout of the Balance Board pressure sensors)*

Motivation

All exercises in Wii Fit are demonstrated by an in game virtual trainer. There are two trainers selectable during initial setup. The trainer can be viewed as a mirror image or from

behind while exercising. The trainer attempts to motivate and assist the user during exercises, to help the user increase the number of repetitions they can perform, thus improving the users rating. The users' rating is presented on completion of an exercise. Wii Fit also attempts to motivate the player outside of exercises by giving them general hints and tips. The motivational values of Wii Fit were examined by Brittany Gardner, in a test of the effectiveness of Wii Fit on balance. The study took place over a three week period in which motivation was measured using a six point Likert-Scale (Gardner 2011). The scale was modified from Brown's study using Wii Fit for treatment of balance problems in stroke patients (Brown et al. 2009). The results of the scale averaged at 3.5, where 3 was defined as "fairly motivated, fairly interested in activity and fairly excited to complete" and 4 was defined as "very motivated, very interested in activity and excited to complete". The results displayed that repetitive activities, in this case the "Basic Step" game received lower scores in the final days of the phase. One of the test subjects commented that "the Wii Fit stepping activities became boring and less interesting due to the repetitive nature of stepping" (Gardner 2011).

Enjoyment

A study conducted on 10 to 12 year old boys assessing the enjoyment of active video games compared with other activities, found that on average the boys enjoyed Wii Fit more than walking, playing PlayStation 3 or watching television (White 2008).

Intensity

Wii Fit Plus has a wide range of intensity from simple stances to complex yoga positions. A study by researchers in the University of Connecticut Health Centre found that the Wii Fit level of intensity allowed patients suffering from chronic obstructive pulmonary disease (COPD) to perform at 60 to 70 percentage of their maximum heart rate (Albores 2011). A study by Grieser found that Wii Fit on average falls into the category of moderate intensity (Grieser 2010).

Approachability

Wii Fit Plus always gives in depth instructions for all its exercises. The in-game motivational trainer gives assistance during each exercise while the "Fit Piggy" and Balance board in game character give hints and tips to the user outside of exercises. In each section: strength training, yoga, aerobics and balance games the only accessible options initially are less intense and easier challenges. These must be completed in order to gain access to more difficult and intense challenges. These initial challenges ease the users into how the game plays overall.

Usability

Wii Fit Plus has a very simple interface with limited options making it very hard for a user to get confused. Wii Fit uses the Wii remote to interact with the menu, and certain games such as jogging where the Wii remote is held or put in a pocket. The in-game menu

designed for Wii Fit Plus is simplistic and intuitive. To initialise any exercise from the in-game menu the user only needs to select the overall category then the specific exercise and finally the difficulty of the exercise. The exercise may then present the user with additional options such as number of repetitions before starting. The primary controller used to interact with Wii Fit is the Wii Fit balance board, which is a pressure sensitive device that measures the application and distribution of a user's weight. The board is used to perform most exercises and balance games as well as for measuring the user's weight to calculate their body mass index (BMI).

Adjustability

There are two static difficulty settings available for each exercise, beginner and advanced. In general exercises that are unlocked later on are of higher level of difficulty for example the starting yoga exercise the 'half-moon' which requires the user to stand with the users arms above head level and lean left or right to stretch. A yoga exercise unlocked at a later stage the 'shoulder stand' requires the user to lay on the ground and then the users legs need to be extended and raised as high as possible, the user then needs to balance using only the shoulder muscles. The difficulty of performing the 'shoulder stand' is higher than performing the 'half-moon'. Each exercise itself generally has some variable factor such as number of repetitions which can be adjusted to alter difficulty.

Social Integration

Wii Fit allows multiplayer of up to two users in some of its mini games. Walking/jogging can be played with two users cooperatively. Hula Hoops can be played competitively with another user. All of the exercises and mini games feature a high score table to add an element of competition to every game. There is no online functionality for the game.

Familiarity

The yoga and muscle exercises will not be familiar to most users however most activities have very basic rules and should be very familiar to most users, such as walking, hula hoop, and football. A study performed by Brittany Gardner testing the effectiveness of Wii Fit on balance found motivation scores were higher for activities the subject was familiar with(Gardner 2011).

EA Sports Active 2

EA Sports Active 2 is the sequel to EA Sports Active. The sequel expanded its targeted platforms from Nintendo Wii to also include the Xbox 360 and the PlayStation 3. EA Sports Active 2 offers an intense workout and is designed as a workout tool rather than a game. While other Exergames feature mini games that are not explicitly for workouts EA Sports Active 2 focuses solely on exercise.

Figure 6 (*In game EA Sports Active 2 screenshot with avatar mimicking user's action)*

Motivation

EA Sports Active 2 allows the user to select one of two personal trainers. The trainer will guide the user through the exercises and challenges and provide motivational support. An example of the motivational support provided is found in the running exercise where the trainer will give the user advice such as "remember to keep your shoulders relaxed and your back straight" or encourages the user to increase running speed to overtake other in-game avatars. If the user is not completing certain tasks the in-game trainer appeared to not recognise this failure for example in the lunge exercise the counter continued to increase even when the user stopped performing lunges.

Enjoyment

EA Sports Active 2 does not contain mini games as found in Wii Fit such as the balance games. This would affect the overall enjoyment value for those looking to play the game for recreational purposes. A study by Bussell and Elliott-Sale from Nottingham Trent University found from discussions with participants testing EA Sports Active 2 that there was a high level of enjoyment experienced during their workout (Bussell and Elliott-Sale, 2010).

Intensity

A scientific study conducted by Dr. John Poracari from the University of Wisconsin discovered that EA Sports Active met the ACSM guidelines for effective physical fitness. The 16 participants in the test reached exercise intensity ranging from 64 to 94 per cent of their maximum heart rate and burned 200-300 calories per session (Poracari 2010).

Approachability

EA Sports Active contains an in-depth setup when compared to Wii Fit. Its initial setup prompts the user to customise their avatar which is as detailed as the character creation found in most role playing games (RPG) such as Fallout 3 and is likely to confuse new users, especially users who are not familiar with video games. The in game tutorials are thorough and a video is shown with the in-game instructor explaining how to perform an exercise before that exercise begins.

Usability

The menus are clearly labelled and easy to navigate. The selection of specific exercises is not intuitive such as lunges are part of the basketball workout which may not be evident to users unfamiliar with basketball. EA Sports Active uses the Microsoft Kinect controller on the Xbox 360 and the Nintendo Wii Remote on the Nintendo Wii. On the PlayStation 3 EA Active also uses their own sensors which are strapped onto the users left and right arm as well as the left leg (see Figure 17). The left arm sensor reads the users heart rate. These sensors are also used with the Xbox 360 and Nintendo Wii in tandem with the respective controllers for those devices.

There is a feeling of inconsistency when playing EA Sports Active 2. Some exercises fully track the users motion while others don't care whether the user participates at all, for example during a lunge exercise if the user stops lunging the counter increments as the trainer lunges.

Figure 7 (*EA Sports Active 2 arm and leg sensors with wireless USB connector)*

Adjustability

The difficulty varies between exercises. Some of the exercises in EA Sports Active 2 are more intense than those of other exergames such as Wii Fit, thus the standard difficulty is higher. Examples include the mountain climber exercise and the basketball workout.

Social Integration

EA Sports Active offers a local multiplayer option. The user is required to own a second set of motion sensors for the second player. The local multiplayer enables both users to compete by completing the exercises before each other or more successfully than the other user. Some exercises have no competitive mode, such as lunges where the users follow the instructor and must complete each lunge in time.

EA Sports Active allows the user to upload their statistics to an online server which can then be compared on different leader boards.

Familiarity

Most exercises in EA Sports Active should be familiar to users. They are general stretching exercises or basic activities such as walking or jogging. The skateboarding exercises may be unfamiliar to users.

Rhythm Exergames

The first rhythm exergame ‘Dance Aerobics’ was released on the ‘Nintendo Entertainment System’ (NES) in 1987. The game used a peripheral dance mat called the ‘Power Pad’ which allowed users to interact with the game by stepping on arrows on the mat. The majority of rhythm exergames are dance based games. There are alternative rhythm exergames that use musical instruments to allow the user to interact with the game, some examples of these include ‘Guitar Hero’ and ‘Rock Band’. The genre has proven to be popular with users, for example Konami’s Dance Dane Revolution (DDR) sold over three million copies when it was released on the PlayStation. The rhythm exergame ‘Dance Dance Revolution’ has been tested against the guidelines of the American College of Sports Medicine (ACSM). The result of this test shows that the game met the requirements for developing and maintaining cardio-respiratory fitness.

The games assessed in this section is Dance Central.

Dance Central

Dance Central is a dance game for the Xbox 360 that is controlled using the Microsoft Kinect peripheral. The Kinect tracks the user’s movements and displays and displays them onscreen using an in game avatar. Dance Central does not require a dance mat as the Kinect performs full body tracking on the user. Dance Central features a “Workout Mode” which tracks the amount of calories burned.

Figure 8 (*Dance Central screenshot with in-game avatar mimicking the dance move performed by the user)*

Usability

The Dance Central menu options are basic with 4 options: dance, your stats, options and buy new dances. Your stats displays general statistics such as favourite track based on the track the user played most. To calibrate the Kinect the user must select the options menu. This menu also has two help options, one beginner one pro to provide support for new and proficient users. Inside dance mode the first selection brings up a list of tracks. Selecting a track brings up a sub-menu containing: break it down which is a tutorial mode

for the current song, perform it which is the one player mode, dance battle which is the 2 player mode and leader boards. If the user selects perform it a difficulty menu is displayed with three static difficulties: easy, medium and hard. After selecting a difficulty the final menu is displayed with the following options: play which begins the dance. Change venue to switch the dance arena and change dancer to switch the avatar. Workout mode which counts calories burned and no flash cards which is an additional difficulty to perform the dance with no assistance. To actually perform a dance requires navigating through 5 menus which makes a menu system complex.

Even though the number of menus a user has to navigate through to play the game the system itself is lower risk than a pointer system which was investigated in a study of the Kinects usability which was performed by cx partners. The company specialises in customer experience consultancies. The test was performed on 10 users, who each played 3 Kienct games, Kinect Adventures, Sonic Free Riders and Dance Central. A result of this study was that the users preferred the Dance Central menu system. The users felt comfortable using the menu system as they felt the swipe method of selecting an option was easier than moving a pointer.

Control Exergames

Control exergames are games that are controlled by the user's motions. Motions can be detected in many ways such as with a motion controller or a motion tracking camera. This section of exergames contains the highest number of games since the release of the Nintendo Wii and controllers for other systems such as the PlayStation Move and the Microsoft Kinect. A wide range of games fall into this category, however for the Join-In project the games selected for this section will be games that are suitable to new and inexperienced gamers.

The game assessed in this section is Dr. Kawashima's Body and Brain.

Dr. Kawashima's Body and Brain Exercises

Dr. Kawashima's Body and Brain Exercises (also known as Body and Brain Connection) is a combinaton of an exergame and a cognitive game. It makes use of the Microsoft Kinect device to allow the user to interact with the game. A cognitive challenge is presented to the user, who must solve the challenge using a physical motion for example making the greater than or less than symbol using your arms. The game is comprised of twenty mini games. The mini-games are divided into five categories each with four games, the categories and games are: Math, Reflexes, Logic, Memory and Physical.

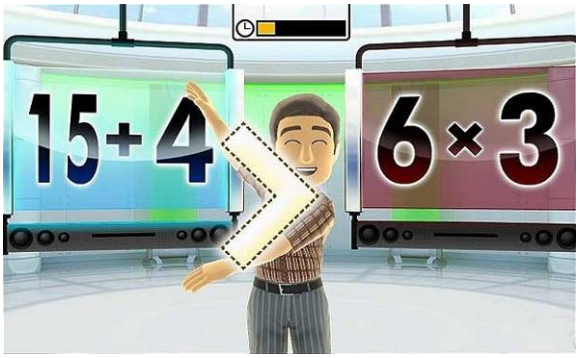


Figure 9 (*In-game screenshot of an avatar demonstrating the correct solution to the math problem)*

Motivation

Body and Brain Connection is part of the Dr. Kawashima game series, which includes Brain Training on the Nintendo DS. Like other titles in the series a digital avatar representing Dr. Kawashima gives advice to the user on how to improve at the game, this avatar acts as the in game motivator. A user's motivation to play the game frequently is the 'brain age' feature. The 'brain age' is a scoring system which asks the user to complete a set of daily challenges after the game has initialised. The score from this set of challenges is used to calculate a 'brain age' which ranges from twenty which is the best possible score to eighty which is the worst. This score is compared to the user's actual age to calculate how many years younger or older the user's brain is performing. The goal of reducing this brain age score is the primary motivation of the Dr Kawashima series.

Enjoyment

Body and Brain Connection attempts to merge popular activities such as 'Wack-A-Mole' and classic video games like 'Pac-Man' with low intensity physical exercise to add an element of enjoyment to the mini-games. The users of the testing session on the 3rd November 2011 found the game enjoyable in a competitive local multiplayer environment.

Intensity

Body and Brain Connection is generally low intensity with the exception of the 'step mania' mini-game. The 'step mania' game requires the user to memorize a pattern of lights and then walk and jump to the pattern. A left light means left step, right light means right step and no lights signifies that the user must jump. This mini-game would have a higher level of intensity due to the increased physical activity of jumping. The results from the user group testing indicated that the users had no issues caused by the intensity, members of the group commented that they felt positive effects from exercises such as 'What Time Is It' which requires the user to stretch their arms out like the hands of a clock.

Approachability

A new user must perform an initial setup consisting of three tests mixing cognitive and physical activities.

Activity 1:'What Time Is It' requires the user to match a 24 hour time displayed on screen to a 12 hour clock. The user's arms represent the hands on a clock, if the user is asked to display 21:05 on the clock the user must position the hour hand at 9 and the minute hand at 1.

Activity 2: 'Traffic Control', the user is presented with three coloured roads and coloured cars, the user must move their arms to raise and lower a bridge with the goal of getting the correct coloured car on the matching coloured road.

Activity 3: 'Math Jock', the objective is for the user to kick a football with a number on it to solve an equation. An example challenge such as 5+ [] = 9 is presented to the user. Two footballs are displayed on screen each with a number on it, for this example the footballs will have 4 and 5 respectively. The user must kick the correct ball in this case 4 to successfully complete the challenge.

These three activities calculate a "Brain Age" which is used as an overall score to gauge improvement.

These starting exercises are designed to introduce the user to the concept of the game and to familiarise with the Kinect controller. On the basis of the user testing both 'What Time Is It' and 'Traffic Control' were easy to approach for new users and by the end of the session the group was able to use the Kinect.

Usability

The options on the main menu are: brain test, today's exercises, custom exercises, group exercises and my data. The menu system is controlled using the Kinect. The user moves their hand over the option they wish to select, to complete a selection the user is required to keep their hand on the option while a transparent circle, similar to a standard loading bar is filled. The circle is filled in approximately 3 seconds, which was problematic during user testing as the users accidently selected to repeat a game or return to the main menu before they had read the options. The system of controlling a menu by pointing at the Kinect was found to be difficult to use and high risk for accidental selection. This study found that users expected wanted to make a selection by using a gesture such as a tap motion (Cable, 2010). The users preferred the menu system described in the Dance Central review see 6.2.2.2. A method of measuring usability is SUMI, which was administered to the user group as detailed in section 5.4.2.

Adjustability

There are three levels of static difficulty for each exercise: beginner, intermediate and advanced. How these difficulties affect each game differs for example in the mini-game

'Pop Till You Drop' the static difficulty affects the number of balloons presented to the user. The game is based on the Stroop Test which is a test of reaction time. The test displays the name of a colour, the colour of the text is not the same as the name, for example the word 'Yellow' is displayed but the word is coloured in red. The mini-game implements this test using coloured balloons and a word appearing in the centre of the screen (see Figure 21). The static difficulty changes as follows: beginner has three balloons red, blue and yellow, intermediate has four balloons red, blue, yellow and white, and advanced has the same four coloured balloons but the two words are displayed at once so the user must pop two balloons at the same time.

Figure 10 (*Demonstration of the mini-game 'Pop Till You Drop' showing how the Stroop Test is implemented.)*

The game also features adaptive difficulty which alters the static difficulty based on the user's performance during the exercise. An example of this is in the game 'Math Jock' where an equation such as (2 +? = 4) is presented to the user. As the user correctly answers these questions they increase in difficulty for example (43 - ?+ 8 = 48). If the user continues to correctly answer these questions the difficulty will increase, if the user fails to answer questions the difficulty adapts and reduces the equations to the starting format.

Social Integration

The local multiplayer option in Body and Brain Connection is a turn based system. Each user takes a turn completing a mini-game. The mini-games in the multiplayer mode have additional difficulties such as mosaic effect which blurs the screen randomly. These additional difficulties are randomly selected before a user starts a mini-game.

There is no online multiplayer available in Body and Brain Connection.

Familiarity

The mini-games in Body and Brain Connection will not be familiar to users, elements of the mini-games will be familiar. Activities such as pointing out the time on a clock and doing maths will be familiar to the user even though the gameplay implementing these elements will be new to the user. An example of the concept of mixing familiar elements together even though the end result will not appear familiar is the 'Math Jock' mini-game. The physical element of kicking a football is familiar and the cognitive element of solving basic

addition is familiar. The end result of kicking a ball with number on it to solve the equation is not a familiar idea.

Sensory Exergames

The sensory exergame group consists of custom built hardware for propriety systems. These systems are generally expensive, require a large amount of room to use and require assistance of an expert to set up. Two examples of sensory exergames are the 'Lightspace Play' (see Figure 23) and the 'Makoto II' (see Figure 24). This category of exergame will not be investigated further as the Join-In project aims to develop for platforms that are easily accessible for the elderly, the games in this category do not fulfil this requirement.

Figure 11 *(Demonstration of two users playing 'Lightspace Play')*

Figure 12 *(Demonstration of three users playing 'Makoto II')*

Exergame Machines

Exergame machines are generally devises based on exercise equipment such as stationary cycles and steppers. The two main methods of using these devices are with built in games or by connecting to existing games. The 'Expresso Interactive Cycle' is an example of an exergame machine which uses built in games (see Figure 25). The most popular exergame machine is the 'Gamercize'. The 'Gamercize' devices are an example of machines that connect to existing video games. The devices include a stationary cycle and a stepper that can connect to platforms such as the PC, PlayStation 3 and Nintendo Wii (see Figure 26). Compatible games include: 'Grand Theft Auto 4', 'Killzone 2' and 'Sims 3'.

Figure 13 *(Demonstration of two users playing a built in game on the 'Expresso Interactive Cycle')*

Figure 14 *(Demonstration of a school user group playing the video game 'Mario Kart Double Dash' using the stepper peripheral by Gamercize)*

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Appendix B Open game controllers & motion sensors

This is a list of “open” activity sensors and game controllers that can be considered for the Join-In project.

Blobo

Forget gamepads, joysticks and remotes. Blobo is an incredibly fun PC and Mac gaming experience: this golf ball sized device is packed with future sensor technology and works with *every modern PC. http://www.bloboshop.com (FI only)*

http://blobo.adalia.ee/ (EU shop)
paolo.monasterolo@adalia.ee

Openness: Ball-it Releases Unity3D-compatible Blobo SDK for PC and Mac Date: 11/15/2010

Blobo SDK provides access to advanced sensory and environmental data, including:

- 6 degrees of freedom motion and orientation data
- Advanced analogue squeeze and tap functions
- Mapping real world coordinate system, based on magnetic north and gravity

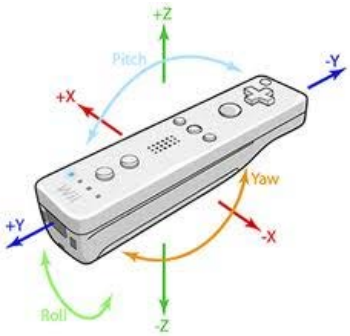
Available platforms:

- Native win32/Windows
- Unity3D Windows / Mac

Price: 60 euro

Nintendo Wii remote

The Wii remote is a game control for the Nintendo Wii that features:



- Bluetooth connection.
- Three accelerometers for calculating the pitch yaw and roll of the device.
- Seven buttons and a control cross (adding 4 more buttons)
- An infrared cam capable of distinguish four infrared spot in a 1024x768 pixel plane.
- A vibrator, a speaker and four leds.

This device has become very popular within the hacker community, since it offers all of the described features for only $40 approximately.

Other devices can be plugged to the Wii remote augmenting its capabilities. The most common is the Nunchuck, a device to hold in the other hand that features another three accelerometers, two buttons and a control cross (4 more arrows). A Wii Motion Plus sensor improves the accuracy of the system by measuring angles.

Openness: Due to its wide popularity, the Wii remote has been the focus of attention of the hacker community since it was launched. The communication protocols of the Wii remote and its hardware architecture has been reverse engineered almost completely. Using this information, many people have programmed libraries and application that make use of the Wiimote from a personal computer, many of them available at http://wiibrew.org. Others have developed applications, using those libraries, which make a creative usage of the Wii remote beyond of it initials specifications.

The most common way to use the WiiRemote is to hold it in the hand and use the hand´s movements to control the game. Another approach is to use the WiiRemote an infrared camera and track the infrared sources movements. For example, the WiiRemote can be next to the user and track infrared leds that are placed in the user's fitness device.

Price: approximately $40

Nintendo Wii board

The Wii board is another control for the Nintendo Wii. It consists on a plain square device where the user stands up. The four zones in which the device is divided contain weigh sensors to measure the user weigh and (derivate from that data) the user movements and equilibrium abilities. This device uses Bluetooth for wireless connections as well.

Openness: there are open source APIs to access data from the device.

Price: around 50 Euros

iPhone and Android smart phones

Both devices have built in motion sensors that a mobile application (apps) can exploit in order to act as a controller to interact with games on a bigger screen. They also tend to incorporate a compass that can be used to track the direction it points. Bluetooth will be the communication channel.

Openness: these mobile phones provide open APIs to access the hardware resources. However, they may put limitations on the distribution of software (apps) their on-line app stores.

Price: 300-700 Euros

Dancing Mats

Dancing mats are the main interfaces for dancing games where the users need to step on different parts of the mat according to the music performing aerobic exercises.

Openness: many of the dancing mats have open source libraries for Linux.

Price: around 20 Euros

Sensor Mats

Professional sensor mats from Future Shape (www.future-shape.de/en/) are the basis for different applications like fall detection, burglar alarm, light switching, heating control and counting of persons. Every mat consists of several sensor pads. Each sensor pad has several capacitive sensor fields and one active wireless transmitter. The mat design is very flexible concerning colour, surface material and shape of sensor fields.

Currently the following interfaces are available:

- Keyboard simulation for selected keys
- MIDI interface, see piano and music mat
- Wireless controlled wall outlets
- RS232 serial interface with raw sensor data

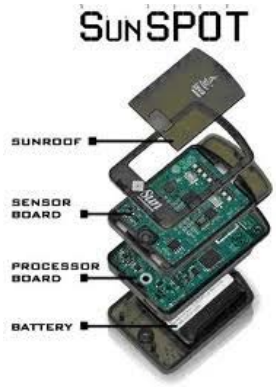
Currently drivers for fall detection are available but not for general pressure, acceleration or weight evaluation. A co-operation with Future Shape would be possible.

Price: around 800 Euros for a mat with 8 sensor pads

Experimental sensor mats are easy to build based on conductive films. It is possible to build sensor mats tailored to special requirements below any surface. At www.instructables.com/id/Stickytape-Sensors several solutions and materials are explained in detail.

Electronic components and software for interfacing are available at www.arduino.cc and www.phidgets.com. Phidgets provides capacitive sensors with extendable area beside of many other sensor types.

Development mote with accelerometer



There are many development platforms for wireless sensor networks that incorporate accelerometers. For example, many commercial motes are using http://www.tinyos.net/, also there are motes with Java (e.g. http://www.sunspotworld.com/).

Openness: completely open most of them, but the only provide low-level APIs.

Prize: 120 Euros

Inertia Technologies ProMove-2

An example of motion sensors and wireless sensor networks are the ProMove motes from Inertia Technology in the Netherlands (http://inertia-technology.com/).

ProMove-2 is a highly miniaturized inertial sensor node that captures and communicates wireless full 3-D motion and orientation information. It combines the latest advances in MEMS sensor design and low-power wireless communication. The sensor information consists of: 3-D acceleration, 3-D turn rate (gyroscope) and 3-D magnetic field intensity (compass). The data is communicated using the 2.4 GHz wireless radio to the FastGateway, which connects through USB to a computer. Multiple ProMove-2 nodes can form a network and report the sensor data fully synchronized to the FastGateway. The sampling rates scale with the number of nodes in the network, e.g. 200 Hz for 6 nodes, 100 Hz for 12 nodes.

The ProMove-2 is the motion sensors used in the AAL project IS-ACTIVE (http://www.is-active.eu) where Norut and Norwegian Center for Telemedicine participates. For IS-ACTIVE we use a ProMove-2 that also supports Bluetooth directly on each sensor node. IS-ACTIVE will use the Promove-2 as sensor and controller for applications aiming at increased daily activity and physical exercising.

Openness: The protocol is open

Price: N/A

Cube-Game

Using hardware similar to the wireless motes previously described it is possible to built small computer devices with LCD screen and sensors. These can be used to build advanced pervasive games.

The product is not yet in the market.

https://www.sifteo.com/product

Kinect

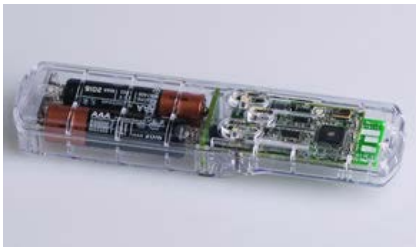
Kinect for Xbox 36 is the latest game controller launched by Microsoft. Using advanced artificial vision technologies it is capable to recognize 3D movements with the highest precision by just using its camera.

Openness: Microsoft has not made any attempt to limit the use of the technology for other purposes and the open source community has already developed open source APIs for the device. However, those APIs are only available for windows machines.

Price: 120 euro

Freespace / Hillcrest Labs

FSRK-BT-1 Reference Kit (bluetooth version)



This reference design incorporates a complete six-axis Freespace® motion solution integrated with Bluetooth® RF. To simplify evaluation, the reference kit includes a remote control packaged in a small form factor. The removable module in the kit includes the Freespace MotionEngine and microprocessor together with MEMS inertial sensors, and supports prototyping with other form factors.

The FSRK-BT-1 can be used with the Freespace Motion Studio and libfreespace for performance evaluation, software development and device configuration.

http://hillcrestlabs.com/products/freespace-tools.php Freespace Motion Studio free download, http://libfreespace.hillcrestlabs.com Open Source Software

Price: $119 for FSRK-BT-1 plus about $100 for delivery to Europe

Loop Pointer / Hillcrest Labs

The Loop™ pointer is the in-air mouse that moves your cursor with natural hand motion. Simply point and click on the TV that's connected to your PC or Mac. Use the Loop pointer just like a mouse while you browse the Internet or view your own media content. The distinctive ergonomic design has just four buttons and a scroll wheel.

The Loop Pointer is sold in the US only (currently).

Openness: Controller development kits are available also from Hilcrestlabs http://hillcrestlabs.com/products/freespace-reference-kits.php

Price: $49 for Loop pointer only

Sixense Truemotion

This Sixense truemotion is a motion based controller that is essentially a refinement of the Nintendo Wii remote. It offers six degrees of freedom motion tracking and uses a magnetic field for tracking position and orientation. Unlike the Wii remote, line of sight is not required and it would appear to be targeted towards PC users. http://www.sixense.com/

Openness: Development kits are available from Sixense, but it is not clear whether non-commercial game developers can avail of them.

Price: Not on sale yet but scheduled for release in 2011.

OCZ Neural Impulse Actuator (NIA) Game Controller

This product was released in 2008 and is a headset that translates facial expressions, eye movements, brain Alpha waves and Beta waves into control signals. The box that performs the signal processing is connected to the host PC via USB, so the user is effectively tethered to the PC. (http://www.ocztechnology.com/products/ocz_peripherals/nia)

In our lab tests this device is hard to use and is not a real solution for the elderly.

Openness: An SDK was released in December 2010 and is freely available.

Price: €100 approx.

Emotiv Epoc Neuroheadset

The Emotiv EPOC is a high resolution, neuro-signal acquisition and processing wireless neuroheadset. It uses a set of sensors to tune into electric signals produced by the brain to detect player thoughts, feelings and expressions and connects wirelessly to most PCs. The headset has a built-in gyroscope to generate positional information for cursor and camera controls.

The Emotiv Epoc is available to buy from the US only.

https://emotiv.com/index.php

Openness: A researcher edition SDK is available for $750.

Price: $299 excluding shipping costs.

Playstation Move

The Move is a combination of two devices; 1) a handheld motion controller with a sphere that lights in different colours at the top and 2) a video camera, known as the Playstation Eye camera, that tracks the movement of the controller through the lit sphere. The Move is designed for the Playstation 3 game console. The Move controller includes a three axis gyroscope, a three axis accelerometer and a terrestrial magnetic field sensor, as well as a colour-changing sphere that is tracked by the PlayStation Eye camera.

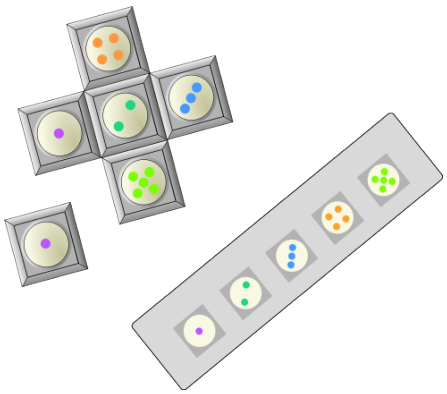
The Move controller also includes several buttons that replicates some of the functionality of the Playstation dualshock 3 wireless controller (a separate product).

http://us.playstation.com/ps3/playstation-move/product-information/

Openness: The open source community is currently working on APIs for this device for the PC.

Price: € 60 approx for one controller and the eye camera.

Genesis Game Controller



Genesis has developed games and special controllers mainly for handicapped persons, that are individually labelled (e.g. Dots) according to the keys on the screen, allowing to play the game without being forced to use mouse or keyboard. The key functions are configurable with the Genesis software and are permanently stored in the keys.

A modular keyboard, which allows for any combination of the single keys (9cm x 9cm) e.g. in one row or as a cross, was developed. One is free to play with five, two or even with only one key, depending on the abilities of the person playing. The controller is constructed in a way that resists even strong beats. Set price about 760 €

As a second alternative a flat button keyboard (35cm x 10 cm) is planned for about 200 €, that responds to light touches. The threshold for reactions is adjustable. It is constructed as a closed device with a flat surface made of Plexiglas, therefore it is easy to clean.Up to four keyboards can be connected to one computer via USB, that allows that up to four players can play games like ‘Glückskoffer’ together. Especially puzzles are suited for elderly persons. The games are not available for Browsers. Genesis open source games are available for Windows, Mac and Linux. The fee for Genesis light with four games is 29 €. Upgrades are protected with a usb-dongle.

http://www.efi.fh-nuernberg.de/genesis/

Videoconferencing Equipment

Face Vision TouchCam N1

FV TouchCam™ N1, a HD VideoCam with embedded H.264 encoder chip and dual microphones supporting beamforming technology, offers synchronized, crystal clear HD video (720p, 3X DVD resolution) and superior audio quality. The embedded H264 encoder with low latency makes it suited especially for STBs. The availability of drivers for linux is not known currently.

Price: < 120 €

Appendix C Exergames scenarios and example exergames

This appendix contains the personas and (before-after) scenarios made in Join-In with exergames examples, and some example exergames envisaged.

The secret forest scenario (Astrid and Kari)

Astrid and Kari are two old friends in their late 70s. They participate in training sessions in a centre for seniors once a week. Both of them are relatively healthy widows, and they have spent a lot of time together after they both became widows. Lately they have been introduced to a couple of exergames particularly developed for elderly, and they spend some time of the training session “play-training”. The games are very easy to use with clear instructions and few choices, and the instructors at the senior centre have also been guiding them through possible pitfalls. The games have stories, music and images that are better suited for seniors than for the young. The game controllers both comprise dance mats and handheld remotes (that can be strapped around the wrists).

A game of special liking for Astrid and Kari is one where they walk through a forest in search for items and buildings. In the buildings they get tasks. For instance, if they find a cottage they can get tasks such as laying a table getting cups and plates from the cupboard, lifting kettles off the stove or taking a cake out of the oven. This means that they both have to stretch and bend for real. It is also possible to find garden sheds, a pick-nick place, etc. Items they find in the forest can either be used to solve tasks, decorate the “home” cottage or it can be given to the game friends – either to those playing simultaneously or to someone who is not present at the moment, but is a game friend or buddy. The players might also encounter a barking dog, forcing them to walk a bit faster. In some places in the forest, they can meet others playing simultaneously. One can “buddy up” with other players, and it is possible to give items to these buddies, also when they are not playing.

The two women often forget that they are exercising when they walk through the forest, bending down to pick flowers that they can give to each other – or to one of the men who are also participating.

Training sessions in the senior centre are only offered once a week, and both Astrid and Kari would like to meet and train and play more often. They would also like to both be able to do their regular training and “play-train” more.

After a few weeks they are offered to try to play the game online from home. They would still see the same image on the screen, but they would only see each other’s avatars, not the real person in the same room. The two women agree to play at the same time at least a couple of times a week. They still enjoy the game a lot, but they miss the chat that they have when they play in the same room. Since they cannot write at the same time as they pick flowers, they game developers promise to see if it is possible to add a simple oral chat function to the game when played online.

Exergame bike scenario (Terje)

Many years ago Terje quit using his exercise bike, but now that he has installed some games on it he has started to use it again. The bike is even connected to the Internet, so that he can play together with his friends.

Every Wednesday at noon he and 5-6 friends can meet each other in the game. The game can be played both alone or in a co-operation mode. On this particular Wednesday there are four of them, and they play in co-operation mode. They agree to play a rather childish game that makes them feel like little boys again. In the game they meet on a square in a medieval town and start to bike. The first quest this day is to save a “virgin in need” from a monster in a castle. On the way there are four obstacles, giving one task for each of them. These tasks must solved before they can save the young lady. One has to hunt down a dragon and run him down, one has to find a ladder somewhere in the hills outside town, one has to find an old lady who will give him the key to the castle and the last one has to find poison to give to the dog watching the tower. They can all follow the other players' progress, and when all have succeeded they meet in front of the castle. The dog gets the poison, the gate is opened with the key and the virgin can climb down the ladder without the monster noticing.

The game is controlled by biking in different speeds and turning in different directions. They also get hints on the way as to where to find the items they are looking for, but basically they just have to exercise to reach their goals. There are several quests in the game build over the same template. Each player can adjust the speed to his or her physical condition, so that they can reach the goals within the time they have planned to exercise. They play one more game this day. Now they have to find two treasures each to bribe the monster to leave the area.

On the next Wednesday they agree to play a kind of treasure hunt game. A senior association has found and scanned a lot of photos from their youth showing both locations, buildings and photos of people with the fashion of the old time. In the game they are supposed to find photos that have disappeared from a photo album. They cycle around in a forest, and find hidden photos either on the ground or in cottages that they pass by. This is also a collaborate game, and they all win together when the album is complete.

Exergame dance scenario (Marit and Leif)

Both Marit and Leif used to love dancing, but there are not many occasions now. Marit's balance is too bad to dance, and Leif is at a retirement home where there is no dancing. But now they have been introduced to this game where they actually can dance together over a distance. This is a dance game where motion sensor cameras is used. The “players” or dancers get handicaps, making it possible both to sit and stand while dancing. The dancers are represented by avatars on the screen, and it is possible to dance together – or at least have the avatars dance together. Marit and Leif used to dance a lot together in a dance club when they were younger, and now they enjoy meeting in the game, dancing to tunes from back then. Marit also loves to change the appearance of her avatar, dressing her up in different outfits and changing the hairdo every once in a while.

A Visit to the circus scenario (Margot and Kurt)

Margot and Kurt visit the circus. Instead of only visiting, they become the artists

They

- Juggle balls
- Train the sea lions
- Balance on the high rope
- Do a trapeze trick
- The make a dog do tricks
- Clowning
- Perform
- Move puppets on a string
- Horse riding
- Shooting
- Playing the various instruments from the orchestra

A walk through the seasons

- Winter
  - snowball fighting
  - cross country skiing
  - tobogganing
  - Alpine skiing
  - building an igloo
  - ice-skating
  - preparing for Christmas (baking, cooking, wrapping parcels,…..)
  - playing indoor games, e.g. charades
  - painting pictures
- Spring
  - Paying ball games
  - Hide and seek
  - Rolling eggs
  - (Painting eggs)
  - Playing with marbles

- Hopscotch
- Hula-hoop

- Summer
  - Going swimming to a lake
    - Getting the clothes ready
    - Getting the food ready/preparing for a picnic
    - Cycling to the lake
    - Putting the blanket on the ground
    - Putting on sun lotion
    - Lazing around
    - Playing ball,
    - Playing badminton
    - Going swimming
    - Making sand figures
    - Doing a picnic
  - Going on holidays
    - Hiking
  - Picking mushrooms
- Autumn
  - Picking fruit and making use of them (baking cakes, making jam, eating them,)
  - Collecting chestnuts
  - Building things /making pictures out of leaves /fruits
  - A walk through the forest
  - Building and flying a kite

A collaborative Walking Exergame

The collaborative walking game allows many users to walk together through a virtual world. The user is not pressured to walk at any pace but is encouraged to walk frequently to build up steps. Steps can be used in a multitude of ways, such as competition between groups or unlocking new worlds. Users can play with their friends locally and online so their steps are added together as a team. The interface for the game is minimalistic allowing the user to choose the world to walk in, to play alone or with friends and how long to play for (Fig 1). The user can select the virtual locations to be real locations that the users may not get to visit or local areas to allow users to tell stories about their past. Alternate routes can be accessed if the required number of users are walking at the same time, to encourage multiplayer participation. Additional physical challenges such as balance challenges and coordination challenges can be played as mini games or toggled on or off in the standard walk mode. The balance challenges test a user's ability to keep balanced as they walk on a virtual balance beam. If the user fails they are returned to the start of the challenge, if they fail three times they may skip the challenge. Elements of the Berg Balance Test can be tested too such as walking with your eyes closed. The coordination challenge makes users walk in unison or their steps aren't counted. This game will implement intergenerational interaction by increasing the intensity of the exercise for younger players. They will need to jog to keep up with the elderly player and any challenges will have stricter rules, such as what counts as a fall in the balance challenge. As players walk through the world they can press a record button to record a story for other users to play back. User data such as personal records and team records are available to view in the stats screen. (Fig 2)

Figure 1. Mock up: In-game interface. Top left is the player step data, the blue line with information shows an area of interest or landmark, top right is the story record button and bottom right is the menu button. The balance beam in the middle of screen is used in balance challenges.

Figure 2. Mock up: Stats screen, on the left is individual player data, right is team data.

Figure 3. Screenshot of the current Collaborative Walking Game prototype, the demo is running in the Firefox 4 browser.

Persona including possible AAL applications (Anna)

<table>
<tr><td colspan="2">Anna, 69 years old

“I miss my grandchildren“</td><td>  </td></tr>
<tr><td colspan="2">—</td><td>Possible AAL applications</td></tr>
<tr><td>Life situation</td><td>Lives in the city of Tromsø, the largest city in Northern Norway, with 60.000 inhabitants.

Grandchildren living in the capital of Norway, Oslo, 1600 km further south.

Moved to a flat when her husband died a few years ago.</td><td>Playing games on the computer together with her granddaughter in Oslo, a game where they solve challenges together, and achieve new levels based on this.

She is also watching movies with her granddaughter in Oslo, they are both film enthusiasts. They can see each other and chat while watching the movie on the same TV screen.</td></tr>
<tr><td>Profession / attitude towards/ experience on technology</td><td>Has a mobile phone, use it for voice call and for text messages

Has a computer at home, but only uses it for banking and solitaire

A former secretary in a shipping firm, used computers at work</td><td></td></tr>
</table>

State of health	Severe COPD, GOLD stage 3-4 Participates at the LHL level 1 peer based exercise group	Exergaming from home with peers from the rehabilitation centre. Performing exercises together, seeing the others as avatars, nice surroundings, e.g. a “gym session” in the park or nature, and with music that she likes. After the session the participants have a chat, it is difficult to chat an exercise having COPD. She also plays the same exergame with her granddaughter, who finds it extremely fun even the exercises are tailored specific to grandma.
Goals / needs	Increased physical activity and exercising especially in the winter season. Have joint activities with her grandchildren, despite the long distances between them.	
Hobbies / daily routine	Knitting and needlework. Likes to play card games, but nowadays only solitaire since her grandchildren live so far away. Watching movies.	

Before scenario Anna

Anna lives in the city of Tromsø, the largest city in Northern Norway, with 60.000 inhabitants. She is 69 years old. Her grandchildren are living in the capital of Norway, Oslo, 1600 km further south, and she really misses her grandchildren a lot. When her husband died a few years ago she moved to a flat.

She is a former secretary in a shipping firm, and used computers at work in those days.

At home, she has a computer, but uses it only for banking and solitaire. She uses her mobile phone, both for voice call and text messages. She is diagnosed with severe COPD, GOLD stage 3-4.

Anna is annually, due to her severe COPD, referred by her GP to the out-patient rehabilitation centre in the city, for an eight week pulmonary rehabilitation program. The program includes, among others, exercising in a group-based setting. She also participates at the lung and heart patient organisation (LHL)[63] level 1 peer based exercise group once a week. But, in the winter season, lasting from October until April, it often happens that she can not participate. She finds it difficult to get there, due to the often hash weather condition with snow, wind and slippery pavements. Taking a taxi, every time the weather is too bad, is too expensive for her. Once a month LHL also has a dancing arrangement, and if the weather allows for it she participates. She is still today, really fond of music and dancing, as she was in her younger days.

She also enjoys knitting and needlework, and likes to play card games, but nowadays only solitaire since her grandchildren live so far away. Another hobby of her is watching movies.

After scenario Anna

Overall goal: Increased physical activity and exercising especially in the winter season.

Have joint activities with her grandchildren, despite the long distances between them.

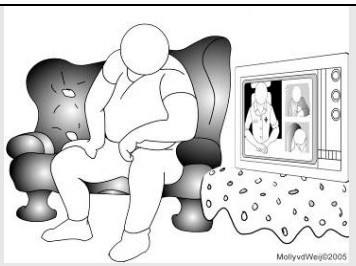
Anna was introduced to the Join-In system by the local branch of LHL, where she participates at the peer based exercise session, and contacted a physiotherapist at the rehabilitation centre.

By using Join-In she can play exergames with peers performing disease related exercises together, seeing the others as avatars in nice surroundings, e.g. a “gym session” in the park or in nature, and with music that she likes. The exergames has tailored exercises and movements. After the exergames session is finished the participants have a chat, since it is difficult to talk during an exercise while having COPD. She also plays the same Join-In exergame with her granddaughter, who finds it extremely fun even though the exercises are tailored specific to grandma.

By means of the Join-In system, she is also able to play games on the computer together with her granddaughter in Oslo. It is a game where they solve challenges together, and achieve new levels in the game based on this. By using the Join-In system she also watches movies with her granddaughter in Oslo, they are both film enthusiasts, and have a lot of pleasure watching movies together. They can see each other and chat while watching the movie.

So, by using the Join-In system she is both able to have contact with her grandchildren in Oslo, and to exercise together with others in a social supportive environment from home, in the winter season, which is important for her health.

Persona including possible AAL applications (Simon)

Simon, 73 years old *" My days are long"*		
—		**Possible AAL applications**
Life situation	Living in a small village in rural North Norway, on the north-vest coast of the island Senja, facing the open sea. He lost his wife two years ago. Living near his daughter and her husband, but they both work. His son lives with his family in Tromsø. Has a sister that lives on the west coast of Norway, that he has regularly phone contact with	
Profession / attitude towards/ experience on technology	A former bus driver at Senja. Has mobile phone, uses it for voice calls primarily Has no computer at home	
State of health	Chronic Heart Failure (CHF) Receiving help from the Home Care Service Visits the CHF policlinic at the hospital twice a year. LHL has a peer based exercise group at Finnsnes, also on Senja, but he does not feel well enough to participate, since it is more than an hour drive away. There is	Biking on a stationary bike at home. The bike is wireless connected to an online exergame were he can bike alone or together with a group of peers the community centre at Finnsnes has set up. They can bike through nice landscapes together, or maybe bike together to

	also a community health centre at Finnsnes, arranging exercise for the elderly.	"Rome". He also uses the bike in stand-alone mode of the game. Dancing sitting in a chair, with tailored movements / exercises in the dance. In the dance exergame, an instructor avatar shows the way to move.
Goals / needs	Increased physical activity and exercises all year through, especially in the long and often hash winter.	
Hobbies / daily routine	Listening to music, reading crime novels, doing wood carving, or watching TV. Loved to dance before he became too ill for that. Interested in genealogy, but without a computer this is challenging.	

Before scenario Simon

Simon, a former bus driver, is living in a small village in rural North Norway, on the north-west coast of the island Senja, facing the open sea. Three years ago, he lost his wife. He is living near his daughter and her husband, but they both work during daytime. His son lives with his family in Tromsø, and he has a sister that lives on the west coast of Norway, with whom he has regular phone contact.

Simon has a Chronic Heart Failure (CHF), in a stable phase. He receives help from the Home Care Service for medication, and for cleaning the house. He also visits the CHF policlinic at the hospital twice a year. LHL has a peer based exercise group at Finnsnes, also on Senja, but he does not feel well enough to participate, since it is more than an hour drive away in each direction. There is also a community health centre at Finnsnes, arranging exercise for the elderly.

He has a mobile phone, and is using it for voice calls primarily. He has no computer, and has never used one.

Simon likes listening to music, reading crime novels, do wood carving, and watching TV. He really enjoys dancing, but nowadays he is too ill to participate in dancing arrangements. He is also interested in genealogy, but without a computer this is challenging.

After scenario Simon

Overall goal for Simon: Increased physical activity and exercises all year through, especially in the long and often hash winter.

The CHF policlinic has advised Simon to take contact with the community health centre at Finnsnes, to learn more about the Join-In system for training and exercising at home. The Join-In system provides exercise plans adjusted for the participants. It is important to stay active and exercise when suffering CHF, such as going for a walk or riding a stationary bicycle, however, not on days when the weight has gone up from fluid retention or when you are not feeling well.

Simon is using the Join-In biking game on a stationary bike at home. Join-In sensors are attached to the bike or him, and are wirelessly connected to an online game on a Tablet. Simon can bike alone or together with a group of peers. The community health centre at Finnsnes has set up the group. The participants can bike together through nice landscapes or parks; they can also virtually bike to places far away, for example biking together to Rome. Simon can also use the bike in a stand-alone mode of the game (asynchronous playing) or use it together in time with the others (synchronous playing). When biking together, the Join-In game can compensate for speed (compensation for handicap), so that they can bike together in different speeds if they have different physical capabilities. In the game they have both common and individual goals, and a combination of pictures and music is used for motivation.

Simon has also started using the Join-In dancing game, where he can dance sitting in a chair, and the movements and exercises are tailored for his physical capabilities. In the dance game, an instructor avatar shows the way to move.

With the help of the Join-In tools, Simon exercises regularly the whole year though with peers online in a social setting, which contributes both too his physical and psychical wellbeing.

Appendix D Publications

Publications from the project related to this deliverable:

Brox E., Luque L. F., .Evertsen G., Hernández J. E. G.: *Exergames For Elderly* First International Workshop on Therapeutic Serious Games & Pervasive Computing(UbiTheraGames'2011), Dublin 23-26 May 2011

Johnsen E., Burkow TM., Vognild LK.: Den sosiale gruppa som motivasjon til fysisk trening (The social group as motivation to exercise), forthcoming in *"Helsesosiologi"*, Aksel Tjora (ed.), Oslo, Gyldendal Akademisk, 2012