A Group Game Played in Interactive Virtual Space
- Design and Evaluation

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ABSTRACT
We have designed and evaluated Nautilus - a group game played in interactive virtual space. This was a study about new kinds of computer games with new types of user interfaces. Our aim was to reduce the boundaries between the surrounding physical space and the virtual space designed to appeal to users’ senses. We utilized the iterative Human-Centred Design (HCD) approach in the study. We created a new way to experience and play computer games, where players use their natural body movements and interact with each other. We have received information on the use of bodily and spatial user interfaces for location-based entertainment (LBE) solutions.

Keywords
Computer games, virtual space, user interface, human-centred design, shared experiences

INTRODUCTION
Traditional games and sports, such as soccer or dodge ball, have been played jointly in groups. Players move naturally and work together during the game. Communication is essential to success.

Despite the basis of playing, computer games are mostly played alone at the computer or players participate online multiplayer gaming. The user interface usually contains a computer with a display, as well as a mouse, a keyboard or a joystick as a game controller. Human senses and the natural movements of users, in particular, are not utilized in a versatile way in these interfaces. Steering wheels and force feedback joysticks are advanced game controllers but they still rely on controlling the game by mainly using one’s hands and fingers.

Conventional virtual reality games try to make the user interface transparent or invisible. The player has to use special devices, such as head-mounted displays [16] and data gloves. The aim of bodily and spatial user interfaces is to utilize human senses and movements more diversely than before [1, 3, 4, 17, 21]. In order to create multimodal feedback and versatile input, the user interfaces require advanced technology and methods to assist with the recognition of movement, touch, voice etc.

The game design process is largely based on designing a movie (screenplay, scenes, characters, sound etc.) [18] and design interaction. In addition to conventional game design objectives such as identification and exaltation, the designers of new games use 3D engines and aim to strengthen the feeling of immersion by, for example, creating realistic characters, immersive playspaces and impressive scenes.

Traditionally, the evaluation of usability and ergonomics consider issues such as how easily a system can be used and how effective it is for work tasks and for receiving information, for example [8, 13]. Instead of requiring a low mental capacity, the games should be challenging and entertaining. Design of new user interfaces requires advanced methods of achieving interactive systems where the user’s needs are taken into account in many different ways [11, 17, 20]. The view chosen by the player is a step forward in game design and offers a player a personal experience by presenting realistic movements. Multiplayer games are also a trend in game design.

With the Nautilus design, the aim was to create an intuitive user interface that blended in with the surroundings of the users, used human senses more diversely than before and thus provided a wealth of experiences. In addition, it acted as a research and development work of bodily and spatial user interfaces [24]. We integrated the player’s natural movements into the game. Our aim was to weaken the boundaries between the room and the interactive virtual space. In the game, players do not wear any virtual space devices, such as data helmets or gloves. The devices are uncomfortable and limit the movements of the players. We
developed and evaluated a game into an interactive virtual space. We used a Human Centred Design (HCD) approach in the design process [9]. This paper describes the design and evaluation of Nautilus - a group game, which is an underwater adventure using a diving bell.

**Referring applications**

In this section, we look at applications that are similar to Nautilus and its development. Many applications already utilize human senses and are rich in experiences. Group games are also being developed. These applications were discovered by surveying existing entertainment solutions, research projects and interactive media art.

**Entertainment**

In the area of entertainment, we studied computer and video games and the relevant LBE-applications. The games were either games for one player or multiplayer games like Disney’s interactive theme park ride Pirates of the Caribbean - Battle for the Buccaneer Gold [4], where players play in a group of seven. They have roles according to their game controllers such as cannons and the rudder. They can communicate with each other by shouting, gesturing and pointing during the game.

For home use and for arcades there are the so-called rhythm-action genre games like Konami’s Dance Dance Revolution [3], where the player dances in rhythm on a carpet according to the directions on screen. The player controls his/her agent on the screen. In these rhythm-action games, the players have their own control devices.

Infrared sensors are also utilized in home entertainment solutions to represent players’ physical movements with the onscreen characters. Sega Genesis’ Activator [18] replaces ordinary control pads as players control the game with kicks, punches and other moves. Also, some coin-operated arcade machines, e.g. Namco’s Tekken 3 [12], use this kind of interaction technique.

Sports and driving simulators use more advanced controllers. In addition to racing wheels, even force feedback fishing rods and exercise bikes are connected to computer games [6, 7, 23, 26]. There is development work for the sports simulators where the entire body acts as a computer control device. The Vivid Groups’ Mandala system uses a video camera interface to allow players to interact directly with a virtual world. The players see their own image superimposed onto digital backgrounds and they can interact with the application without having to wear, touch or hold any hardware [22].

**Research studies**

The research area case studies focused on solutions made for entertainment or education for children groups. The Massachusetts Institute of Technology’s (MIT) Media Laboratory has developed KidsRoom, an interactive playspace for children. [1, 21]. KidsRoom uses vision-based recognition to identify activity in the space. The players do not have to wear any special clothing or virtual reality devices. In KidsRoom, up to four people can play simultaneously.

At the University of Nottingham’s Mixed Reality Laboratory, a "magic carpet" has been produced, which is a tangible interface for storytelling for use in schools. The interface supports group interaction and is developed in cooperation with children and teachers [20].

**Interactive media art**

In the field of media art, there are many open-minded studies and developments dealing with bodily and spatial interfaces. Media artists also consider exemplary dramatic aspects, not just experiences created by effects. Myron Krueger has demonstrated several applications where the user uses his or her body to interact with 3D graphics [10]. Jeffrey Shaw also uses technology to make it possible to move in virtual spaces without any physical limitations [5].

Nautilus could be seen to be an entertainment solution. It is a new kind of computer game. Nautilus was developed and evaluated as part of a two-year research study and it has elements of a work of art. In Nautilus, the way to play and experience differs from other virtual reality games. The players do not have agents on the screen, they do not have personal control devices, and they do not need to wear any virtual reality devices. Nautilus players can move freely around the room. Players interact as a team with the space around them.

**NAUTILUS - AN INTERACTIVE GROUP GAME**

**Story & Controlling**

In the game, the players (a group of 3–6 players) are the crew of the diving bell Nautilus. Their mission is to rescue a dolphin, which is stuck under a shipwreck at the bottom of a lake. Before the game, the players watch a pre-show video, where the diving bell captain Jaakko Kustonen gives the players the background. The captain guides the players through their mission and also explains the control methods.

The adventure begins at a diving bell depot. The diving bell goes through an underground tunnel to the bottom of the lake. In the lake, the players have time to familiarize themselves with the control system and the underwater world created by lighting and sound effects and a view on the screen. The players control the diving bell with their body movements and movements on the floor (Figure 1). It is essential for the players to move as a close group. Direction and speed are controlled by the group’s centre of mass. The game recognises players’ movements and calculates the approximate intensity centre of these movements. When the group moves forward, the speed of the diving bell increases. The speed depends on how far forward the group is on the floor. The players can reverse the diving bell by moving to the rear section of the floor.
Nautilus turns to the left when the group moves to the left, and so on.

During the journey to the wreck, the players can earn extra points by collecting seahorses and starfish (Figure 2). While moving the players have to control the diving depth to collect seahorses and starfish, which swim at different depths. The group has to bypass obstacles at the bottom of the lake and they have to avoid getting stuck to the bottom. They can tell their diving depth by the depth gauge on the left of the screen (Figure 2). The player group can raise the diving bell with rapid up-and-down arm movements ‘flapping their wings’ or by stamping their feet. We invented these movements, when we designed signal processing. These movements were not originally meant to be part of the game. The floor sensors and the signal processing software recognise both of these movements as rapid changes in pressure. The diving bell will dive if the players crouch down at the same time. Standing still has the same effect. The crouching down movement was invented during usability evaluations with children. Crouching eliminates redundant movements on the floor and gives the feeling that it is a natural movement for lowering the diving bell.

On the way to the wreck, a shark will twice try to hit the diving bell. If the players cannot avoid the shark attack, the diving bell will be stalled for a few seconds. When the players reach the shipwreck, they have to push the wreck three times to free the dolphin (Figure 1). Once the dolphin has been rescued, an octopus attacks and tries to crush the diving bell by squeezing it. The players can avoid the octopus by rising up the diving bell. Finally, the players have to bring the diving bell to the surface. If the players succeed in rescuing the dolphin and bring the diving bell back to the surface, the dolphin thanks them by jumping.

The players have to free the dolphin before their oxygen runs out. When the game starts, they have enough oxygen for four minutes. The oxygen meter is on the right of the screen (Figure 2). At the end of the game, the group is given feedback according to how they performed. The group sees its points and is given a verbal description of the results. Playing Nautilus involves not just Human-Computer interaction, but also interaction between the players. The players are in the same room. But they do not only share the space physically, they have a common collective purpose and they share experiences while playing and also after the game.

**Technical concept**

At the moment, the Nautilus game is located in a room measuring 25 square metres (5x5). The room looks like a normal empty room except that there is a screen on the wall. A large screen is a competitive substitute for a head-mounted display (HMD). By using a screen, the negative aspects of the head-mounted display such as limitations in movement and simulator sickness can be decreased [15]. In Nautilus, the fact that the players do not need to wear any virtual reality devices enables the players to freely work as a team.

Six lighting effect devices hang from the ceiling. Lighting effect devices are similar to the devices used in theatres or on concert stages. 3D game sounds are produced using eight loudspeakers and a subwoofer. The loudspeakers are located in the corners of the room. Two computers control the effect devices. One computer is for the game software and the other for sound. Signal processing software is on the same computer as the game software. The computers are in the room next to the playing room. (Figure 3).
Players’ movements and location recognition are made by floor sensors. The floor sensors are hidden under the floor tiles. The floor comprises 49 pressure-sensitive floor tiles measuring 60x60 cm. Every floor tile contains four EMFi™ (Electro-Mechanical Film) sensors [25]. The sensors are located on each corner of the tile and one tile includes a microcontroller board for signal processing. The sensors respond to changes in pressure instead of absolute pressure. This feature of the sensors affects the signals received from the floor. For instance, detection of people moving is a lot easier than detection of people standing still.

HCD APPROACH
We used the Human Centred Design (HCD) approach in the development of Nautilus [2, 9]. We chose HCD because it uses the opinions of the end users of the system as efficiently as possible during the development process. The users did not merely participate in the usability evaluation. They were an essential part of the design process from the early stages. We defined the users’ needs and requirements before starting the concept development. HCD is an iterative process and necessary changes to Nautilus were made according to feedback from the users.

We approached the design process in two ways. We made a state-of-the-art survey of playing computer games and the game user interfaces. We also had survey experiences of spatial and bodily user interfaces in games and in media art. In participatory evaluation, the end users participated in the design process by evaluating developed solutions and by giving new ideas for the game.

During the design process, we had a multidisciplinary team with expertise in the areas of usability, user interface design, programming and signal processing. The presentation of the game was created together with sound and lighting designers and a graphic designer.

User Requirements
Context of use
The Nautilus game was designed to be a new kind of approach to amusement park-like location-based entertainment (LBE). The game could be used in environments such as theme parks or science parks. The environment requirements were established through discussions with the project partner, the Adventure Park Tampereen Särkänniemi Ltd. The game should not last more than 5 minutes in order to enable a large number of groups to play during their day at the theme park. The amount of players able to play at the same time also has an effect on the capacity.

Target group
People rarely visit theme parks on their own. Instead, they go in small groups to enjoy the experience together [4], so Nautilus was designed for small groups of players. The average Nautilus players were defined to be Finns who spend their summer holiday as a family and groups who spend time at theme parks. Some of the families or groups rarely visit theme parks and might only play Nautilus once.

Nautilus should be a game of interest to the whole family, although the content was designed to be of particular interest to children aged between 8-13 years. The players’ experience of computer games may vary considerably. Our aim was to create a system, which does not require any previous experience of computer games. Age or sex should not significantly impact the successful completion of the game.

As an interface, we chose floor sensor recognition, because it allows several players to play and move freely on the floor at the same time. The players do not have predetermined roles in the game or specific positions in the room. They do not need to have any special clothing or virtual reality devices.

Scenario-Based Design
Scenarios are fictional, a maximum of one page, contain stories about the game and about users’ interaction with the user interface. In designing Nautilus, approximately 20 story scenarios were conceived. We divided the scenarios into four genres. These genres were based on movements in the game. In the floor targets genre, the players try to step on activated spots on the floor. According to the group balance idea, the players have to move uniformly. The space can illustrate objects such as vehicles and the mission of the players is to control the vehicle by moving on the floor. Hands and other parts of the upper body are supposed to be used in a versatile way in the body-waving genre. It also includes jumping and running movements. The only genre where the players have predetermined roles and devices was the controls genre. Despite the roles, they have a common purpose in the game.
We chose the group balance genre and its scenarios for further development. This genre best supported the group action, because success in the game demands action as a close group. The genre was also appropriate for the floor sensors recognition system. From the story scenarios, we selected the Nautilus scenario, because the idea of the underwater world was fascinating and because the project partner Adventure Park Tamperen Särkänniemi is located beside a lake and has a dolphinarium. The room size was believable as being able to present a diving bell and the control metaphor was intuitive. Also, the players have a shared objective and they have to act as a group when they are playing the roles of the diving bell crew. At this stage, Nautilus was only a half page scenario, which was carried on to the storyboard phase.

Storyboard
At the beginning, we made a text-based manuscript for Nautilus – an underwater adventure in a diving bell. It included detailed ideas of the game world in different phases, which required evocations of effects and visual presentation during the game. Also, we created a separate list and descriptions of the characters in the gameworld such as the seahorses, starfish, dolphin and octopus.

After finishing the text version, our graphic designer put together a multimedia presentation of the storyboard. The presentation was a Flash animation and it was available via the Internet. The animation included 28 scenes of the game from the pre-show to the end (Figure 4). Every scene also included a verbal description of the story and the effects. The users could navigate between the steps in the story.

Figure 4. Scene with the dolphin under the shipwreck in the storyboard.

Storyboard evaluation
The aim of the storyboard evaluation was to collect opinions about the idea and features of the game and evaluate the captivation and logic of the plot of the game. Considering the feedback and the needs of the users, the storyboard was developed further. Before implementation, it was essential to eliminate potential conflicts within the game structure.

The storyboard was evaluated by a school class (20 children aged 10 to 11 years) and 17 families (26 children and 20 adults). In February 2000, we had one evaluation session with the school children. We presented the storyboard on the screen and interviewed the children. The children also filled in questionnaires where they were asked questions about issues to do with Nautilus, playing computer and video games and visiting theme parks. Families participated in the evaluation via the Internet by using an interactive storyboard during March 2000. They wrote down feedback to the questionnaires and sent them to us. The questionnaires included the same themes as the children’s questionnaires.

The users’ opinion of the target age group was children over 7 years. The game characters and the plot were found to captivate this age group in particular. The users were clearly of the opinion that the game would not be of interest to teenagers (aged 14 to 19 years). The girls were fascinated by the underwater world while the boys were interested in the equipment and the functionality of the diving bell. The boys would have wanted more action in the game, shooting, for example. But the unnecessary brutality would have reduced girls’ interest in the game.

Despite the fact that the users did not play the game in a spatial user interface, their thoughts about playing as a group and controlling the game with their body movements were of some consolation. Most of the users found the use of their body in the game to be fascinating. Most of them preferred to play the game with their friends and relatives. They were a bit more reserved about the idea of playing with strangers.

There was no real need to change the storyboard’s plot or the characters. The feedback from users mainly concerned details such as adding the characters or killing sharks, which had no significant effect on the game or concerned issues, such as force feedback that could not be achieved in the environment. The conclusion of the storyboard evaluation was that the story was ready to be taken to the next step of the development work, which was to design interaction and a game world to the spatial user interface.

Implementation
Graphic design
Graphic design and other design areas were based on the storyboard, where the characters and the underwater world had already been described and sketched. We did not aspire realism in designing the visual world of the game. A colourful, cartoon-like presentation was appropriate for the game and supported its entertainment value. Our graphic designer developed the visual 3D game world by modelling and animation. The 3D modelling was made with Kinetix’s 3D Studio Max 3.1 program. In the animation we designed
the skeletal systems for the 3D models of the characters. The movements of the game’s 3D objects were based on their skeletons. The 2D gauge face plate including depth meter and oxygen meter were also part of the game’s visual world design.

Sound design
Sound in the Nautilus game fall into one of three categories. Ambiences created the atmosphere of being in the underwater world or on the surface of the lake. Ambiences are extended background sounds. Effects are used for creating rhythm and information such as crashing sounds when the octopus squeezes the diving bell. Musical sounds are themes, which increase suspense and give clues to imminent events, such as shark attacks. Sounds were made by recording sounds, manipulating sounds with effects or using a sound effect library. Sound files were integrated into the game software by using MIDI and GigaStudio 160 software.

Lighting design
As well as sound, the lighting effects are used to enhance the atmosphere of strength in the underwater world. In addition to illuminance, the light devices affected the hue of the surrounding light. The lights were integrated into the game’s phases such as red lights before shark attacks. The light devices were also controlled by MIDI.

Signal processing
Signal processing integrates hardware - the sensors and microcontrollers under floor tiles – into the game. Using signal processing, we translated control signals such as ‘flapping wings’ and group’s average mass centres for the game software. The work required integration of spatial signal processing and temporal signal processing, multiple sensors in space and values in multiple times. The integration of the signals locates the players on the floor and provides information on what they did in the past. Signal processing software is independent. It does not receive any feedback from the game software.

Software engineering
The software has been designed using object-oriented methods to achieve modularity and to make the game structure well defined. Characters, underwater plants, the bottom of the lake and the diving bell are objects in the game that have their own functionality and dependency with other objects. In the game software, the event model and state machine helped interaction between objects such as octopus attacks after freeing the dolphin. A remarkable achievement of software design was the implementation of the skeletal animation system for the 3D graphics engine. The skeletal system enabled 3D objects to move according to their skeletons.

EVALUATION

Expert evaluation
Expert evaluation of Nautilus was made before evaluations with end users. The evaluators who carried out the user evaluation proceeded with the expert evaluation, because they then had experience as users. Some of the evaluators also participated in the design process from the beginning of the project.

The aim of the expert evaluation was to test the functionality of the game and the technical concept. Evaluators tried to locate system faults and areas requiring further development. It was very important to find the most crucial faults before evaluation by end users, because malfunctions might have had too much influence on the end user evaluations.

Expert evaluation was heuristic [14]. Evaluators played Nautilus as end users. Every evaluator had a checklist, which they filled in independently at the end of the game. Every malfunction and proposed amendment was noted according to the stability limits. We had three classifications of faults and priorities

1. Cosmetic problem, low priority
2. Usability problem, obstructing players from achieving intended goals
3. Functional problem, to be fixed immediately.

Results were put on the checklist form. Changes were detailed for the designers. Notes were mainly about the pre-show, timings of the game, and sound and lighting effects. In addition, there were proposals for players’ actions, especially about how players should be activated to move more closely as a group. One suggestion was that the diving bell could sink slowly if the players do not move enough. As part of the final feedback, it was suggested that the players could be able to see the top five game scores in order to motivate players to play the game again.

End user evaluation
We carried out end user evaluations during two periods, the first evaluations were in November 2000 and the second evaluations were in February 2001. Overall, nine groups played Nautilus. For the November evaluations, we selected player groups, which we considered to contain the most potential users in the final usage environment. They were families and school kids, which are groups likely to visit theme parks. Two families and two groups of school kids played and evaluated Nautilus in November.

Small number of groups enabled us also to make qualitative analyses, which were in this case appropriate. We wanted to interview users freely and not to be restricted to rating scales. In this study finding out subjective user experiences was as important as defining usability problems.
In February, we evaluated the Nautilus game with five groups. Two groups of players were from lower secondary level (average age 15), two high school groups (aged 17-19), and a group of active adult computer game players (aged 29-30). According to the user requirements, teenagers and young adults were not the main target group for Nautilus. In the evaluations during February, we wanted to know how well the game, which is designed for children, works with people aged over 13 years. Also, by changing player groups we can get more versatile feedback from users.

Every playing session started with familiarisation between the evaluators and the users. We told the users, that they were playing and evaluating a new kind of game. Before the game, users saw the pre-show. The users played the game in groups of 3-6 players, which is the required amount of players for the room. Evaluators observed the game from the control room. After the first game, the players were allowed to ask for tips on how to achieve better results in the game. Then they played Nautilus again. After the second game, the players filled in questionnaires and were interviewed. The questionnaires and theme interviews included open ended questions, which were focused on five topics. The topics were defined according to the goals of the evaluation. The topics were:

- immersion
- bodily and spatial user interface (body movements and interaction within the game)
- learnability, intuitiveness
- collaboration and shared experience between the players
- story.

Immersion
In terms of immersion, the design of the underwater world and diving bell environment succeeded well. The users forget their surroundings while playing. Primarily, they did not see Nautilus as a computer game. They could not mention any distinct and coherent reference point for Nautilus. In other words, the game was seen as being a mixture of a theme park attraction and an interactive movie as well as having elements of team sports. Effects have an essential role in creating the feeling of being inside a diving bell. Sound effects are effective form of an expression for evoking emotions and atmosphere, and, the users especially liked them. After the game they could not mention any particular sounds as some of the players did not notice the lighting effects. On the other hand, some of the players said that the lighting added to the underwater atmosphere, as it was designed to do. Hence, Nautilus gave the players the feeling of being a part of the game rather than of controlling the game (Figure 5).

Figure 5. Group of schoolgirls tries to avoid the shark attack.

Bodily and spatial user interface
The bodily and spatial user interface allowed the players to use natural body movements such as walking, running, stamping feet and crouching. Use of one’s body was a new and exhilarating way of controlling a game. Playing as a team in an interactive virtual space was found to be natural and fun. The team playing was familiar from other context such as sports and traditional plays and games. Movements in the game were not physically too stressful or too easy. The players did not pay much attention to technical issues in the game. Most of them assumed that the movement recognition system was based on the floor. The players preferred the game area to be clearly marked and the room could then be staged.

Learnability, intuitiveness
The control metaphor of the Nautilus game was learned easily. The pre-show helped the players to understand the idea behind the game and the players learned more during the game by their own actions or from other players. They received important feedback on their actions. Also, the story of the game was found to be well defined and logical. Usually, player groups were unable to rescue the dolphin in the first game but succeeded in the second time, once they had been given some tips by the evaluators.

Collaboration and shared experience
In Nautilus, the visual and audio displays are shared. The players hear the same things and are looking at the underwater world from almost the same point of view. This allows them to communicate freely during the game. In addition, one’s individual playspace is not limited so it provides a natural social interaction between the players.

In families, one of the parents took the lead role and gave orders to other family members, because the children were young (7-10 years) and the parents presumed that they did not understand or remember all the instructions they had received in the pre-show. In the other groups, the players shared comments and tips diligently. There were no specific roles and everybody could give orders or ask questions. Player groups usually planned their strategy
after the first game. They discussed how to be more effective and how to score more points.

**Story**

We found that the background story in the pre-show helped the players to understand the game and reduced the boundaries between the real and the virtual environment. The main goal of the game, rescuing the dolphin, was clear and the achievement of the shared goal increased groups’ satisfaction at the end of the game. The control metaphor supported the story. Points become an incentive when the game has been played many times and the players have succeeded in rescuing the dolphin. According to the players, the underwater world was appropriate for the game, because the visual world and the lighting and sound effects were in balance. Only a few players wanted the bottom of the lake to look more realistic. Characters related to the story well and their meaning and features were understood. The dolphin was found to be likeable and the sharks even scared the adult players.

**Remarks**

These results indicate that a player does not have to wear any extra devices for interaction in order to be immersed in a virtual environment. The interaction with the computer game as a group using body movements was found to be particularly novel and captivating for the users. The game was played with the same enthusiasm by school kids and young adults. Players’ age or sex unexpectedly had little effect on the experience received from playing Nautilus. In the future, the evaluation should consider users’ feedback and collaboration, when Nautilus is played in a real environment by groups of strangers.

**DISCUSSION**

We have succeeded in creating a new kind of group game, which involves not only human-computer interaction, but also human-human interaction in the interactive virtual space. The players can interact with each other while they use their natural body movements for interaction with a spatial interface. As well as being a new kind of computer game, Nautilus also provides location-based entertainment. Considering that Nautilus is controlled by teamwork, the game is suitable for environments where people go together to find new experiences. Although Nautilus was designed to be used at theme parks, it could be a new kind of game for schools or at home. We have also noticed that Nautilus has features that support teamwork training.

The floor does not identify the persons that move on the floor. This recognition would have given more possibilities and challenges to the design. However, in this case the application was designed to work as a group game where the identification is not needed and team work is supported. There is a need for design and evaluation methods in the field of bodily and spatial user interfaces. The Nautilus design applied expertise including animation, sound and lighting design, graphic design, which are usually used independently in their own context.

Design guidelines for developing HCI in bodily and spatial user interfaces according to this study are:

- **Relate HCI to the storyboard.** The user interface design should not be restricted too much to the story. The story can be enhanced with new interaction related to the user interface.
- **Importance of timing.** Timing between movements and causes in the game should be well synchronized.
- **Intuitiveness.** The control metaphors should have reference points to natural action and should be embedded in the game.
- **Evaluate the immersion of experience instead of diversifying perception of senses.** Especially in the entertainment field, it is a question of how rich an experience the user interface can provide.

**ACKNOWLEDGEMENTS**

Nautilus was developed and evaluated as part of a two-year Lumetila (Virtual Space – User Interfaces of the Future) study, which ended in May 2001. VTT Information Technology worked in collaboration with Cube Ltd., Nokia Research Center, Adventure Park Tampereen Särkänniemi Ltd., and the University of Lapland. Tekes, the National Technology Agency, co-funded the study. We would like to thank all those who participated in the study.

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