New Interaction Concepts by Using the Wii Remote

Michael Schreiber, Margeritta von Wilamowitz-Moellendorff, and Ralph Bruder

TU Darmstadt, Institute of Ergonomics, Petersenstr. 30,
64287, Germany
{schreiber,bruder}@iad.tu-darmstadt.de, m.wilamowitz@gmx.de

Abstract. The interaction concept of the video game console Nintendo Wii has created a furor in the interface design community due to its intuitive interface: the Wii Remote. At the Institute of Ergonomics (IAD) of the Darmstadt University of Technology, several projects investigated the potential of interaction concepts with the Wii Remote, especially in nongaming contexts. In a first study an interactive whiteboard according to [1] was recreated, modified and evaluated. In this case, the Wii Remote is not the human-machine-interface but the sensor that detects an infrared emitting (IR) pencil. A survey with 15 subjects was conducted in which different IR pencils were evaluated. In a second study the potential of a gesture based human-computer interaction with the help of the Wii-Remote according to [2] was evaluated by using a multimedia software application. In a survey with 30 subjects, the Wii gesture interaction was compared to a standard remote control.

Keywords: Wii Remote, Wii, gesture based interaction, interactive whiteboard.

1 Introduction

Since the introduction of the video game console Nintendo Wii, researchers all over the world have been inspired by its human machine interface: the Wii Remote. A main feature of the Wii Remote is its motion sensing capability and its resulting intuitive handling. Furthermore, all sensor data can be readout and processed by computers having a Bluetooth interface. Due to these capabilities, an easy adaption of this interface to other use cases is possible and thus, the controller has become very popular for alternative human computer interfaces.

Reference [1] presented, inter alia, software for the tracking of fingers, using an LED array, reflective tape and the infrared camera of the Wii Remote. In this case, the Wii Remote is not directly the human-machine-interface, but the sensor (the Wii Remote is positioned on top or under the screen that is used for the tracking) that detects the infrared (IR) light, which is reflected by the tape on the fingers. This setup enables users to interact with their computer simply by waving their hands and fingers in the air. In addition to the finger tracking, [1] provided a program to track the position of the user's head, with the help of modified goggles that are equipped with IR LEDs on both sides. These IR emitting sources

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were then tracked via the infrared camera of the Wii Remote. By rendering the images on the screen depending on the position of the user's head, it transforms a display into a 3D virtual environment.

Another software application that is provided by [1] is the "Low-Cost Multi-point Interactive Whiteboards Using the Wiimote" that can turn every screen or projector into an interactive interface. In addition to the Wii Remote, users need an IR pencil, which is no more than a pencil with an IR LED on the tip and an on/off switch. This device was rebuilt at the IAD and the IR pencil was ergonomically optimized and tested. The functionality of this device will be discussed in section 3.

Reference [3, 4] used the Wii Remote as a navigation device to inspect volumetric medical data coming from Magnetic Resonance Imaging (MRI) or Computer Tomography (CT), to enhance the performance of clinician tasks. They also combined this tangible interaction with speech recognition. Furthermore, a control of simulated avatars was developed such as the bird character of [5], who demonstrated that the Wii Remote interface provides a better and more immersive control in comparison to joysticks. Reference [2, 6] presented a gesture interaction library (WiiGee) for the Wii Remote based on Hidden Markov Models that is available via the World Wide Web. This software was adapted and used at the IAD to develop a gesture based interaction for a Media Center application. This study will be presented in detail in section 4. Another approach for gesture recognition was shown by [7], who presented the game Wiizards, where the user can execute charms by gesturing with the Wii Remote. A different gaming application was shown by [8], who integrated the controller into a multi-wall virtual reality theatre (similar to a cave), by using a multiple sensor bar setup.

The Wii Remote has also been used in the field of arts and music. The virtual conducting of an orchestra was done by [9]. Tempo and volume of the orchestra's performance are influenced by the motion recognition of the Wii Remote. Reference [10] used the Wii Remote as the input device to capture movement data together with the playback of musical stimuli to score the degree of synchronization between the presented music and the motion of the subject. In the project WiiBand, [11] explored an application where three interactors collaboratively created music using Wii Remotes (e.g. horizontal motions of the Wii Remote alters the pitch of a sound, vertical motions the volume).

In additional to all research projects with the Wii Remote, some research only adapted the interaction concept of the Wii. Reference [12] showed a Wii-like interaction with mobile phones for large public game screens where the phones become game controllers for multiplayer games. In addition to the Wii Remote, the hardware add-on Nintendo Balance Board[1] was used as a device for a virtual reality input by [13] (e.g. for 3D rotation in a desktop visualization application or for navigating a map in a personal VR station).

[1] In addition to the Wii remote, Nintendo presented in 2007 a new input controller, the balance board. The board contains multiple pressure sensors that are used to measure the user's center of balance in order to process an input command.

2 The Wii Remote

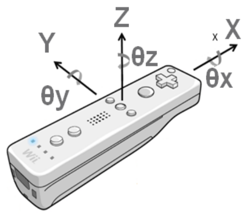

Fig. 1. Wii Remote - the main controller of the video game console Wii

The Wii Remote [14] (fig. 1) is a wireless electronic interaction device of the video game console Wii, which uses the Bluetooth standard for data transmission and is thus cable free. All sensor data can be readout and processed by every computer with a Bluetooth interface. A main feature of the Wii Remote is its motion sensing capability and its resulting intuitive handling. The controller has a 3- axis accelerometer, which can be used to determine relative x, y and z movements and due to the effects of gravity a determination of the current rotation status is also possible. Furthermore the Wii Remote has 9 buttons including a directional pad and a trigger control (located on the bottom side and operated with the index finger) as input controls. A speaker and limited haptic (rumble) feedback is provided by the controller as output signals to the users.

3 Wii Whiteboard

All presented developments in this section are based on the idea of the "Low-Cost Multi-Point Interactive Whiteboards Using the Wiimote" by [1].

The visualization of ideas, concepts and opinions is needed in many different working environments such as meetings, school lessons or workshops. Depending on the room setup and the number of participants, tangible utilities such as flip charts, black- and whiteboards or electronic devices like overhead projectors are suitable options. Nonetheless, these tools lack the possibility to save the developed ideas and notes directly to the computer and make them become easily interchangeable and sharable, something becoming more and more important. A device that combines the advantages of an intuitive handling of tangible utilities and the advantage of a direct digital recording (e.g. for backup of all notes or special software utilities) are interactive whiteboards. These devices connect a computer and a projector to a touch-sensitive display, where users control the computer using a pencil or finger. The main benefit of these systems is that users can user their mental models and skills of the handling of conventional pencils or pieces of chalk even without any experience in dealing with computers.

3.1 Interactive Whiteboard

In addition to prototypes in research laboratories [15] and commercial solutions [16] starting at several hundred dollars, [1] proposed a low cost alternative by using the Wii Remote. For the realization of this low cost interactive whiteboard the software of [1], a computer with a Bluetooth interface, a Wii Remote ideally with an appropriate mounting (e.g. tripod), a data projector, and an IR pencil are needed. In the general setup, the infrared camera of the Wii Remote points at a projected screen to detect the IR point that is emitted by the IR pencil. Through the calibration software of [1], a

Fig. 2. Three versions of an IR LED Pencil for the operation of the Wii electronic Whiteboard. Pen v1.0 and pen v1.1 are using LED and a switch. Pen v2.0 is using the integrated switch on the tip of the pencil.

relation of the IR source and the mouse position on the screen is possible. All movement of the pencil on the projected image (e.g. on the screen or wall) is linked with the position of the mouse. As mentioned in section 1, this whiteboard was rebuilt at IAD and the IR pencil was re-engineered. The software was not modified. At the end of the design process, three IR pencils were created and are shown in fig. 2. Pen v1.0 and pen v1.1 are simple versions of an IR pencil consisting of a shell of a board marker, IR LEDs (one LED for pen v1.0 and 3 LEDs for pen v1.1) and a button to turn the LED on. Both prototypes have a serious disadvantage. The interaction is not equal to real pencils, because of the frequent activation of the IR source, which had to be turned on and off constantly when writing and clicking. In the case of writing block letters, users have to push and release the on/ off button at least one time for every letter (e.g. to write the word "Hello" users have to push and release the on/off button 7 times - 3 times for the capital H and 1 time for every remaining letters).

The main requirement for the development of pen v2.0 was a more pencil-like handling to make the interaction more intuitive and simple. The design team came to the decision to put the on/ off button on the tip of the IR pencil. Due to this advancement, every time the IR pencil is touching the screen, the electric circuit is closed and the LED turns on. The result of the development process is shown in fig. 2 (image on the right). Since the on/ off button is on the tip of the pencil, the LEDs have to be moved elsewhere. In the solution of IAD, the LEDs are arranged in a circle around the on/ off button on the tip of the pen.

3.2 Exploring the Usability of Pen v1.1 and Pen v2.0

For the evaluation of the capability and efficiency of the electronic whiteboard, one of the simple IR pencils (pen v1.1) and the improved IR pencil (pen v2.0) were evaluated in a usability study. In the experiment, the subject had to perform typical operations of a workshop. 15 subjects (mean=28.4 years; SD=5.6 years) took part in this experiment, where nine subjects tested pen v1.1 and six persons the improved version (pen v2.0).

Before the experiment started, the subjects were asked to fill in a questionnaire with general questions about their experience and qualification with electronic devices. Afterwards the subjects were briefed on the functionality of the Wii electronic whiteboard and the software Jarnal, which is an open-source application for note taking, sketching and annotating a document with which they had to work during the

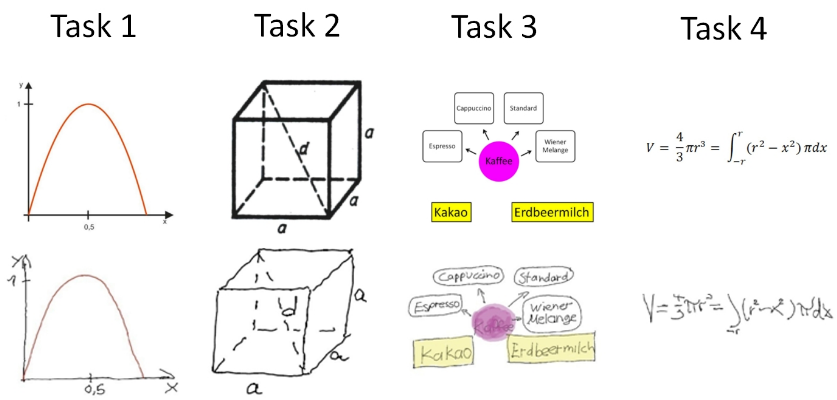

Fig. 3. Upper Line: Four different tasks given to the subjects during the study. Lower line: Example of the result of the drawings/writings of one subject with the pen.

experiment. Then the subjects received a written introduction with precise instructions for every task. The whole experiment contained several different tasks such as drawing (e.g. a graph or a cube), handwriting (e.g. an equation) and writing with the screen keyboard. Examples of the drawing and handwriting tasks are shown in fig. 3 on the top. At the bottom of the figure the result of the task for one subject is displayed. After the subjects completed all tasks, they were asked to use the IR pencil to save their documentation. Afterwards the subjects were verbally interviewed and requested to fill in a questionnaire about their impressions when interacting with the Wii Whiteboard. For the investigation of such new concepts, not only the efficiency and effectiveness of interaction is essential, but also the satisfaction with the design, the joy of use and the customer's inherent need to develop themselves have an impact on perceived quality of products.

Therefore, the subjects filled in the AtrakDiff [17, 18], a questionnaire about different quality aspects of products (e.g. electronic devices) with the feature of separating the pragmatic from the hedonic quality. The pragmatic and hedonic quality is measured by a specific value with a rating between 1 and 7, whereas 7 is the best and 1 is the worst and can be defined as follows [18]:

Pragmatic Quality (PQ)

Shows product usability. Can the user achieve his goals with the product?

Hedonic Quality (HQ)

Indicates to what extent the functions of a product enhance the possibilities of the user, stimulate him or communicate a particular identity (e.g. by creating a professional, cool, modern or any other impression).

3.3 Results of the Usability Experiment of the IR Pencils

After the subjects had finished the experiment, they filled in the AttrakDiff to measure hedonic and pragmatic quality of the Wii Whiteboard with pen v1.1 and pen v2.0. Additionally, a questionnaire was given to the subjects concerning the interaction

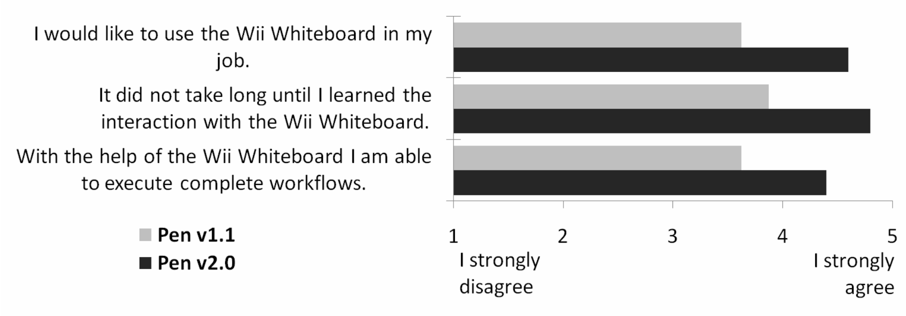

Fig. 4. Extract from the results of the questionnaire that was given to the subjects after the experiment. N=9 for pen v1.1 and N=6 for pen v2.0. All questions are translated from German to English.

with the Wii Whiteboard. Three exemplary questions are shown in fig. 4. One can see that for the interaction with both pens the rating is at a medium to high level. The subjects who tested pen v1.1 agreed with the statement that they would like to use it in their job and they expect that they can execute complete workflows with it. Furthermore, they confirmed that it did not take long to learn how to use and interact with it. Due to the refinements to pen v2.0, the assessment of interaction with the Wii Whiteboard was improved to ratings that are close to "I strongly agree" on all of the scales.

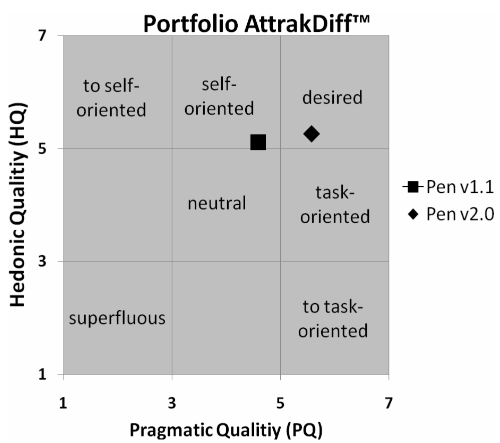

Fig. 5. AttrakDiff Portfolio for pen v1.1 and pen v2.0. N=9 for pen v1.1 and N=6 for pen v2.0.

The results of the AttrakDiff are shown in fig. 5 with the help of the portfolio presentation that is used to visualize the relation between pragmatic and hedonic quality of the product. The hedonic quality of both pencils were in the upper area; their results showed values of 5.11 for pen v1.1 and 5.26 for pen v2.0 with a range between 1 and 7, where 7 was the best and 1 was the worst. The pragmatic quality of pen v1.1 was only in a medium area, and achieved a value of 4.59 (the rating was also arranged from 1 to 7, where 7 is the best). With the improvements of pen v2.0, the pragmatic quality was increased to 5.57. The simplified interaction by putting the on/off switch on the tip of the pen led to an increase in the usability and utility of the product. This also explains the higher satisfaction in the other questionnaire.

4 Wii Gesture Recognition

Gesture recognition applications are becoming more and more popular in the field of human computer interaction. In addition to character recognition on tablet computers or palms, which have already entered the mass market, hand and finger gestures also extend their range of use, especially in research projects (e.g. for the operation of in-vehicle infotainment systems [19, 20] or remote control of robots [21]). Furthermore, a few products with finger and hand gestures have entered the market, such as the iPhone. However, the gesture recognition is not a new type of interaction. Already in the 1980s, [22] demonstrated a media room where users could interact with a wall-like screen and [23] showed the potentials of gesture interaction with a DataGlove, which was also equipped with piezo actuators for tactile feedback. Since Nintendo released its Wii, a low cost device is on the market that provides programmers with the hardware to implement gesture recognition algorithms. In a study at the IAD, the potential of a gesture based human-computer interaction with the help of the Wii Remote was evaluated by using a multimedia program. The Wiigee gesture recognition algorithms of [2, 6] were used for the implementation and matched to relevant Windows applications. Those algorithms are based, as many other approaches for gesture recognition [24, 25, 26], on Hidden Markov Models, a statistical tool for modeling a wide range of time series data.

4.1 Exploring the Usability of Wii Gesture Recognition

For the exploration of the usability and the aspects of joy of use while interacting with the Wii gesture recognition, an experiment was conducted, where subjects had to perform different tasks in a Media Center[2] application with both the gesture recognition and a standard remote control.

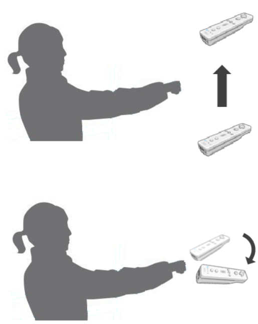

Fig. 6. Example of gestures input in the Media Center. Top: upward stroke of the Wii Remote to navigate one step higher in the navigation menu.

The navigation though this program is normally done by a remote control, mouse, or the keyboard of a computer. For the navigation in the Media Center, the user mainly needs a directional pad (up, down, right, or left), a button to enter or to confirm, a "back" button, and a "play" button. In the gesture recognition interaction, these buttons were replaced by motions of the Wii Remote, e.g. to navigate one step to the right in the Media Center menu, users had to perform a motion with the Wii Remote to the right (compare fig. 6 bottom). These movements/gestures are derived from a prior study with 20 subjects.

30 subjects (mean=24.2 years, SD=3.9 years) participated in the study. At the

[2] A Media Center is an application designed to serve as a home-entertainment system that might include pictures, music tracks, music videos, television channels, movies, etc.

beginning, an introduction was given regarding the use of the standard remote control and the Wii remote gestures as well as time to practice (with) both of them. Then everyone had to fulfill a series of common Media Center tasks, such as navigate to a predetermined music track, check the temperature for today in the weather forecast or search for a specific picture in the picture database. The subjects had to complete the series of tasks with the common remote control and similar tasks with the gesture based Wii Remote. Hidden Markov models were used for the gesture recognition, which implies that the gesture must be trained either by the subject or by the experimental conductor. Due to the training time of such gestures, they were predefined by the conductor. Nonetheless, in a small supplementary study, with five subjects, the potential of individual trained gestures was investigated. Subjects filled in the AttrakDiff [18] and the System Usability Scale (SUS) [27] questionnaires for the evaluation of both interfaces after they finished the tasks.

4.2 Results of the Wii Gesture Recognition

The results of the AttrakDiff show on the one hand that the hedonic quality is significantly higher for the Wii Remote gesture application than for the standard remote control. The subject visibly enjoyed the interaction through gestures. But on the other hand, the pragmatic quality and the score of the SUS, with a result of 73.8, showed the advantages of the standard remote control (in comparison to the Wii Remote with a score of 53.25). The main reason for this result is probably the high amount of misinterpretations of the not self-trained gestures. In the supplementary study with five subjects, which was conducted after the main study, the potential of individual trained gestures was investigated and it turned out that misinterpretations could be highly reduced. Thereby, the pragmatic quality was enhanced as is shown in fig. 7 as Wii Remote (improved). Thus, the type of gesture training has a major impact on the perceived quality of the interaction concept. For a future gesture based Media Center, the gestures should therefore be self-trained. The training of the system is to be done once at the beginning, taking about 15 minutes and then the system will improve its recognition during usage. This should ensure a highly desired, fun provoking and usable interaction.

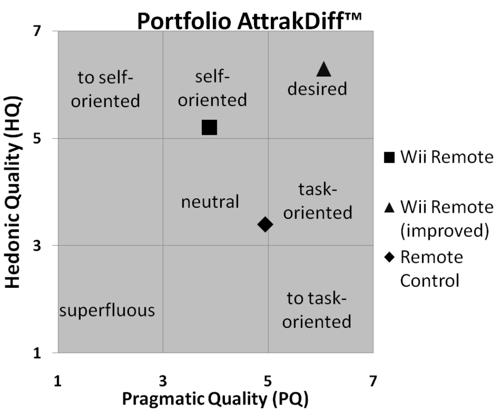

Fig. 7. AttrakDiff Portfolio for the Wii Remote gesture recognition with pre trained gestures (Wii Remote), the Wii Remote gesture recognition with subject trained gestures (Wii Remote improved) and a standard remote control (Remote control). N=30

5 Conclusion

The literature review and both projects that were conducted at IAD show the potentials of the Wii Remote for existing low cost interaction concepts. Most of the aforementioned Wii applications do not achieve the quality of commercial solutions (e.g. electronic whiteboards). However, it was shown that with small improvements (e.g. from pen v1.1 to pen v2.0 of the IAD electronic whiteboard), usability engineers are able to considerably improve the usability of those prototypes and make them nearly equal to the quality of commercial applications, with lower costs. Not only existing ideas could be emulated with the Wii remote, but also new ideas, such as the gesture control of a media center, were surveyed by the IAD, giving new exciting opportunities. Further research and developments might be necessary, but the potential for a future application is foreseeable. Another essential aspect of doing research with the Wii Remote is the power to create new ideas and stimulate research. This is due to two major reasons. First, the possibility to access the sensor data of the Wii Remote. This makes it easy to adapt the interface to all kinds of applications that were programmed all over the world. And second, most of the developed applications are available via the World Wide Web and can be downloaded, modified and experienced by everybody. This is creating a powerful network with researchers and amateurs from all over the world being inspired, sharing their ideas about the Wii Remote and creating a new community to develop a part of the interaction of tomorrow.

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