Wizard of Oz Prototyping of Computer Vision Based Action Games for Children

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ABSTRACT
This paper describes the use of the Wizard of Oz (WOz) method in the design of computer vision based action games controlled with body movements. A WOz study was carried out with 34 children of ages 7 to 9 in order to find out the most intuitive movements for game controls and to evaluate the relationship between avatar and player actions. Our study extends the previous Wizard of Oz studies by showing that WOz prototyping of perceptive action games is feasible despite the delay caused by the wizard. The results also show that distinctive movement categories and gesture patterns can be found by observing the children playing games controlled by a human wizard. The approach minimizes the need for fully functional prototypes in the early stages of the design and provides video material for testing and developing computer vision algorithms, as well as guidelines for animating the game character.

Author Keywords
Wizard-of-Oz method, computer games, perceptual user interfaces, computer vision, physical interaction, children.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces - evaluation/methodology, input devices and strategies, interaction styles, prototyping, user-centered design.

INTRODUCTION
Computer games play an integral part in children's lives. According to one study, 17 percent of 2-7 year-olds and 37 percent of 8-13 year-olds play computer games on any given day in the United States [24]. However, some media studies suggest that children's extended computer use may have negative effects on their physical development [6,28]. One factor causing these effects is the traditional human-computer interaction styles and input devices, such as keyboard, mouse and game pads, that promote a sedentary lifestyle for children.

IDC 2004, June 1-3, 2004, College Park, Maryland, USA

Our research project focuses on the design of perceptive children's computer games that are played using body movements and voice, and designed to support children's physical development. The user interface is perceptual and multimodal: the user controls a dragon character that mimics the user's body movements and breathes fire when the user shouts. The game works on a Windows PC equipped with a low-cost web camera and a microphone. The prototypes used in the study were single-player action games where the player controls an avatar that runs, jumps, swims, and tries to escape from the spiders as shown in Figure 1.

The main challenge in the interaction design of perceptual action games is to ensure the usability and playability of the game controls. These qualities are, on the other hand, highly dependent on the intuitiveness and physical appropriateness of the movements used to control the game character. The Wizard of Oz study was carried out for two main reasons: (1) to find out whether perceptive action games could be prototyped and evaluated using a wizard that observes the children and controls the game using traditional input devices, such as a mouse and a keyboard, and (2) to discover what movements and gesture patterns emerge when children control the game prototypes without any instructions given (by the researchers) and only relying on the visual cues in the game.

Our study extends the previous Wizard of Oz studies and shows that the WOz approach can successfully be used to prototype perceptually interactive action games in the field together with children. The results also show the versatility of the gathered data which can be used in later design phases to test the computer vision algorithms and to animate the game character's responses according to the players' movements.

The paper has the following structure: first the related work and the concepts behind our perceptual user interface are reviewed, then the prototypes and the methodology are described, and finally the results and findings are discussed.

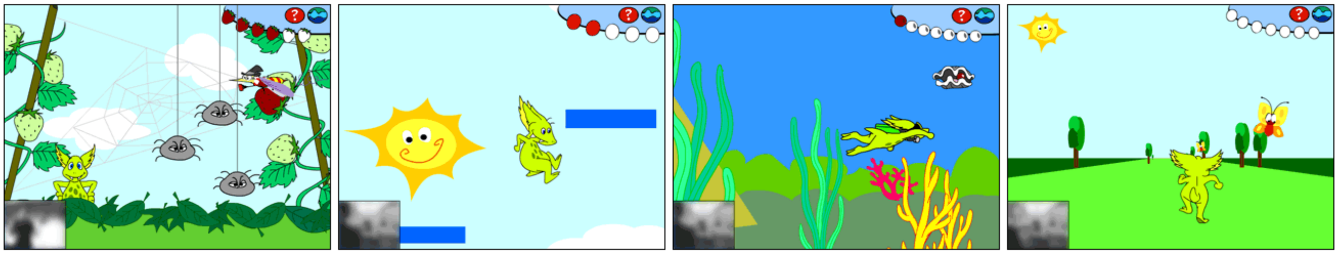

Figure 1. The four game prototypes - spider game, jumping game, swimming game and running game

BACKGROUND

Perceptive Computer Games for Children

We chose computer vision and hearing as the interaction technologies because we wanted to design a natural and unobtrusive user interface that would also be physically motivating. We did not want to use any sensors attached to the user's body, as such sensors are easily breakable and also awkward to use if several children want to play the game together or take turns playing.

Our work is closely related to KidsRoom and other physically interactive story environments [4,23,26,29]. These include several applications where one or multiple humans are tracked and the sensory data is used to control a graphical representation of the user or the reactions of other characters. Computer vision as a technology has been extensively studied, as seen, for example, in Moeslund's survey of more than 130 related papers [20]. Computer vision for games in particular has been examined by, for example, Freeman et al. [12]. There are also some commercial computer vision based games by Intel, Mattel [10], and Sony (EyeToy). According to our knowledge, our *QuiQui's Giant Bounce* game is the world's first computer vision and hearing based action game that is based on child-centered design and research on children's physical development. In addition, compared to previous work, our games add voice as a second modality for controlling the game character. This study, however, focuses only on the physical modality of the game.

As the previous research has mainly dealt with technological issues, there is still a lot to explore in computer vision from the point of view usability [8] and applicability. Furthermore, the methods for designing and evaluating the perceptual user interfaces have to be studied more closely. Our goal is to make the games usable by children of ages 4 to 9 without adult guidance, which calls for robust technology that works in an unpredictable and changing environment. The design challenge is even more difficult because of the variety and unpredictability of children's movements and the low image quality produced by many webcams.

Intuitive movements for game controls

The controls of computer games should be intuitive, easy to adopt and responsive in order to provide a pleasant play experience. This also holds true with perceptive action games that are not based on predefined key presses or joystick manouvering, but instead on the player's gestures that are always individual to some extent.

The narrative context plays an important part in designing intuitive movements for controlling the game. For example, in the sea the avatar needs to swim and thus the player is expected to make swimming strokes to control the character. Using these *contextual movements* decreases the need for instructions and makes the learning phase shorter, which is important in interactive products intended for children [11]. Each of the games has a set of contextual movements that are selected according to the milestones of children's physical development. In addition to using these movements, the game controls are based on *avatar imitation* which means that the cartoon avatar tries to continuously imitate the player's movements or use of voice. The animation of the game character gives hints to the children on what kind of movements are expected.

An obvious and direct mapping exists between the user's and the avatar's movements only when the avatar acts as a mirror image of the user, and the real and virtual environments are similar. The user's movements become restricted or ambiguous if the perspective or orientation is presented differently in the virtual world or the avatar is, for example, flying in the air or swimming in water. Since games should allow the player to adventure into worlds different and unknown, the intuitive and feasible ways of moving in them have to be found through iterative design and test sessions with children.

Wizard of Oz approach

Previously, we have used functional prototypes in the usability tests. Action games require immediate feedback from the system, thus making it difficult to use prototyping tools, such as paper prototyping or the CrossWeaver multimodal storyboarding tool by Sinha et al. [27]. Although game prototypes are easy to implement using commercial multimedia authoring tools, developing computer vision technology is laborious and time-consuming. One of the reasons for this study was to evaluate the user interfaces before putting extensive effort in building functional computer vision based prototypes.

For the prototypes presented in this paper, we decided to experiment with a Wizard of Oz (WOz) approach. We replaced the computer vision technology with a human wizard who observes the users and controls the prototypes with a mouse and a keyboard. The approach was first used by Gould et al. [13] in prototyping speech user interfaces, although the term Wizard of Oz, (or originally the Oz paradigm,) was coined by Kelley [17,18]. The WOz method has been widely used to design and collect language corpora in speech-based systems [9]. We were also interested in collecting a corpus, but based on the children's body language and the intuitive gestures. The Wizard of Oz method has also been employed in some projects involving children [14,22,25], however, these studies have concentrated on applying the method in the context of participatory design or the evaluation of interface agents.

Although the Wizard of Oz approach is widely reported in HCI literature, the papers contain little ethical discussion related to the method. Organizations like ACM and APA do provide ethical codes [1,2] but there are only a few examples of how these ethical principles can be applied in practice [5,21]. We decided to use the Wizard of Oz method for the following reasons:

- The method provides us with invaluable information on the intuitiveness of the movements. It also allows us to collect a "movement corpus" that we could not find in any previous research. There is no existing research on what movements children prefer in different game contexts.
- Using a wizard ensures that the experience is not unpleasant, frustrating or discriminating for the children, since the wizard is more likely to be able to interpret their movements than a computer vision system developed with no prior usability tests.
- Based on our earlier experience in developing perceptive games, we deemed that we could apply the results in practice, possibly benefiting children's physical health and activity.
- We assumed that children would have behaved differently if they had known that the game was controlled by the wizard.

Wizard of Oz has also been used in prototyping and evaluating perceptual user interfaces and an affective game control device [3] but not fast-moving action games that have to react with a low latency. We reasoned that although using a wizard would increase latency, the users would be able to adapt to it. The wizard would also be able to empathize with the users, guess what they were attempting to do, and try to control the game accordingly, which would not constrain the children's possible physical expressions.

WIZARD OF OZ STUDY

Interactive prototypes

During the tests we evaluated four game prototypes: the (1) spider, (2) running, (3) swimming and (4) jumping games. The animations and game controls were designed so that they provided the wizard with flexible control over the game events and enabled consistent behavior between the participants. A simplified set of movements of the main character are presented in Figure 2. The point of view varies between the game prototypes. In the jumping and swimming games, the avatar is portrayed sideways. The running and spider games have semi three-dimensional views from the behind and front of the avatar. The prototypes were programmed using the Macromedia Flash multimedia authoring tool. The view of the webcam connected to the computer was placed in the bottom left corner as shown in Figure 1. However, the prototypes were controlled entirely by mouse and keyboard.

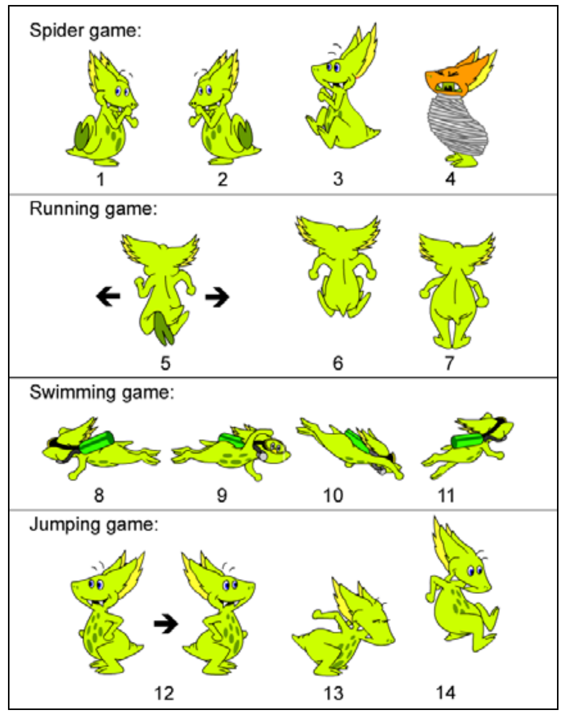

Figure 2. A simplified set of the main character's movements (1&2: moving sideways, 3: jumping up, 4: struggling, 5: running and moving sideways, 6: jump up, 7: stopping, 8&9: swimming left/right, 10: diving left/right, 11: rising towards the surface left/right, 12: turning right/left, 13: crouching before the jump, 14: jumping to the right/left)

Test setup

The tests were held in a local primary school during four days in February 2003. The test space was an ordinary classroom reserved for the testing purposes and the wizard was located in the same space to facilitate the test arrangements. Our WOz approach involved a *wizard*, a pair of children, and an adult researcher called the *interactor* who introduced the test setup, guided the testing and interviewed the children between the tests. The wizard controlled the games, operated the video cameras and took notes during the interviews. The test was carried out as pair testing in order to discourage shyness and to balance the ratio between the adults and the children. According to our previous experiences, young children are more relaxed to communicate with adults when there is another child in the test space. We had two wizards – one with extensive computer gaming experience and another who was a novice computer game player. Before the tests, the wizards agreed on the common rules on how to control the games. Both interactors had previous experience in children's usability testing.

Participants

The participants included 34 children between the ages of 7 to 9. The testing was carried out as a pair testing of 17 pairs (11 pairs of 1st grade students and 6 pairs of 2nd grade students). Both 14 boys and 20 girls participated in the study. Children who had played the QuiQui's Giant Bounce game before were not accepted to participate in the testing. Both the children and their parents were asked for permission for the children's participation in the tests. The parents also filled in a questionnaire with their children to provide us with background information on the children.

The nature of the participants' relationship affects the results and the test setup [16]. Thus, the children were asked to name two to three classmates they wanted to test the prototypes with. The pairs were formed according to the children's wishes. The test sessions for each pair lasted between 15 to 30 minutes, depending on how much the children wanted to comment on the game. The children were not forced to play the game more times than they wanted to, but it turned out that almost all children wanted to play all of the game prototypes as much as they were allowed to.

Test space design

The layout of the test space is shown in Figure 3. The test setup consisted of two DV cameras, a laptop computer, a mouse and a cordless keyboard, and a web camera. The DV camera marked as number 1 in Figure 3 was placed so that the recorded material could be used as such in the design and evaluation of the computer vision algorithms. Camera 2 recorded material also for the purposes of movement analysis. The furniture in the classroom was moved around so that the wizard could easily see both the computer screen and the player's movements. Since the game allows free movement in the gaming space, we used a "magic square" marked on the floor to show the children the optimal playing area in front of the screen.

Procedure

Before the actual testing commenced, the interactor presented herself and the project in front of the classroom, and explained the overall testing procedure to the children. The pairs participated in the test according to a schedule agreed with the teacher. When the children entered the test space, the video recording was started. The actual test session was divided into three phases: (1) the introduction of the test setup, (2) the play session, and (3) the interview.

The wizard was introduced briefly and the test setup was presented to the children by the interactor. The wizard then started the actual WOz procedure with a randomized selection of game prototypes. The first child stepped into the magic square and the other child sat in a chair until they changed turns. In the beginning of each game prototype there was a spoken introduction that explained the idea of the selected game briefly, but did not give any information about the movements expected. When the game began the wizard started to control the game attempting to match the child's movements. Once the first child had completed a game task, it was the other child's turn to play the next game. This procedure continued until both children had played all of the four game prototypes. After the play session the children were interviewed.

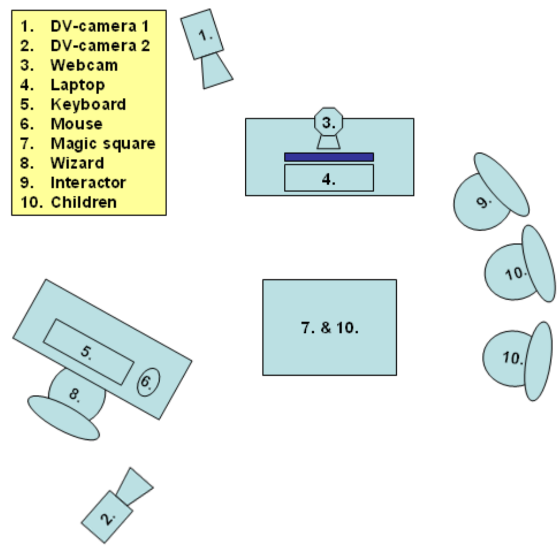

Figure 3. The layout of the test setup.

Analysis methodology

We will use the swimming game as an example of how movements were analyzed since swimming movements provided more versatile and unexpected movement categories than jumping and running. The analysis of the swimming game is also important since the relationship between the avatar and the user is indirect – the avatar is represented sideways and is moving horizontally while player is standing and faces the screen.

As the game character could either swim, dive or rise towards the surface, the children's movements were divided into these *categories*. All the movements within these main categories were listed by adding a new movement item each time a new type of movement appeared in the video. In the swimming category, for example, a total of 17 different *movement types* were found. After listing all movement types, the types were further analyzed and compared to find the patterns and similarities between the types. Finally, the types were summarized into four main *movement styles* as shown in the Figures 5, 6, and 7. In addition, the movement types were analyzed based on their popularity. There were three popularity attributes for each movement type i.e. 1) was it the first movement type a child tried, 2) was it the main movement type in that category for that child, and 3) how many children actually tried to move this way.

RESULTS

Based on the analysis of video data, it is clear that children have their own unique ways of moving. However, the movements can be categorized and compared between the children. The movement styles found by using the WOz method help us choose the most suitable design paths for the computer vision technology and character responses. The following describes the intuitive movements related to the swimming game.

Intuitive movements for the swimming game

The analysis of the swimming game revealed four main swimming stroke categories illustrated in Figure 4: 1) *dog stroke* (a child moves his hands exactly as a dog does when swimming, the arms stay in front of the body and move in a circular pattern by alternately thrusting them forward and pulling them back), 2) *breast stroke* (a stroke in which a child extends the arms in front of the chest, then sweeps them both back laterally), 3) crawl (i.e. freestyle), and 4) “mole” stroke (similar to dog stroke but both hands move together). Two styles, dog stroke (which children in Finland often learn as their first swimming stroke) and breast stroke, were dominant, as seen in Figure 5.

Figure 4. Four different ways to swim - mole stroke (Up, left), crawl, dog stroke and breast stroke.

The popularity of the breast stroke surprised us since the children who participated in our study were 1st and 2nd graders and Finnish children usually learn this swimming style in their 3rd or 4th grade. It was also interesting to see that so many children used breast stroke even though the avatar animations would have suggested them to try out crawl only. Thus the Wizard of Oz study revealed swimming styles that were not anticipated by us due to the designed avatar animations or current swimming education practices in Finland. The results also show that finding the intuitive movements is not restricted to the avatar responses since children were not afraid to try out other movements besides the ones proposed by the avatar animations.

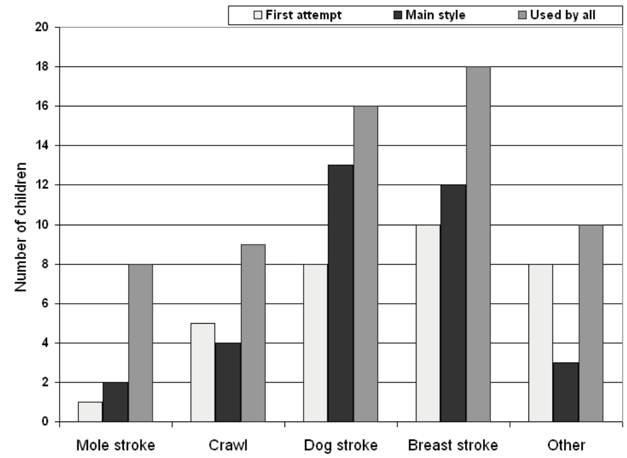

Figure 5. The swimming styles

Our goal is to implement the dog stroke and breast stroke game controls using the actual computer vision technology. The need to implement the crawl into the system will be further studied with children since using it as a game control poses usability and ergonomic problems compared to styles where the player’s hands do not sweep in front of the face and styles that do not require tiring motions above the shoulder level.

In the swimming game, the children tried to dive in many different ways. However, during the analysis of these diving movements, three clear categories were found as shown in Figure 6: the children either dived by (1) swimming “downwards” or (2) “imitating the diving” by flexing the hands in the diving position, or (3) bending their upper body and/or knees and simultaneously making swimming strokes with their hands. In addition, crouching was a very popular style, but it is not very robust or usable for controlling the game since children tend to go out of the camera view and lose focus on the screen.

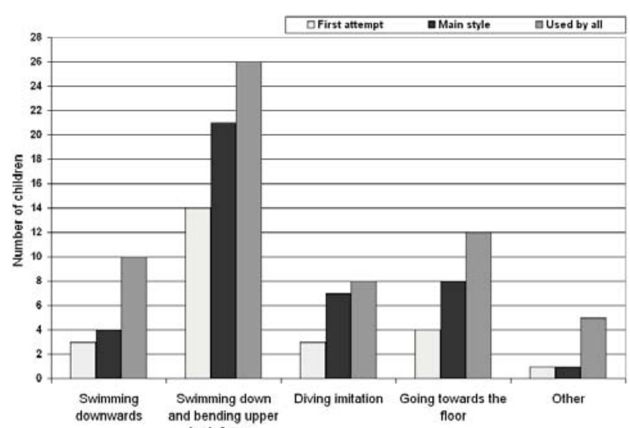

Figure 6. Diving styles

One of the most interesting aspects of studying children's swimming styles is to see how they try to make the horizontal avatar to rise towards the surface or how they make it dive. The results show that the most intuitive way to control the swimming game character to rise vertically is to swim upwards. This means that children continue with swimming but their hands rise up and the direction of the movement of the hands is up to downwards (Figure 7).

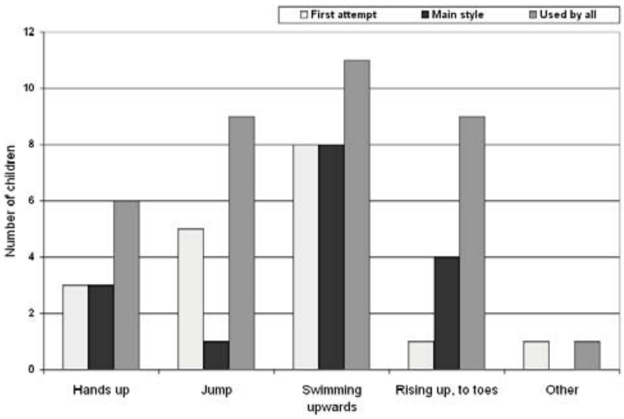

Figure 7. Rising towards the surface styles

Learning effect
In order to minimize the effects of the within-subjects study, the order of the games were randomized. In our tests each child played all of the four games, but she/he was also able to watch the other child play the games. It is obvious that the games a child had already played or observed the other child playing affected the movements used in the swimming game. However, it is important to notice that this is also the case in a real gaming situation.

The skill transfer from one child to another in pair testing also showed that the styles a child mostly copied from his or her peer were dog stroke (6 pairs) and breast stroke (5 pairs), which made these styles even more significant. The children also helped each other in finding the movements to control the character and also instructed one another and gave us hints on where and how the children were trying control the main character. For example, in the spider game children negotiated how to be able to free themselves from the spider's net by saying "you should wave your arms" and showing example.

Collecting a video library
From a technological perspective the most important result is the video footage that can be used for teaching and testing the computer vision algorithms. The collected video library contains samples of all movement styles categorized by game type. The results and experiences of applying the video footage in the design and evaluation of the computer vision algorithms will be reported on in the future. The videos can also be used as a design tool for animating the responses of the game character in order to provide a higher level of imitation.

DISCUSSION
Next, we will discuss the findings and experiences in applying the method in practice from the point of view of the goals of our study, which were 1) to evaluate whether the WOz method is usable in the design of a fast paced and computer vision based action game with children, and 2) to find out the movements to design computer vision based game controls.

USING WIZARD OF OZ TO PROTOTYPE PERCEPTIVE ACTION GAME
There is no prior research done on how the Wizard of Oz method could be applied in the context of evaluating a fast-paced action game. Therefore, we were interested in seeing whether a human wizard could both observe the children and simultaneously control an action game that requires immediate feedback. We were surprised how well the wizard was able to adapt to the children's movements and rapid gesture changes. In some movement types, for example jumping, the wizard's reaction times were relatively short because the wizard was able to anticipate when the child was about to jump since each child crouched a little before they took off. These pre-action cues helped us react quickly and might be used in the design of the computer vision algorithms.

The wizard's presence in the same room made it easier for the wizard to respond accurately due to the children's spontaneous comments during game play. After the test sessions the children often hugged the interactor and asked when they could play the game again. This made us believe that the children actually had an enjoyable playing experience, which was one of the premises of the study.

Intuitive movements
The previous section showed that distinctive movement categories can be found to further design the game controls for a swimming game character. The analysis of the other games mentioned was more straightforward and provided more obvious movement categories, i.e. children usually jumped and ran as the avatar did. In addition, the Wizard of Oz method helped us to analyze other aspects of children's physical activity such as the maximum and minimum jumping heights, the frequency of steps while running, the ability to coordinate movements in a given space and the ability to change from one movement to another. The movement data not presented here will be reported later in more detail. We acknowledge that the quality of the movements is largely dependent on the children's motor skills and sport related hobbies and free-time activities. To get an idea of how these attributes affected our study, we asked parents to give us information on their children's physical development and their indoor and outdoor activities. In further research we intend to take these factors more into account.

The relationship between avatar and player actions
The design of the main character's actions is based on the idea of imitation where the player mimics the movements

of the game character and vice versa. With the video data gathered using the Wizard of Oz method, it was easy to see how the game character's orientation affected the children's own behavior. For example, in the jumping game the children turned in the same direction as the main character to control the jump direction. We could observe a similar phenomenon in the swimming game where the children first faced the screen while the avatar was swimming to the right (Up, left in Figure 4). When the avatar needed to swim to the left, the children started to face in the same direction as the avatar as shown in the lower right corner image in Figure 4. The children did not seem to mind that they had to turn their head to see what was happening on the screen. However, the maximum turning angle must be studied more closely in the future from the point of view of the ergonomics. The findings in this study let us assume that perceptual game controls need not be based only on the first person point of view or the third person point of view (shown directly from behind or front of the character).

Test setup

The tests showed that the wizard can be present in the same space with the participants, which makes it easier to organize the tests especially in schools or day care centers. However, a few children paid attention to the wizard's actions, apparently because the mouse clicks were audible. Every time the child jumped a clicking sound soon followed as the wizard reacted. We propose that the control devices should be as inconspicuous as possible. The keyboard and mouse controls should also be designed so that the wizard's hand movements are small and fast.

Pair testing proved to be a good choice since the children were talkative and provided us with valuable information about their mental model of the games. For example, some children did not understand that in the swimming game the main character was under water in the beginning of the game and thus tried to control the character in ways not anticipated by the "swimming character". As a result, the story leading to the swimming game and the audio-visual cues in the game must be redesigned and evaluated with children.

Problematic issues with the WOz method

There are two main problems with the method. The wizard's cognitive and motor skills restrict the interaction pace and the level of complexity of the system under analysis. Even though our game is based on multimodal interaction, we only focused on one modality since the sound input was already considered functional. On the other hand, had we wanted to try out more complex interaction based on sound input, we could have used separate wizards for each input modality [7]. The multi-wizard approach, however, would affect the test setup. If there are more adults than children in the test space, the balance between adults and children can be distorted.

The collected movement corpus is context dependent and is influenced by the wizard's abilities to adapt to the user's actions. To decrease the wizard's effect on the test data, it is advisable to use several wizards. This, on the other hand, leads to more time-consuming tests and data analysis.

SUMMARY AND FUTURE WORK

Compared to our earlier work [15], the Wizard of Oz method removes at least one iteration of implementing and evaluating the computer vision technology. With Wizard of Oz prototyping the design of the computer vision algorithms can now be based on the versatile movement corpus gathered from children's movements in a real environment. The general finding of this study is that Wizard of Oz tests are easy to arrange as field tests and the method is an invaluable tool for designing computer vision based action games.

As mentioned earlier, the development of computer vision based refined prototypes will be reported on later. Inspired by the experiences and information obtained with the Wizard of Oz method, we plan to continue with working and further experimenting with the approach. The research this far has raised a number of issues dealing with the wizard's hidden role, and how game character's physical attributes and body movements affect the children's intuitive movements. We also intend to study the users' tendency to adapt to the system's rather limited set of commands and feedback, as mentioned in other Wizard of Oz studies [9,19].

ACKNOWLEDGMENTS

We would like to thank all the children who participated in our tests. We are deeply grateful to our sponsors for providing us with the financial support needed to carry out the study.

REFERENCES

1. ACM/IEEE-CS Joint Task Force on Software Engineering Ethics and Professional Practices. Software engineering code of ethics and professional practice. *http://www.acm.org/serving/se/code.htm*
2. American Psychological Association (APA). Ethical principles of psychologists and code of conduct 2002. *http://www.apa.org/ethics/code2002.html*
3. Andersson, G., Höök, K., Mourão, D., Paiva, A., and Costa, M. Using a Wizard of Oz study to inform the design of SenToy, in *Proceedings of Designing Interactive Systems*, London, UK, 25 - 26 June, 2002.
4. Bobick, A., Intille, S., Davis, J., Baird, F., Pinhanez, C., Campbell, L., Ivanov, Y., Schutte, A., & Wilson, A. The KidsRoom: A perceptually-based interactive and immersive story environment. *Presence: Teleoperators and Virtual Environments*, 8 (4), August 1999, 367-391
5. Burmeister, O. K. HCI Professionalism: Ethical concerns in Usability Engineering, in *Proceedings of*

Research and Practice in Information Technology, 2001. Vol 1, pp. 11-17.

6. Cordes, C., & Miller, E. (Eds.). *Fool's gold: A critical look at computers in childhood*. College Park, MD: Alliance for Childhood, 2002. http://www.allianceforchildhood.net/projects/computers/computers_reports.htm
7. Coutaz, J., Salber, D., and Balbo, S. Towards the automatic evaluation of multimodal user interfaces. *Special issue "Intelligent User Interfaces"*, Knowledge-Based Systems, 1993.
8. Crowley J. L., Coutaz, J., & Bérard, F. Perceptual user interfaces: things that see, *Communications of the ACM*, 43 (3), March 2000, 54-64.
9. Dahlbäck, N., Jönsson, A., and Ahrenberg, L. Wizard of Oz Studies -- Why and How, in *Proceedings of the International Workshop on Intelligent User Interfaces*, 1993.
10. D'Hooge, H. Game Design Principles for the Intel Play Me2Cam* Virtual Game System, *Intel Technology Journal Q4*, 2001.
11. Druin, A., Bederson, B., Boltman, A., Miura, A., Knotts-Callahan, D., & Blatt, M. (1999). Children as our technology design partners, In A. Druin (Ed.), *The design of children's technology*. San Francisco: Morgan Kaufmann. 52-72.
12. Freeman, W.T., Beardsley, P.A., Kage, H., Tanake, K., Kyuma, K., Weissman, C.D., Computer Vision for Computer Interaction, *SIGGRAPH Computer Graphics Newsletter* - Applications of Computer Vision to Computer Graphics, Vol.33, No.4, November, 1999.
13. Gould, J.D., Conti, J., Hovanyecz, T., Composing Letters with a Simulated Listening Typewriter, *Communications of the ACM*, April 1983, Vol.26, No.4.
14. Hammerton, L., & Luckin, R. How to help? Investigating children's opinions on help: To inform the design of Metacognitive Software Scaffolding. In R. Luckin (Ed.), *AIED2001 Workshop Proceedings: Help provision and help seeking in Interactive Learning Environments*. San Antonio: St Mary's University, 2001.
15. Hämäläinen, P., and Höysniemi, J. (2002). A Computer Vision and Hearing Based User Interface for a Computer Game for Children, in *Proceedings of the 7th ERCIM Workshop "User Interfaces For All"*, 23-25 October 2002, Paris.
16. Höysniemi, J., Hämäläinen, P., and Turkki, L. (2003). Using peer tutoring in evaluating the usability of a physically interactive computer game with children. *Interacting with Computers*, Vol. 15, Issue 2, 205-225.
17. Kelley, J.F., An iterative design methodology for user-friendly natural language office information applications, *ACM Transactions on Office Information Systems*, Vol. 2, No. 1, March 1984, pp. 26-41.
18. Kelley, J.F., Where did the usability term Wizard of Oz come from?, *http://www.musicman.net/oz.html*.
19. Maulsby, D., Greenberg, S., and Mander, R. Prototyping an intelligent agent through Wizard of Oz, in *Proceedings of ACM SIGCHI Conference on Human Factors in Computing Systems*, Amsterdam, The Netherlands, May, 1993. pp. 277-284, ACM Press.
20. Moeslund, Thomas B. Computer vision-based human motion capture – a survey. Aalborg: Aalborg University, Laboratory of Computer Vision and Media Technology, 1999. (*LIA Report*; LIA 99-02.-ISSN 0906-6233)
21. Molich, R., Laurel, B., Snyder, C., Quesenberry, W., & Wilson, C.E., Panel: Ethics in HCI. *CHI '01 extended abstracts on Human factors in computer systems 2001*, Seattle, USA.
22. Montemayor, J., Druin, A., Farber, A., Sims, S., Churaman, W., and D'Amour, A. Physical programming: Designing tools for children to create physical interactive environments, in *Proceedings of CHI2002*, ACM Press, 2002.
23. Pinhanez, C. S., Wilson, A. D., Davis, J. W., Bobick, A. F., Intille, S., Blumberg, B. & Johnson, M. P. Physically interactive story environments, *IBM Systems Journal*, 39 (3-4), 2002.
24. Roberts, D.F., Foehr, U.G., Rideout, V.J., & Brodie, M. *Kids and media @ the new millennium*. Menlo Park, CA: Kaiser Family Foundation. 1999.http://www.kff.org
25. Robertson, J., and Wiemer-Hastings, P. Feedback on children's stories via multiple interface agents, in *Proceedings of Intelligent Tutoring Systems Conference*, Biarritz, France, June 2002.
26. Rogers, Y., Scaife, M., Harris, E., Phelps, T., Price, S., Smith, H., Muller, H., Randall, C., Moss, A., Taylor, I., Stanton, D., O'Malley, C., Corke, G. & Gabrielli, S. (2002) Things aren't what they seem to be: innovation through technology inspiration. *DIS2002 Designing Interactive Systems Conference*, ACM, June 2002, London. 373-379.
27. Sinha, A. K., and Landay, J. A. Visually prototyping perceptual user interfaces through multimodal storyboarding, in *Proceedings of IEEE Workshop on Perceptive User Interfaces*. Orlando, USA, November, 2001.
28. Subrahmanyam, K., Kraut, R. E., Greenfield, P. M., & Gross, E. F., (2000), The impact of home computer use on children activities and development, *Children and computer technology*, 10 (2), Fall/winter 2000.
29. Wren, C.R., Spacarino, F., Azarbayejani, A., Darrel, T., Davis, J., Starner, Kotani, A.,Chao, C., Hlavac, M., Russel, K., Bobick, A., Pentland, A., *Perceptive spaces for performance and entertainment* (Revised), ATR Workshop on Virtual Environments, Kyoto, Japan, April 1998.