

Interactive Multimedia Touch Sensitive System

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Abstract – In this paper we present the technology framework to building a virtual touch-screen and its characteristics. The idea is to turn any projection area into the touch sensitive surface by using an infrared camera together with the infrared pen as the pointing device. Infrared camera integrated in the Wiimote controller can monitor up to 4 different points at the same time, and provides information about position of the points 100 times per second. The camera can track the pen, giving the smooth trace of the markers moved along the screen. The software embodying all the components was written based on shareware to connect the Wii controller, to its calibration and to simulation of the pointer inside the Windows environment. After the implementation, the characteristics while working with programs such as Microsoft PowerPoint, OneNote, Adobe Acrobat and Adobe ScratchBookPro, were examined. We also implemented the software that displays the level the camera engagement, which directly determines the accuracy of tracking of the infrared pen. The algorithm for the relief of sharp edges, that may occur due to reflection of infrared ray projecting from the surface, was also implemented.

Keywords – Touch-screen, Infrared camera, Wiimote, Office, Electronic whiteboard.

I. INTRODUCTION

The touch screen technology is not a new technology, but the development of new and better touch screens was always far behind the development of regular screens. Today we have 24" displays with FullHD resolution for an affordable price, but we have touch sensitive displays with VGA resolution at the same or even higher price. This leads to a conclusion that this technology is reserved for industrial applications, and graphic professionals, that can afford such expensive devices.

New touch sensitive surfaces have emerged recently. This touch sensitive foils can be placed over the regular screen, and with appropriate software, and usually some extra hardware, we can get high quality displays with touch sensitivity. The price of such foils is much lower than the price of display itself, but the size of foils is usually 19" max. Also, their sensitivity to the touch is questionable, therefore they are usually used for pointing, rarely for drawing. Again, the size of this screens with foils is small, while their resistance to scratches is very low.

For larger sensitive surfaces, used for presentations in education and business applications, electronic whiteboards were developed. Electronic whiteboards have large touch sensitive surfaces, but the picture must be projected on touch surface with some kind of LCD projector. This boards are very useful in classrooms, but their high price limits there use

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as educational tool. Also, picture must be projected on touch sensitive surface, and this can be sometimes tricky to achieve because of the limited space in the classroom.

In this paper, we present the technology that allows us to make any projection surface a touch sensitive. By using the infrared camera that comes from Nintendo Wii Remote, we can track the pointing pen radiating infrared light. The movement of the infrared pen, is translated into cursor movement on the computer, which is connected to the Wiimote via Bluetooth. With appropriate calibration procedure, any projection surface can be turned into a touch sensitive surface, so we can have touch sensitive computer screens, and with the same hardware and software we can have large projection planes turned into a touch sensitive displays. This technology is also very affordable, thus, it can be easily implemented as an educational aid in every classroom that has a projector or some kind of monitor.

In the following Sections, the architecture of system based on proposed technology is described, as well as the application characteristics of the system.

II. ARCHITECTURE OF THE SYSTEM

This touch sensitive system consists of two separate hardware, infrared pen (IR pen) and NintendoWii Remote (Wiimote). Infrared pen must have battery power supply, be easy to handle, and integrated in any environment. Also, the software that connects these two hardwares should be designed and implemented in the most efficient way, easy to use, and start-up time (which includes connecting the Wiimote to the computer and calibration) should be shortest possible. The system's architecture is given in Fig. 1.

In the following Subsections all these components will be explained in details.

A. Nintendo Wiimote characteristics and connection

The Wii Remote, sometimes nicknamed "Wiimote", is the primary game controller for Nintendo's Wii console. The main advantage of the Wii Remote is its motion sensing capability, which allows the user to interact with and manipulate items on screen via movement and pointing through the use of accelerometer and optical sensor technology. Another feature is its expandability through the use of attachments.

Wiimote has infrared camera resolution 1024×768, accelerometer, speaker and Bluetooth adapter.

Johnny Chung Lee from Carnegie Mellon University (Pittsburgh, USA), suggested the way to convert a flat surface

into the electronic board using Wiimote controller. Wiimote can be connected to computer via Bluetooth connection to track the position of the infrared LED and to forward coordinates to the computer if Wiimote is fixed to the stand.

When the infrared pen is dragged over the projection's surface, you are considered to „write“. Wiimote controller, which is situated on the side, detects infrared light, and you can see the results on your computer. The image from the computer, projects on the same projection area, on which we „write“, and that way we get a replacement for the electronic board. When compared our solution to already marketed electronic boards, the disadvantage is the necessity of using two addons: infrared pen and Wiimote controller. The advantages are faster and easier writing, possibility to convert any flat surface into the electronic board, portability and twenty times lower cost.

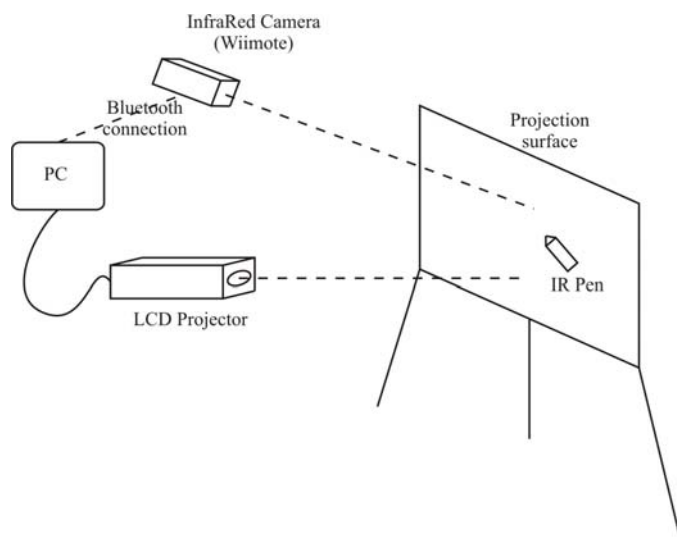


Fig. 1. Scheme of the touch sensitive system

B. Infrared pen

Infrared pen consists of a case which has been taken from an ordinary marker, infrared diode, connected to the battery over the resistor and switch. The switch should be installed at the reachable place for easy and safe handling during operation.

C. Software design

Software, which implements all necessary features of the system is called Wiiboard. Before starting the software, it is necessary to connect the Wiimote to your computer via Bluetooth adapter. You have to press keys 1 and 2 on the Wiimote, and then connect the device via bluetooth software installed on your computer. After successful connecting, Wiimote appears in the list HID devices of computer. When you start the program, computer checks if the Wiimote is present in the list of HID devices. If it isn't connected, the function 'connect' from WiimoteLib library generates an

exception which stops execution of the program and displays information that the device is not connected.

WiimoteLib Library is Managed Library for Nintendo's Wiimote and has been developed by several members of Coding4Fun site. This library is open source, so that it can be adapted to specific needs.

The most important functions of this library are: *connect*, with this function we make the connection with the Wiimote controller, and *WiimoteChanged* event, which is activated each time Wiimote's camera and accelerometer send new data to the computer. The entire functionality of program is based on this event. Every time this event is activated, the function *wm_OnWiimoteChanged* activates, in which the data are downloaded from the Wiimote controller. The Coordinates are obtained in the plane of the camera. With the help of function *warp()* from class *warpier*, these coordinates can be transformed into the coordinates of the projection surface plane. This transform is available only if the transformation matrix is generated. The transformation matrix is generated after the calibration process is finished.

Calibration is performed at 4 points. Before we start working with the system, and after running the Wiiboard program, the calibration function is activated, and 4 markers appear in the corners of the white screen. Each of these markers should click in a specified order. The transformation matrix can be determined using the coordinates of markers in the plane of the projected image and the coordinates of markers in the image plane, which are supplied from Wiimote controller.

Knowing that viewing angle of the camera is 45° and that accuracy of tracking of the infrared pen depends of camera's position against the projection surface. The camera should be set in the way that the projection surface occupies a larger area on the picture of the camera. The bigger surface used the greater accuracy of the tracking. The relation of useful surface in the plane of the camera's image and the entire image can be seen as a factor of usage on the primary form which is displayed after starting the program.

An important functionality of this program is the algorithm for edge smoothing. Namely, it is often that projection surfaces (like TFT monitors and LCD TVs) are highly reflective, and the infrared beam from the tip of the IR pen reflects of those surfaces into the camera. In this way, the camera now sees two, instead of one point. The program can then choose the wrong source of light for original source, and there can be sudden jump from one to another source of light that represents the cursor. Also, because of the lower camera resolution comparing to screen resolution, and the used ratio and whole camera picture surface, a bigger area on projection surface can be mapped to one camera pixel. Hence, the algorithm for edge smoothing is needed, and it finds the mean value of x and y coordinates for last 4 to 20 points (programmable). The amount of used points in this algorithm is determined with the slider on the main form, shown on Fig. 2.

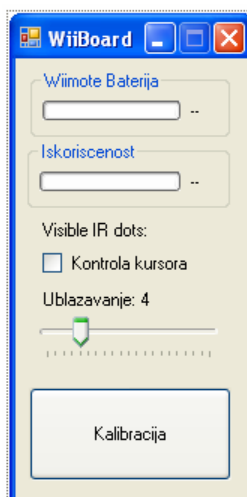


Fig 2. Main form of Wiiboard application

D. Testing results

We have tested this system with different types of monitors and projectors, but mostly on 40" LCD TV. While testing with regular computer monitor, because the camera was relatively close (on distance of 50cm) tracking accuracy was very good. Sensitivity depended on how much the last points were used in edge smoothing algorithm. In this case we used 8 points, and results were similar to those we get with professional drawing boards. It is impossible to quantify these results, so we can only rely on descriptive evaluation of performance while using this system.

When the system was tested on bigger screen of an LCD TV and LCD projector, and it was necessary to find appropriate place for camera. Camera should be placed in such position so the user cannot interrupt infrared beam on its way to camera, while writing on the surface. It should be placed aside of the user, left to the right-handed or right to left handed users. Thus, the special camera stand has to be made for this kind of applications. The tracking accuracy, in this case, was a bit worse, because of the distance of the camera from the screen, and the a lot bigger surface of the screen. The bigger the surface and the screen resolution means that more pixels from the screen are mapped on one camera pixel, and because of that tracking accuracy becomes lower. Also, the distance and the reflexivity of the screen can cause much more errors while tracking, so we must use more points for edge smoothing algorithm, which leads to worse responsiveness.

We find out that Microsoft Office Tools, especially with Power Point, draws full benefit of this system as the user can have the direct interaction with presentation. If it is necessary the user can mark some part of the presentation, underline some text or even write something new on the

current slide. Changing between slides in presentation is achieved by short switching on-and-of of the infrared pen, which is considered as the left click of the mouse. To do this, there is no need for IR pen to be leaning to the screen, or projection surface.

When we tested the system with graphic tools, work with such applications proved to be more intuitive and easier than while working with the mouse, because the user draws directly on the screen, and the edge smoothing algorithm allows much precise drawing. There is one flaw of this system which manifests itself in use of the system with graphic tools. That flaw is that we don't know the position of the cursor all the time, not until we activate the pen. This can cause problems while working on precise elements of the drawing, like in CAD programs. Also, we cannot use the pressure change, which is supported by this kind of programs when working with graphic tablets. However, we can upgrade existing drawing pen with few more components to achieve the same functionality as we have when we combine a regular pen and a mouse.

III. CONCLUSION

In this paper, the technology for turning a projection surface into touch sensitive was described, as well as one example how we implemented it. Besides all the limitations this system has, it's price, design simplicity, installation and use, makes it exceptional educational aid, and every classroom equipped with LCD projector should have one. Placing, installation and calibration of the system takes less than a minute. One main advantage of this system, comparing to other available solutions, is that projection surface is not limited to one type. We can project picture on any available surface in any size, and all we have to do is just to recalibrate the system to new conditions. Also, with few improvements in software, along with the appropriate drivers, we can make a systems that follows up to four infrared pints simultaneously, so we can make a multitouch screen. Multitouch technology is supported by all new operating systems for PC computers.

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