

# Interactive whiteboards based on the WiiMote: validation on the field.

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**Abstract**— We run a project involving a large number of schools introducing an inexpensive, Wiimote based Interactive Whiteboard. Our aim was to verify how far such solution was from the industrial solutions. We found that in spite of some minor nuisances, the devices are actually well usable. An advantage is that since the solution is cheap, it can be used also at home. Another important point is that the extra burden of setting up the system by one selves increases the teachers' awareness.

**Keywords:** *interactive whiteboards*

## I. INTRODUCTION

Interactive whiteboards (IWB) are becoming more and more popular in schools [1]. The concept of interactive whiteboard is a simple one: the computer screen is shown on a large surface which is touch-enabled: by touching the surface users can interact with the computer (move the cursor, click etc.). The didactic value of such device is well recognized: it allows putting the computer screen at the place of the blackboard, but unlike what happens when simply projecting PowerPoint-like slides, the interactivity dimension is preserved. It is hence possible to annotate the projected screen as if one was writing on a blackboard, and one can interact with simulation or didactic software. On this simple idea, a whole industry has grown: companies like Smart Technologies run a very successful business producing and selling IWBs. The cost of these devices is however not negligible, and the Internet community devised a clever and inexpensive replacement of the industrial IWBs. The idea is to use a Wiimote (which is a component of the popular Nintendo videogame technology called Wii) to reproduce the functionality of an interactive whiteboard.

With the institutional and financial support of the local government, we run an experiment of relatively wide scale usage of these devices. The project Wii4Dida2 involved more than 30 schools and about 60 teachers were involved in the experiment for an entire scholastic year. We followed them teaching how to install, set up and use the device in class. We collected their experience and feedback through direct interaction, focus groups and questionnaires.

Teachers were also involved in web 2.0 activities, running blogs to document their activity.

Also, the project supported the development of an open source software tool called Ardesia. Ardesia allows annotating the screen with a virtual pen, and was developed using a participatory design approach, keeping the users (teachers) in the loop.

Another product of the project was a Linux distribution especially designed with the IWB on mind. Such distribution, called WiildOS, includes a wide selection of tools usable with the IWB, and can be fit on a USB pen drive so that it is possible to boot any (relatively modern) laptop from it and, with the help of a projector and a wiimote, have an immediately fully functional IWB system without caring about installation of drivers and software that may hold back unskilled teacher.

Other tools we developed include an authoring environment for web-based learning objects suited for interactive use on the whiteboard, and a hierarchical Learning Object Repository that uses semantic technology for extracting metadata.

Finally, we started experimenting an alternative inexpensive way to emulate a IWB by using the Microsoft Kinect.

In this paper we briefly present the project results.

## II. THE WIIMOTE-BASED INTERACTIVE WHITEBOARD

In December 2007 Jonny Chung Lee, who later became a researcher at MIT, started a project for creating a low-cost multi-point IWB using the Wiimote [2]. The wiimote (or Wii Remote) is the component (controller) of the Nintendo Wii system that is typically kept in the hand by the player. This controller is a very interesting piece of hardware, featuring an accelerometer, an infrared camera, Bluetooth connection, several pushbuttons and (in the last version) also a gyroscope.

J.C.Lee idea was very simple: the Wiimote is put in a fixed position so that its infrared camera can "see" the projected computer screen. The user holds a pen-like device that has an infrared light. The wiimote detects and communicates (via Bluetooth) the position of the infrared light to the computer, the screen of which is projected. Thanks to a calibration operation performed at the beginning, the computer is able to map the pen location onto the virtual space of its (projected) screen. This position is then used to move the mouse cursor, so that it

follows the infrared pen. Hence, the pen becomes equivalent to the mouse, and the user can interact with the computer by moving the pen. The basic functionality of an IWB is there, performed by a piece of software that is usually called “a driver”). Since the Wiimote can track up to 4 infrared lights simultaneously, the IWB can actually become a multi-touch IWB simply by using multiple “pens”. Since the Wiimote is an inexpensive piece of hardware, the IWB functionality can be emulated with only 50€ (plus obviously computer and projector), as opposed to much larger amount of money needed to get an industrial IWB (for which far more than 1,000€ are needed, in addition to computer and projector).

The open source community has since provided several different drivers, which are available for all the major platforms (Windows, Macintosh and Linux).

The Wiimote based IWB (that in our project we call WiiLD, where LD comes from the Italian words for IWB, Lavagna Digitale) has since grown in popularity.

### III. SOFTWARE SUPPORT FOR THE WII LD

A typical IWB is nothing more than a sensing device that maps a position obtained in the physical space onto the virtual space of the computer screen. As such, it is nothing more than a sophisticated mouse that transforms a projected image onto a giant touch tablet. The IWB market battle has two components: the physical device (where precision and motion detection accuracy are the most important quality factors) and a software layer. Although anything that runs on a PC can (obviously) be used on an IWB, typically vendors offer a set of software tools specifically designed for using the IWB. There are two main functionalities.

The first is a screen annotator that creates a sort of transparent layer on top of the computer desktop. By using it, it is possible to draw in front of anything that is displayed on the screen, without interacting with it. One can hence e.g. draw a circle around some attention point, or write a comment on the side of a text or image. The most sophisticated screen annotators also offer the option of incorporating the note in the underlying layer: i.e. they can e.g. include a handwritten notice onto the underlying PowerPoint slide. Such functionality is usually limited to a set of predefined supported software (which usually include an Office suite).

The second main functionality is a sort of container, or “notebook”, onto which one can collect some prepared material. For instance, one could prepare a lecture by putting onto the “notebook” a PowerPoint-like presentation, images, notes etc. Presentation software itself (MS PowerPoint, OpenOffice Impress, Apple Keynote) is a sort of container of the same kind, but usually those for the IWB allow easier operations, e.g. the splicing of entire files or the inclusion of (live) web pages.

Such functionalities were needed in the open source community. Within our project, a software of the first type (screen annotator) was developed (by P. Pilolli) and made available as open source. It is called Ardesia [3]. Its main functionalities include:

- Draw freehand in any color
- Configurable brush size
- Other tools include arrows, text and geometric shapes
- Save sketches as .png or .pdf files
- Recording and playing back actions
- Ability to stream ‘live’ screencast of your desktop as you use Ardesia
- Undo/redo feature

To be able to import and export from other IWB software, Ardesia can save and read files written in the IWBff [4] (IWB file format) defined by the British Educational Communications and Technology Agency (BECTA).

An interesting point about the development of Ardesia is that it was developed in close interaction with teachers, who dynamically and constantly provided feedback and requirements: a typical example of interaction design.

The “notebook” functionality was already present in the open source community, as the Sankoré software [5] (developed by a French group) is a reification of the concept.

By working on the field with teachers we then observed that operations that are trivial for a reasonably skilled computer users (e.g. retrieving and installing the needed software) were a big hurdle for many educators who only had basic operational knowledge of a PC. Moreover, such operations are time-consuming also for people who are more familiar with technology. Based on these considerations, we understood the need to provide a “canned” solution.

We therefore produced a distribution where all what is needed to operate a WiiLD is prepared and pre-configured. Everything what we deemed necessary is included, but at the same time particular care was used to avoid to create a gigantic set. The result, that we called WiildOS [6], includes an operating systems, all the needed drivers for the communication with the WiiMote, Ardesia, Sankoré and a number of tools which are useful in the classroom.

WiildOS is the first GNU/Linux live and installable distro supporting the Wiimote whiteboard for educational purposes. The distro is available as an ISO image and it can be used to burn a bootable CD-ROM, to build a bootable USB key or to be tested inside a virtual machine such as virtualbox. The great advantage of such solution is that even without actually installing anything on a classroom computer, one can run WiildOS from the USB key or from a CD, and the computer is immediately ready for using the WiiLD.

The WiildOS includes a large number of open source tools which are either general purpose (such as tools for working with images, or the open source version of Office, libreoffice) or specific for certain type of didactic purposes such as e.g. tools for Math (like Geogebra), for introduction to Programming (like Scratch), for Music (like Solfege), or for mind mapping (Freemind).

The distribution includes (among others) lubuntu-desktop, lxlauncher, python-whiteboard, spotlighter, curtain, florence-ramble, wmgui, wiican, easystroke, vmg, gimp, tuxpaint, tuxmath, tuxtype, dia, scribus, Jokosher, stellarium, xournal, educazionik, drawswf, pdfedit, vue, , dmaths, jclick, openuniverse, prism, tracker, gcompris, wxmaxima, jokosher, musescore...

Not only WiildOS saves time and makes the installation of a WiiLD an easy task – it also presents a user interface that has been designed specifically for the use with the WiiLD. For instance, using an IWB it is not always easy to deal with small objects. Also, double-clicking operations feel less natural than when performed with the mouse. A mouse has (usually) two or more buttons. Even on Macs, that traditionally had only one button on the mouse, the concept of right- and left-clicking is now present. An infrared pen has typically only one button – which defines two distinct states: light on and light off. It is much more natural (on a whiteboard) to perform operations on single clicks rather than on double clicks. These considerations brought us to define standards in WiildOS for single-click activation and for somewhat larger-than-usual icons. Also, given the richness of software choice that comes with WiildOS, the WiildOS interface is organized in thematic tabs.

#### IV. LEARNING OBJECTS AND THEIR ARCHIVAL

IWB are employed in class together with learning objects (LO). Such LO range from interactive tools (e.g. for performing simulated experiments or demonstrations) to more traditional presentations (in an extension of the PowerPoint-like concept).

It is well known that the creation of learning objects is an expensive activity in terms of time. It is therefore extremely important to be able to share, find, retrieve and evaluate learning objects. A number of LO repositories (such as e.g. Merlot [7]) has been created to facilitate the exchange process. Whether they are a successful initiative is a controversial issue. Archiving LO in a meaningful way is a boring process: to facilitate effective retrieval, one needs to provide several metadata: a task that the average user does not love doing.

Another problem is copyright. A teacher preparing a LO may need external resources, e.g. images. Obtaining suitable images is easy thanks to Google, but verifying that such images are copyright-free requires time – probably even more time than finding the image. If the LO is only used in class, copyright violation is often not considered a problem by most teachers, even though it is illegal. If a LO contains a copyright violating resource however, sharing it is (obviously) perceived as a more serious issue. Since, as we said, making sure that an artifact is not subject to copyright may be a relatively lengthy process, the adopted solution is usually not to share the created LO. Alternatively, the LO are only shared locally, closing them in a Learning Managing Systems (LMS). Such systems, originally intended to foster and favor sharing, are often used as fences to protect and hide from the outside world [8]. A way to deal with this complex issue is to raise the level of awareness of the problem, and to become knowledgeable of copyright-free collections (such as e.g. Wikimedia Commons).

We attacked the overall problem by creating an experimental hierarchical repository that attempts mitigating the two above-mentioned problems.

To address the metadata problem we tried to facilitate metadata creation by using suitable defaults based on the profile of the teacher and using automatic metadata generators. A middle school history teacher will obviously most likely generate LOs about history, which are suited to middle school pupils. Hence knowledge about the teacher can be used to infer facts about the LO s/he creates. Gathering profile information is done only once, and such information can be reused over and over. Such information can then be used to provide defaults, and to restrict the set of keywords that are proposed to the user to describe the LO. All this can make the process of metadata generation faster and easier for the LO creator. Combined with automatic metadata and keywords extraction from the LO, it can reduce the metadata definition process to a simple confirmation instead of generation. For automatic extraction of metadata and keywords from the LOs we adapted a tool called SamGi [9] produced by E. Duval's group.

To address the resistance given by the copyright issues, we resort to a hierarchical multilevel repository. A teacher can privately archive LOs, or share them on a local basis (i.e. within the school) or on a wider basis. This approach allows using the type of protection granted by a LMS, but at the same time it permits easily changing the protection level, so that the teacher can defer the copyright verification phase and, after clearing, change the sharing and visibility level of the LO. Of course this is no substitution for a full understanding of the copyright issues, for which only educational campaign can help (so that people are aware of the problem, and learn where to find copyright free resources, how to publish their own resources with suitably open licenses, and how to check if a resource is open or not).

Another issue is evaluation of the available resources. Even in the lucky case when a teacher is able to find plenty of LOs that fulfill her/his needs, the choice of one among many may be time consuming. A social network approach where people who actually used a resource grade it would help a lot, as it happens on the Internet for music, movies, hotels... We did not implement yet such a mechanism, although we created hooks from the repository into Facebook and other popular social networks.

#### V. INVOLVEMENT OF SCHOOLS AND TEACHERS

The project involved a large number of schools (more than 30). We helped with the installation of the WiiLD, gave mini-courses about their use, familiarized teachers with various software and assisted those who wanted to experiment.

Teachers were invited to keep blogs about their experience: a way to document the work done and to share ideas. Blogs were not individual ones, but rather school blogs where the activity of a few teachers was recorded. The aim was to foster internal cooperation in the schools. These blogs, which started rather late – towards the end of the scholastic year – did not grow much, but we consider them as seeds that we hope will grow in future.

At the end of the scholastic year we run focus groups to gather the feedback from the participant teachers. We report here the main findings that emerged from discussions with the teachers and from the experience we gathered following them step by step.

The WiiLD compare well with the industrial IWBs. All these system require a bit of user adaptation – they all look very natural to use, but their use is not always fully painless until the user builds a degree of confidence and familiarity. For instance, with the SmartBoards users need to understand that touching the board with the hand has different effects if a pen is held in the other hand or not: in the first case it draws on the screen, in the second it acts like a mouse move or click. With the WiiLD users need to become familiar with pushing the button on the pen, and to pay attention not to shadow the pen with their body. In all cases some practical training is needed to gather the experience that allows feeling natural what we do. In this respect it's not much different than learning how to ride a bike or to drive a car, event though it requires a much shorter training time. And what happens if a teacher finds different IWB types in different classroom? As we mentioned, different IWBs need familiarity with different aspects, so that could be confusing. According to the experience gathered from our users however, this turns out not to be a problem. Users compared it with the experience of driving cars of different makers – the gear shift may have different arrangements and the controls of lights or windshield washer may be different, but passing from one car to the other does not constitute a problem – especially after one gets a bit familiar with both.

IWBs are celebrated by vendors as revolutionary tools that can change the teaching paradigm. Scientific literature has (rather uncritically) often supported this view, until recently some discarding voice started complaining (especially on some teachers' blogs). The most extensive investigation on IWBs, the "Marzano Report" [10], commissioned by a IWB vendor, reports evidence of a positive effect on the learning. It has to be noted that in the investigation not only IWB were used, but the so-called "ActiveClassroom", i.e. a classroom with the IWB plus devices (similar to remote controls) that allow getting instant feedback from students. However, looking closely at the report, one can observe that a positive effect emerges rather clearly only in the primary school. For middle school Marzano's results show conflicting evidence, and for high school the statistics is small so that result cannot be considered significant.

In practice, it is not rare that expensive IWBs are left unused. There are several reasons for this. In part, many projects aimed at the introduction of the tool are technology-oriented: it is assumed that it is sufficient to give tools to the teachers to change the state of things. Unfortunately it's not that simple. Teachers need to be instructed how to use the devices, giving them the necessary training and showing best practice. Unfortunately training courses are often organized and run by vendors, who stress the technical aspects and focus on teaching how to use the software that accompanies the IWB rather than focusing on the pedagogical aspects.

Far from fostering a revolution in teaching style, IWBs tend to reinforce frontal teaching. For many teachers they are only a

slightly more sophisticated projector, and they tend to use a presentation style based on the transmissive paradigm. The students' role remains passive as it was in the last century. Although it is obviously possible to use IWB to enhance interactivity and foster participative aspects of learning, it does not happen magically.

On the positive side, bringing an IWB in class means bringing a PC, Internet and a projector, so that immediate access to a wealth of information and resource becomes available. The IWB makes all this a bit more convenient, both because it allows a less clumsy control of the PC (as opposed to use mouse and keyboard to pilot the projected screen) and because it allows annotating the projection with handwriting.

From the point of view of supporting handicapped students, the presence of the IWB gives clear advantages in several scenarios. Certain types of visually impaired students can have the content of the whiteboard replicated on a screen on their desk, at a distance where they can see the content (sometimes with the help of magnifier tools). Students with motion disabilities can work from their desk and remotely show their work on the board (although this could be achieved also with a more traditional projector). Students with difficulties in taking notes can be provided with transcripts of all that happened on the whiteboard.

From our investigation it also emerges the important role of school directors in motivating the teachers, and making sure that technicians keep a collaborative attitude. It is not too rare that some technicians, who consider themselves depositary of the ICT knowledge in the school, boycott initiatives that they feel as external intrusion into their realm. For instance, in some schools the installation of any software may require privileges that only the technician has. In such situation, delays may result from non-cooperative behaviors. Although such conflicts should be prevented by wise management of human resources, the WiildOS approach that we took (with the possibility of booting the PC from a USB key without installing anything) may be of help circumventing such difficulties.

## VI. FUTURE LOW COST IWBs: THE KINECT?

Although the Wiimote approach is interesting, a few drawbacks are there: the need of a battery-operated infrared pen and the process of Bluetooth pairing between the WiiMote and the computer may generate some nuisances.

The recent introduction of an innovative game device, the Kinect for Xbox 360 by Microsoft, opens new scenarios for low cost IWBs.

Kinect for Xbox 360, or simply Kinect is a "controller-free gaming and entertainment experience" by Microsoft. The Kinect sensor is a horizontal bar connected to a small base with a motorized pivot. . It features an RGB camera, depth sensor and multi-array microphone running proprietary software, which provide full-body 3D motion capture, facial recognition and voice recognition capabilities (although this feature is only enabled in some countries).

It is designed to be positioned above or below a video display and it is used mostly to recognize the body gesture and

map it into commands to control videogames. Its accompanying software has a component able to recognize and track player identity [11]. The Kinect has been an outstanding commercial success, holding the Guinness World Record of being the "fastest selling consumer electronics device": 8 million units in its first 60 days [12]. Right after the commercial launch, a company challenged the open source community to produce a Linux driver for the device, offering a reward. Within a few days, an open source driver was released for all major platforms: Mac, Linux and Windows. Soon after, PrimeSense, whose depth sensing reference design Kinect is based on, released in open source the middleware (NITE) map the raw signals produced by the device into body and motion tracking. Since then, numerous developers are researching possible applications of Kinect that go beyond the system's intended purpose of playing games. For instance, an MIT Media Lab team is working on a JavaScript extension for Google Chrome called depthJS that allows users to control the browser with hand gestures. Experimental applications of the Kinect range from 3D videoconferencing to virtual or augmented reality applications such as e.g. surgery assistance.

It is thinkable to replace the interactive whiteboards with Kinect-based, hands-free interaction with the projected screen. We set the goal to use the Kinect to track the motion of a person in front of a blackboard with the aim to allow him/her to interact with free hands with a computer, though the projected desktop. In other words, we aim to reproduce the functionality of the Interactive Whiteboard without a sensitive touch screen and without using active devices such as infrared pens.

The first step was to be able to move the mouse pointer simply by moving the hand. Achieving this goal was relatively easy, although obtaining a good enough precision was a bit harder. We had then to disambiguate the user's intention: when does s/he want the gestures to be associated with the mouse movement, as opposed to doing gestures of other nature? We devised and experimented a few tentative solutions. After some experimentation, we dropped the idea of using gestures to mean clicking (and all its variants: right-clicking, double-clicking...), as they were too risky. Unintentional hand waving could start programs, erase portions of text etc. We therefore kept gestures only for performing two tasks: alignment (and re-alignment) of the system (which needs to constantly map the user onto a skeleton), and moving the mouse. We delegated clicks to a wireless mouse linked to a belt. That mouse is blind in the sense that it does not detect motion, but its buttons remain enabled, so that the user always has them conveniently at hand. The resulting system seems rather natural and handy to use, but our experimentation with users is still in an initial phase, and its results will be reported elsewhere.

## VII. CONCLUSIONS

We reported the results of a rather extensive experiment that involved several tenths of teacher in primary and secondary schools. The experiment introduced the WiiLD, a Wiimote-based interactive whiteboard, in the schools. It was accompanied by software development to make such devices comparable with commercial solutions. We found this sort of

inexpensive IWB roughly equivalent to their industrial counterparts.

We obtained some interesting indications from our users, such as the IWB value in supporting various forms of handicap. Also, our users confirmed that there is no magic associated with these tools, than can support a transition to more interactive teaching styles, but by no means automatically favor it. As matter of fact, in most cases they reinforce a tendency to frontal teaching.

Finally, we reported some early experimentation with the Kinect as an alternative tool to obtain a low cost IWB, with the advantage of working on the screen with free hands rather than with an active device.

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## REFERENCES

- [1] M. Ronchetti, B. Dandoy, "Introducing interactive whiteboards in the schools: report of an experience" in Proceedings of the ICL2007, Kassel, Germania: Kassel University Press, 2007, p. (1)-(6). - ISBN: 978-3-89958-279-6
- [2] J. Chung Lee, <http://johnnylee.net/projects/wii/>, last visited Aug.30, 2011
- [3] <http://code.google.com/p/ardesia/>, last visited Aug.30, 2011
- [4] <http://open-sankore.org/>, last visited Aug.30, 2011
- [5] <http://iwbcff.sourceforge.net/>, last visited Aug.30, 2011
- [6] <http://code.google.com/p/ardesia/wiki/WiILDos>, last visited Aug.30, 2011
- [7] <http://www.merlot.org/merlot/index.htm>, last visited Aug.31, 2011
- [8] M. Ronchetti. Should Learning Management Systems be considered harmful? The vanishing dream of an open cultural exchange. In L. Cantoni & C. McLoughlin (Eds.), Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004 (pp. 140-145). Chesapeake, VA: AACE.
- [9] M. Meire, X. Ochoa, and E. Duval SAMGI: Automatic Metadata Generation v2.0. In Montgomerie, C and Seale, J., editors, Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications (EDMEDIA) 2007, pages 1995-1204, AACE, 2007
- [10] Marzano Research Laboratory, Evaluation Study of the Effects of Promethean ActivClassroom on Student Achievement, [http://www.marzanoresearch.com/documents/Continuation\\_Study\\_2010.pdf](http://www.marzanoresearch.com/documents/Continuation_Study_2010.pdf), last visited Aug.31, 2011
- [11] T. Leyvand, C. Meekhof, W. Yi-Chen Wei; Jian Sun; Baining Guo, "Kinect Identity: Technology and Experience", Computer, 4 p.94-96 (2011) DOI 10.1109/MC.2011.114
- [12] <http://community.guinnessworldrecords.com/Kinect-Confirmed-As-Fastest-Selling-Consumer-Electronics-Device/blog/3376939/7691.html>, last visited Aug.31, 2011