

# Intuitive E-Teaching by Using Combined HCI Devices: Experiences with Wiimote Applications

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**Abstract.** The wide availability of game based technologies and sophisticated e-Learning possibilities creates new demands and challenges on Human-Computer Interaction and Usability Engineering (HCI&UE). Solid research in HCI must support improvement in learning ability and creativity for *both* teachers and students. According to recent market surveys the Wii remote controller or Wiimote is currently more wide spread than standard Tablet PCs and is the most used computer input device worldwide. As a collection of many sensors, also including Bluetooth technology, accelerometers and IR sensors, Wiimote is of great interest for HCI experiments, especially in the area of e-Learning and e-Teaching. In this paper, we present results gained from the investigation of the potential of Wiimote as both a standard input device – such as mouse or presenter – and as a gesture and finger tracking sensor. We demonstrate, on the basis of examples from e-Teaching, how easily everyday gestures can be interpreted in regular computer applications utilizing Wiimote’s hardware modules and some additional software modules.

**Keywords:** Wii, Wiimote, finger tracking, gestures, usability, e-Learning.

## 1 Introduction and Motivation for Research

Gestures are an important part of non-verbal communication within demonstration and presentation tasks, which are essential for human cognition and represent a pervasive element of human communication across cultures [9], [13].

Gestures depend on many factors including personality, cultural background, social and geographical surrounding, level of previous knowledge etc. In user interfaces, gestures can also be used for scoping or marking displayed objects, for target indication to point to the location of interest, for entering operations, such as mathematical

operations and for literals (handwritten word) and modifiers (handwritten parameters for operations) [12]. In this paper, we demonstrate that gestures can enhance the quality of the lecturing process, consequently positively influencing the information transfer. Merging those gestures by use of unified interfaces can offer the possibility of transposing a non-verbal “communication code” to a certain, objective, purpose; in our case this is the transfer of information. Tracking gestures, in scope of the demonstration and presentation of teaching subjects, will be used to highlight and underline the essence of presenting the material. For example, to point on a particular location saves time and sometimes can be more efficient than a verbal description of it. If the information is presented incidentally in a wrong way, significant loss of information for the end users can be a fatal consequence. When referring to e-Education, we define this as *using technology for education* [3], [4]. We can further differentiate between e-Learning and e-Teaching, consequently defining e-Teaching as *using technology for teaching* and e-Learning as *the student’s use of technology*, supplied by the teachers, to enhance the learning process. Learning is a cognitive and social process, and teaching is a didactical and social process, accordingly there is a lack of experience and evaluation of benefits and risks of e-Teaching techniques [10].

## 2 Background and Related Work

An additional benefit of using the tracking gestures method is to adapt the use of computers to users with special needs. This target group needs a much wider support for additional input channels than average users. The amount of information and the possibilities for communication are much more limited (e.g. hearing, vision problems). Therefore, there is a strong need to support users with special needs with additional devices and interfaces, which enable them to work equally to average users. Gesturing, such as the “Go right” demonstration, involves sensing the direction of pointing. This achieves an economy in dialogue by substituting a pronoun plus a pointing gesture for a much longer number of words. Such methods are an essential example of human–computer interaction, because they do not simply offer redundancy. Instead, the modalities supplement each other’s information. When the speech part is uncertain, the system takes information from the gesture to support the decision about what was said [1]. A further benefit is that advanced multimodal user interfaces are becoming continually affordable due to the availability of low cost mass market interfaces, such as the Nintendo Wii gaming console [8], including the wireless input device Wii Remote, or short: Wiimote, which can, together with the Wii sensor bar detect motion and rotation in 3D through the use of accelerometer technology [2], [6], [11], [17]. Separating the controller from the gaming console, the accelerometer data can be used as input for gesture recognition and this can be use for various new multimodal user interfaces [14].

## 3 Methods and Materials

We follow the general research recommendations presented by Stephanidis & Salvendy (1999), [16] in order to provide evidence on the impact of our implementations. We prove whether and to what extend the use of gestures during real life

university teaching settings can enhance the efficiency of lecturing as well as the learning in large traditional lecturing rooms. Apart from pure technological testing on site, we additionally used interviews and short questionnaires, supported by usability inspection methods including video analysis [5].

### 3.1 Questions of Research

The following research questions will be answered within this paper: 1) What is the central advantage for both teachers and students of using intuitive interfaces devices such as a Wii remote controller? 2) How can such controllers enhance current e-Teaching methods? 3) What basic design considerations must be taken into consideration?

### 3.2 Technological Environment and Development

As the main user interface device for our experiments we used the Wii Remote Controller (Wiimote), which is equipped with a 128 x 96 monochrome camera with an infrared (IR) pass filter in front of it. Additionally, Wiimote also includes an in-built processor capable of tracking up to 4 moving objects at a frequency of 100 Hz. These features classify Wiimote as a very feasible sensor for infrared projection planes. The on-board 8x sub pixel analysis is used to provide valuable resolutions (up to 1024 x 768) for the tracked points. The IR pass filter detects reflecting sources up to 940 nm wavelength with approximately the double intensity of equivalent 850 nm sources, however, does not resolve them very well at very close distances. The IR sensor alone, without the filter, can track any bright object. Additionally to some other sensors, the Wiimote includes a Bluetooth interface for communication, which enables it to connect to any Bluetooth compatible device.

Using the in-built features and adequate open existing source library, we were aiming to implement communication, finger tracking and capturing of infrared reflections. Every infrared reflecting surface can be the used as a projection surface (computer screens, beamer projections etc.). A simple LED-array, made of long-range infrared light diodes, was used to enhance the range and the supported working distance.

This approach offers the possibility of interaction once the tracked movements – such as mouse movements, mouse clicks, selections or keyboard commands – are interpreted into the boundaries of operating system. The implemented gesture recognition enables interaction which enhances the learning and teaching process and information transfer between the participants.

In order to prove our assumptions, we developed a practical demonstrator kit, based on the Wii technology, used as support equipment for a test bed on multi medial teaching methods. This kit includes the Wii remote controller and an infrared diode array (IR LED array) as sensors and reflecting finger pads as interaction hubs inspired by existing examples. The reflecting finger pads are used as pointer and as interface for gestures, while the Wiimote itself is also used in one of two tested setups in order to simulate a hand free mouse and an interaction tool on projected surfaces. For connection, communication and the parameterization of the hub, we developed a special application.

We tested two different setups: in the first setup, the Wiimote served as the capturing and input device. The IR LED array, with its radiated IR field, was the static sensor reference. In the second setup the Wiimote acted as passive sensor field receiver enhanced by the radiation strength of IR LEDs array. The software component used to support these two setups is called *Wiimote Control Desk*.

The *Wiimote Control Desk* application was developed based on the code of Wiimote *Whiteboard*, originally programmed by *Johnny Chung Lee* as part of his experiments [7]. Originally it was meant for controlling and tracking an IR Pen using an IR sensor of Wiimote as a capturing device in order to simulate a white board. For the purposes of finger tracking and mouse remote control it was lightly changed and some features were added in order to achieve the new goals. The Wiimote Control Desk was implemented using the Visual Studio C# Express edition which is freely available on the Web. It runs on the Microsoft's .NET Framework 2.0. Communication inside relies on the Managed Wiimote library for .NET. Originally the library was developed by *Brian Peek* from ASPSOFT Inc. The Application Programming Interface (API) uses Bluetooth to communicate with the Wiimote and to retrieve and handle the various states of the Wiimote components. Consequently, the Wiimote is treated as an HID (Human Interface Device) compliant device when connected to a regular PC. The API uses the advantage of the P/Invoke mechanism. In general, there are two different ways to retrieve data from the API: using events or using polling. Our implementation uses the event based approach. Hence, the Wiimote Control Desk can be operated corresponding to planned setups in two different modes:

1. Controller mode
2. Presenter mode

The *Controller mode* was implemented in order to use the Wiimote as both a pointing and presenter device, similar to a free hand mouse. As capturing background, an IR LED array was used. Some Wiimote's buttons were reprogrammed to fire mouse and keyboard events. An appropriate setup for *Controller mode* can be seen in figure 4.

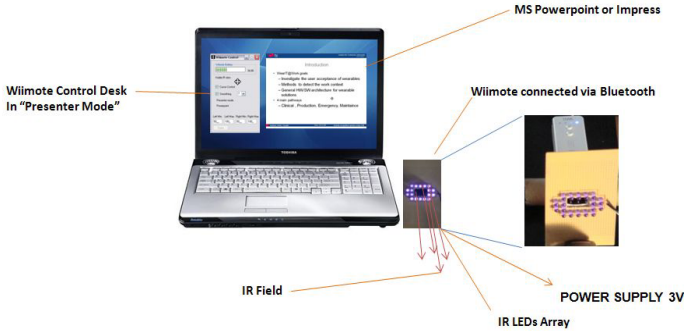
The *Presenter mode* is required when using finger tracking support. This mode enables the user to navigate through the presentation slides of MS PowerPoint or Open Office Impress presentations, or any other applications which supports the forward or back function based on keyboard events.

This is basically done by firing the left or right keyboard keys or, alternatively, by using the relative position of the mouse cursor on the screen pointed through the finger tracking pad. The appropriate setup for the *Presenter mode* can be seen in figure 1 and figure 2.

Our IR LEDs array was built using the highly reliable SFH 485 IR Emitter Diodes built by Siemens [15]. The main areas of appliance for this diode are remote controls, hi-fi and TV sets, video tape recorders and various sorts of dimmers. The average wavelength at peak emission is 880 nm, which is quite adequate and most suitable for the Wiimote's IR sensor. The IR LEDs array requires a constant 3V (1A) power supply.

## 4 Experimental Results

The first tested setup considers finger tracking as a natural gesture interpreting method. The finger tracking setup consists basically of three main components: the IR LEDs array; the Wiimote and the Wiimote Controller Desk, as shown in figure 1 below.



**Fig. 1.** Sensor setup for finger tracking

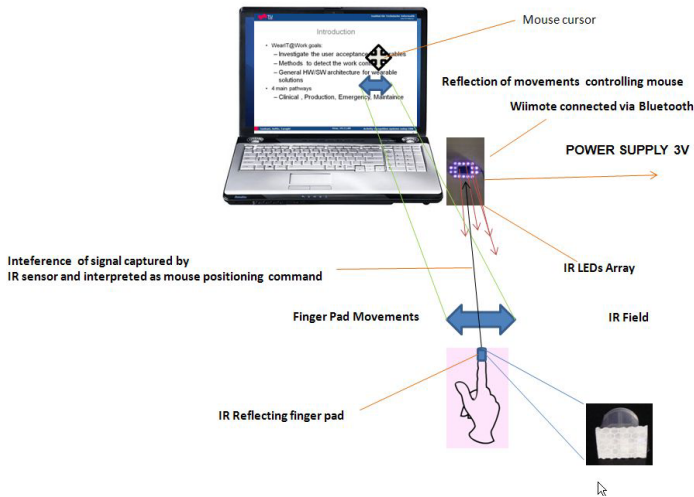
The IR LEDs Array radiates an IR Field towards the observer standing in front of the setup. The IR sensor of Wiimote is placed behind the array looking through the hole provided in the middle of board. In this way, the sensing area of Wiimote’s sensor is enhanced by the strength of the emitter diodes in the IR LED array. This increases the area covered by the Wiimote, which would otherwise be too narrow.

As the reflecting device, a reflective tape, commonly used with light barriers, was mounted on a standard bottle plastic cap. The finger pad used for sensing can be seen in figure 2. As part of the Wiimote Controller Desk implementation, the smoothing mechanism calculates and rejects the falsely sensed points in order to interpolate the movement of the single tracking path, thus smoothing out any unintentional tremors.

The bottom line of this setup is to set the appropriate position of the mouse on the screen, corresponding to the appropriate position of the reflective finger pad in the area covered by IR field. Depending on position and length of appearance of mouse cursor *Wiimote Controller Desk* interprets the appropriate actions.

This setup is only used actually for navigating through presentations in MS Power-Point or Open Office’s Impress. After starting, the Wiimote Controller Desk software checks continuously at short intervals whether there are any common presenter applications, such as MS PowerPoint or Open Office’s Impress running. In the case that an instance of these applications has been started, it switches automatically to “Presenter mode”.

Bringing the reflecting pad into the radiation field of IR array activates the Wiimote IR sensor to recognize the reflecting point and its movement. The position of the finger pad is then interpreted and projected on the computer screen.



**Fig. 2.** Finger tracking in action

To simulate the “forward” and “backward” commands properly in a running presentation, it is necessary to calibrate the *Presenter mode* in the *Wiimote Controller Desk* by setting up the appropriate heuristic values for ticks ranges.

Holding the projected cursor on the right or left side of the screen for a previously defined heuristic time interval and then removing it from the field, e.g. by hiding or covering the reflecting area of the finger pad, will then be interpreted as a command to switch to the next (right) or previous (left) slide, depending on which half of the screen (left or right) the cursor was detected.

Switching slides can be triggered by holding the projected cursor on the right or left side of the screen for a previously defined heuristic time interval and then removing it from the field, e.g. by hiding or covering the reflecting area of the finger pad. Depending on where the cursor is detected, this is interpreted either as a command to switch to the previous slide (left half of the screen) or to the next slide (right half of the screen).

All other moving or positioning patterns and time intervals will only lead to sole mouse pointing action. Both behaviors are depicted in figure 3. Provided the setup for using the Wiimote as a pointing and presentation input device is depicted in figure 4.

Basically, the second setup consists of a IR LEDs Array positioned in front of the screen of targeting projecting surface. The field rays from the IR LEDs array should be aligned vertically upwards along the screen of the projection area. *The Wiimote Controller Desk* should be also up and running. Operating in this setup, the Wiimote can be used instead of a mouse, supporting all the basic mouse functions, such as cursor pointing, left click, double click and right click. Additionally, the navigation button enables the Wiimote to simulate the operations of the selection, forward or backward actions keyboard arrow keys (e.g. when running presentations or image galleries).

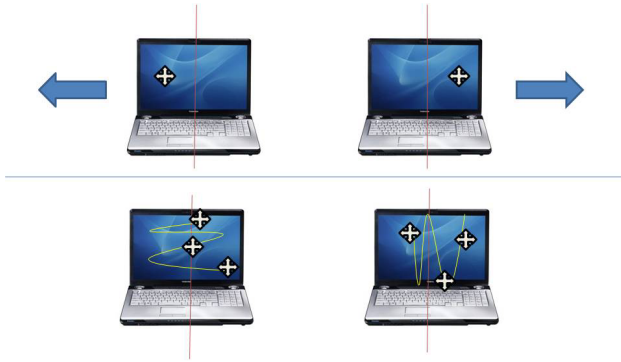


Fig. 3. Moving patterns

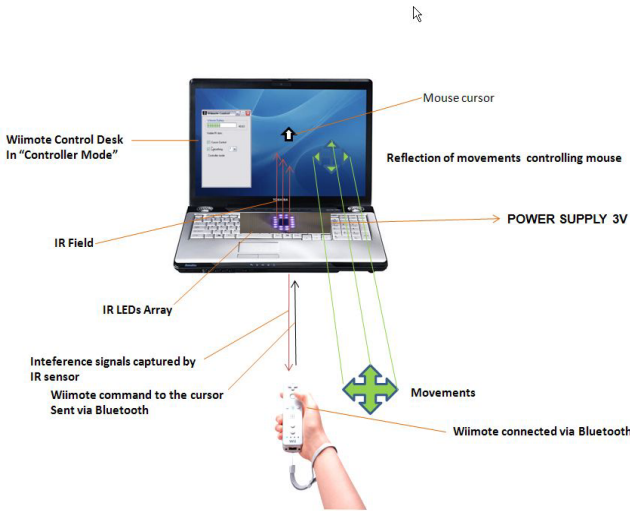


Fig. 4. Setup for using the Wiimote as a pointing and control device

The principle of projection of mouse movements is very simple: The field vertically to the projection area radiated by the IR LEDs Array (here notebook display) represents static reference to the moving IR sensor on the Wiimote. As long the Wiimote is moving, its perception of the constant IR field in front of the display deviates at the point of observation. This deviation will be recognized as an isolated IR signal and reported to the *Wiimote Control Desk*, which treats this information as an instruction to point the mouse on the appropriate place on the projection screen. The Wiimote's button "A" is used for the left click and pressing it quickly twice has the same effect as the regular double click of the mouse. Button "B", located underneath, triggers the right click.

In this way, Wiimote becomes a very handy mouse controller and pointing device with a range wider than the usual wireless mouse.

## 5 Conclusion and Future Work

Our demonstrator kit was used as a presentation tool during various lessons and practical lab sessions at Graz University of Technology. Moreover, it was used as an interactivity and cooperation tool during learning and discussion tasks using a visual tracking of mouse movements on electronically shared whiteboards. In comparison to the classic approaches, our method allows the direct intuitive cooperation between all participants within the learning process. Consequently, our approach offers more comfort and provides more flexibility in everyday e-Learning and e-Teaching activities. Furthermore, it can be pointed out that there are no similar low cost products, which contain a higher or equal grade of interactivity and such a wide appliance area that could be as suitable for these purposes.

Altogether it can be said that Wiimote is a fascinating collection of sensors that can be used for many purposes, even for recognizing gestures, and which can be adapted freely using adequate open source libraries available at the internet.

Using Wiimote as a Pointing and mouse device works well but demands more work in order to capture the mouse positions and moves more accurately. Using the approximation of motions could result in improved smoothing, an area which should be considered for future development considering area of application targeted. Future research will include the use of IR LEDs with a lower wave length to assess the achievement of a wider range and more accurate isolation of tracking points and increasing the number of LEDs in the array, to see whether this increases their accuracy. The main area of research will be other methods off triggering commands. Using time as base for command delegation shrinks massively the potential of possible operability range. To improve better personal gesture interpretation capturing the data from Wiimote's accelerometer should be also considered as important research issue.

Tracking general basic gestures relevant for e-Teaching and e-Learning tasks works stably for several meters (3-5 m) distance to Wiimote (depending on the light conditions and the position of Wiimote) with enhanced radiation field as shown in the finger tracking example. While testing different setups, heuristic experiences showed that placing the Wiimote beside the computer at a height between 1 and 1,5 m, and at an angle between 45-60 degrees, offered the best setup.

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