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Design and Development of a Cost Effective Wiimote-Based Multi-Touch Teaching Station

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Abstract: With the innovative use of Wiimote controller, this study developed a cost effective universal multi-touch teaching station that is able to run both standard educational collaborative software such as Classroom presenter and the customized Multi-touch teaching module that supports fingers' gesture controls on teaching materials. The combinational use of advanced modern computer like tablet PC and multi-touch tabletop together with educational collaborative software as teaching tools to enhance the delivery of teaching materials is gaining popularity in universities recently, as it brings positive improvements to the classroom. The advanced hardware allows instructor to electronically hand-write notes easily, while the educational collaborative software fosters an active participatory classroom environment among students and instructor. With customized multi-touch application, instructors can interact with teaching materials more naturally through fingers' gesture controls on the teaching station. However, to acquire such an advanced teaching tools requires huge amount of investments and therefore most of the universities in developing countries do not have the opportunity to leverage on such effective tool. Hence, in this study, we reported an innovative application of Wiimote to create a cost-effective universal multi-touch teaching station that is able to operate with standard educational collaborative software like Classroom Presenter as well as customized Multi-touch Teaching Module that supports fingers' gesture controls on teaching material. This multi-touch teaching station can be used as an alternative to the expensive commercially available teaching tools of similar features for instructors and students in a budgeted environment. Therefore, in Multimedia University, the Wiimote-based multi-touch teaching station was designed and developed for instructors and students and it costs only a fraction of the commercially available teaching tools that are of similar features.

Key words: Wiimote, multi-touch tabletop, teaching station, teaching tool, educational collaborative software

INTRODUCTION

The adoption of modern computer such as tablet PC (Wolfe, 2002) and tabletop (Scott and Carpendale, 2006) in Western universities as teaching tools has brought about positive changes in the classroom as compared to traditional lecture-based pedagogy when properly implemented (Toto *et al*., 2008; Wilkerson *et al*., 2005; Tront, 2005). These teaching tools ease the instructors in handling the daunting task of delivery complex and large amount of information to the students. Using these tools, instructors can handwrite notes onto their computer electronically and share them with the students. Thus, many universities in developed countries are exploring the possible use of these modern computers to enhance the delivery of teaching materials to the students. These advanced teaching tools when used together with educational collaborative software like Classroom presenter (Anderson *et al*., 2007; Berque, 2006; Tront *et al*., 2006), provide innovative learning environments that support more interactive, relevant and effective teaching that give students valuable experiences. Although, studies on the combinational use of the advanced teaching tool with educational collaborative software indicate positive results in students' learning experience, acquiring such advanced hardware in university requires huge amount of up-front capital. Thus, this study presents the design and implementation of a cost-effective Wiimote-based multi-touch teaching station that provides an equally effective alternative to the aforementioned advanced educational tools in a budgeted environment.

Tablet PC, a mobile computer with an electrostatic digitizer screen that enables pen-input feature using a stylus or with fingertip to facilitate natural writing and drawing, has been adopted in universities of the Western

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countries in recent years to enhance teaching or learning process (Toto *et al*., 2008; Tront, 2005). Instructors use tablet PC to hand-write notes or draw schematic diagrams with digital ink onto their computer electronically via stylus during a lecture session to enhance teaching. Examples of tablet PC includes HP TouchSmart Tx2, Dell Latitude XT2, Fujitsu Stylistic ST6012, etc., with a selling price referring to Google product search (as of 1 November 2009) ranging from USD 900 to USD 2,900 depending on the specifications. However, for a lower range tablet PC, the touch screen panel is rather small and is rather difficult to be used as a teaching tool by instructors.

The direct touch tabletop, or in short, tabletop, is a surface on which input sensing and output display are superimposed, which serves as a computer with a large horizontal display, has also been adopted in education industry lately in developed countries (Buisine *et al*., 2007; Kobourov and Pitta, 2005). Commercially available tabletop generally supports multi-touch capability, which is an ability to recognize more than one point of contact simultaneously. The multiple points of contact can be multiple fingers of same hand, both hands of the same user or different hands from multiple users. Existing multi-touch tabletop are either built on electronic field sensing technology or camera-based (Jefferson, 2005; Dietz and Leigh, 2001). Multi-touch tabletop allows multiple interactions from users via touches on table surface providing a more natural user interface for both instructor and students to enhance their teaching or learning experiences. Example of the off-the-shelves tabletop includes the microsoft surface and the diamond Touch, with the up-front cost of hardware and installation of around USD 10,000 to USD 20,000 (Wolfe *et al*., 2008). Due to the high price of the multi-touch tabletop, the efforts of adopting this technology in universities have been slowed.

Wiimote is the input controller for Nintendo Wii gaming console that uses accelerometers and infrared (IR) sensor to provide accurate and responsive motion sensing capability. Wiimote and Wii console communicates through Bluetooth wireless technology using Bluetooth Human Interface Devices (HID) protocol. This allows Bluetooth-enabled computer to connect and use Wiimote easily as a native HID device (Sreedharan *et al*., 2007). Wiimote contains a 128×96 monochrome camera equipped with an IR pass filter in order to detect IR light and ignore visible light. The built-in processor in the camera can track up to four moving IR blobs simultaneously with a resolution of 1024×768 (Lee, 2008). With this specification, Wiimote is able to track movements of IR sources and send the information to any Bluetooth-enabled computer for further processing.

SYSTEM DESIGN AND IMPLEMENTATION

The Wiimote-based multi-touch teaching station was designed with an objective to provide a large electronic writing space for instructor as oppose to small writing space offered by a tablet PC. Besides allowing instructor to hand draw or handwrite digitally using an IR pen similar to a tablet PC, the teaching station when operate together with the Multi-touch Teaching Module supports gesture-based interactions such as zooming, panning, rotating, etc., thereby providing a more natural way for the instructor to interact with the teaching materials.

Figure 1a shows the hardware design for the Wiimote-based multi-touch teaching station that consists of a projector, a Wiimote controller, a mirror, a glass table surface with projection screen, a Bluetooth dongle, a CPU and an IR pen or ring. The design principle for the Wiimote-based multi-touch teaching station is based on the functionality of a Wiimote to track and send the movement of the detected IR sources to a Bluetooth-enable computer for further processing. Projector is used to project teaching materials to a suitable size on the glass table surface. Mirror is used to reduce the throw distance from the projector to the table surface as to achieve the projection of the desired size. The glass table surface is covered with tracing paper that serves as the projection screen. The Wiimote is placed on top of the projector lens for optimum detection of IR sources on the table surface. The IR ring or pen is to provide the touch point coordinates on the table surface that will eventually be translated into appropriate actions. Figure 1b shows the data path for the Wiimote-based multi-touch teaching station starting from the input on the table surface (touches) to the various software components and finally reaches the output which returns to the table surface. Before using the teaching station, the Wiimote must first be paired with the computer as a HID device. Once the connection is established, the Wiimote can start detecting any IR blobs on the table surface when the surface is touched and the data is continuously sent to the CPU as serial data for processing.

The first module to process the data is the WiimoteTUIO that comprises of the. NET Wiimote Library (WiimoteLib) and the WiimoteWhiteboard module. The Wiimote Library is used in communication between Wiimote and WiimoteWhiteboard where the latter maps any detected IR blobs on the table surface in 3D space coordinates to computer desktop coordinates (Lee, 2008). The WiimoteTUIO module then sends out these desktop coordinates in TUIO messages, which are simple UDP messages based on OSC (Open Sound Controller) protocol (Wright *et al*., 2003), to the Windows/Flash switcher module for further processing. The Windows/Flash switcher module is written in C to allow

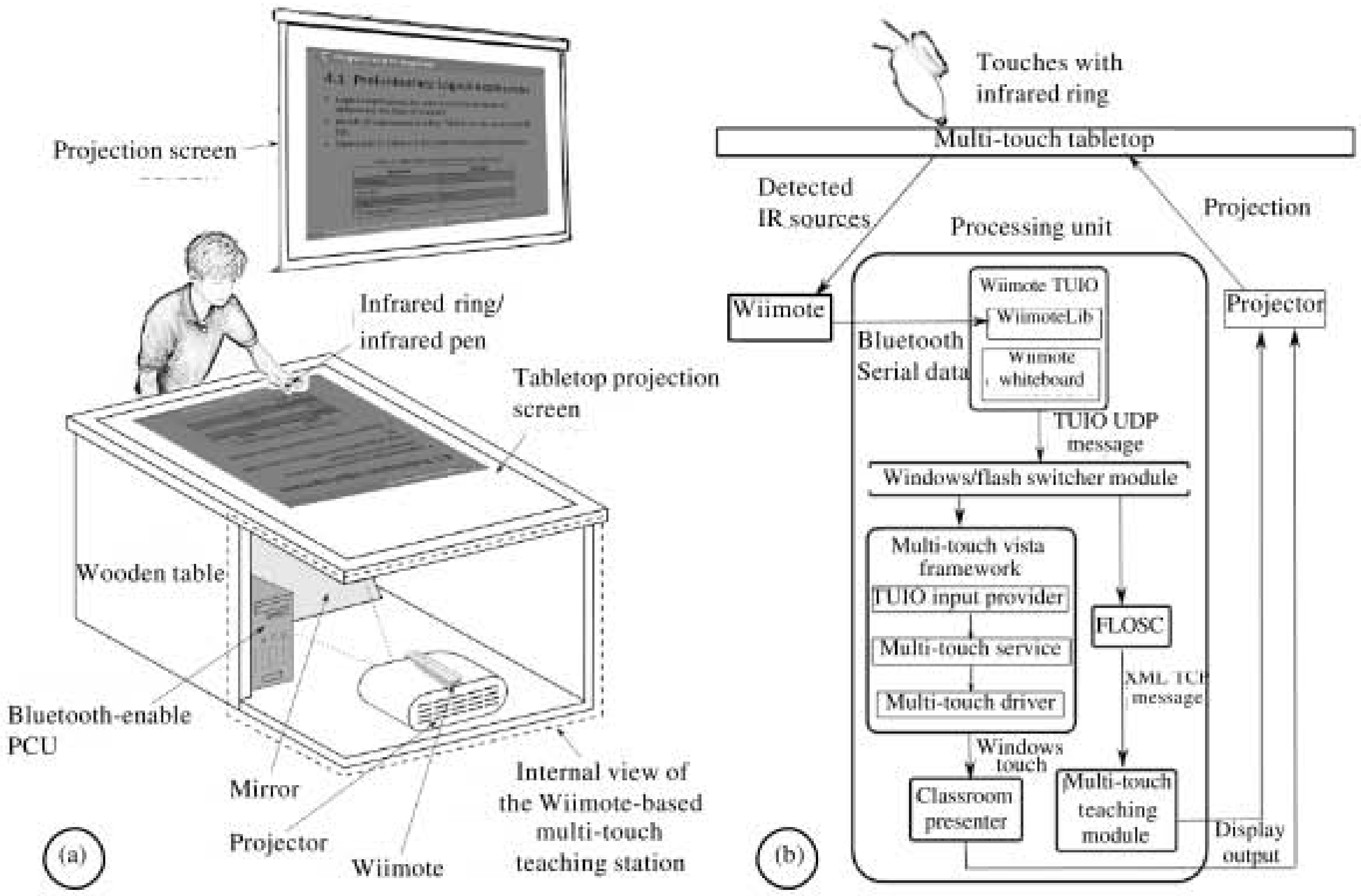

Fig. 1: (a, b) Hardware and software design of the Wiimote-based multi-touch teaching station

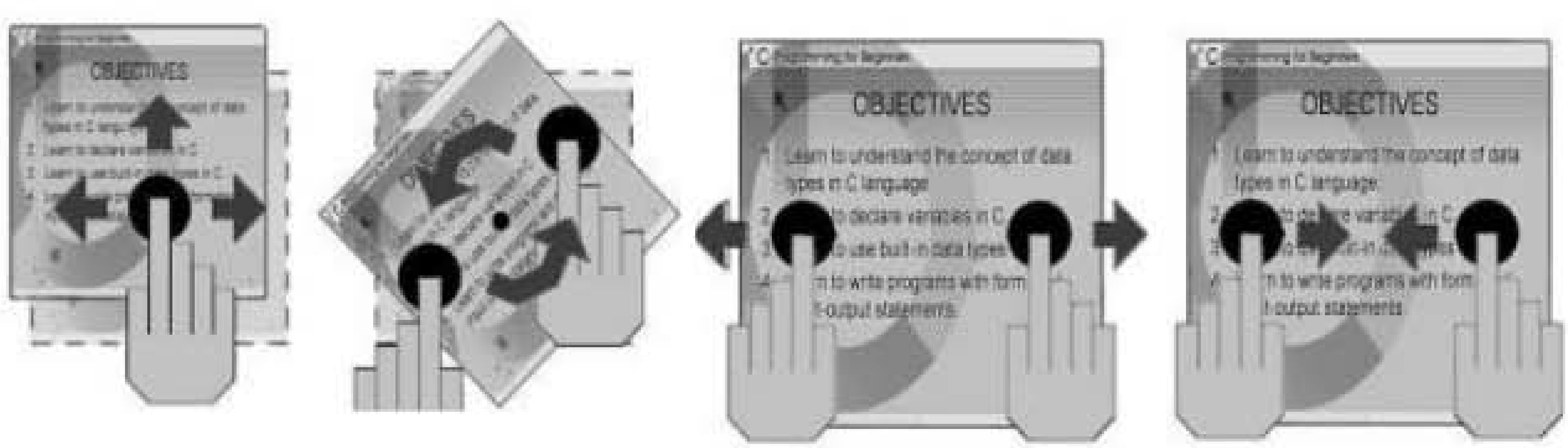

Fig. 2: Basic gesture-interactions supported by the Multi-touch teaching module

instructor to use the teaching station either with standard single touch educational collaborative application like Classroom presenter or to use it with customized multi-touch application such as the Multi-touch Teaching Module. The switcher module will channel the TUIO Message to the Multi-Touch Vista Framework if it is used with standard Windows application and to the Flash Open Sound Control (FLOSC) if it is used with the customized multi-touch application.

If the instructor wishes to exploit the gesture-based controls when using the Wiimote-based multi-touch teaching station, the Windows/Flash Switcher Module will pass the TUIO UDP messages to the Multi-touch Teaching Module via FLOSC, a software tool written in Java that acts as a proxy to receive TUIO messages from the UDP port 3333 and send XML messages to the TCP port 3000. The Multi-touch Teaching Module was developed with Adobe Flash using ActionScript 3.0 to capitalize on its highly compelling nature in presenting and manipulation of multimedia elements in teaching slides (Peters, 2007). The teaching module receives touches data like IR blobs IDs, X-Y coordinates and various touch events such as touch down event in XML messages from TCP port 3000. When dealing with images in teaching slide, the Slide Canvas Class will be called to start a canvas and acts as the entry point to place images in JPG format. To manage basic gesture-based interactions as shown in Fig. 2, the Rotate Scalable Class will then be called. When single touch is detected, teaching slide can only be dragged. However, if there are two touch points, scaling and rotating of teaching slide are allowed. The rotation involves a calculation based on a tangent function while the scaling involves a more complicated calculation to determine the center point of reference before the comparison with the original coordinates.

If the instructor wants to use the Wiimote-based multi-touch teaching station with standard educational software like Classroom presenter, data is first passed to Multi-touch vista framework, a user interface management framework available on CodePlex Open Source Community at http://www.codeplex.com/ MultiTouchVista that is able to handle various multi-touch input sources such as from WiimoteTUIO and normalizes it against the targeted window size. The framework is used in the teaching station to provide a bridge connection between the touch input on the table surface and the Classroom presenter. The Multi-touch service and driver within the framework will process and decode TUIO UDP messages from the Windows/Flash Switcher Module into stylus events recognizable in Windows 7, as inputs from a 255-touch-point touch input.

The total hardware cost to deploy a Wiimote-based Multi-touch teaching station is approximately USD 757 as shown in Table 1, based on a conversion rate of USD 1 = MYR 3.4 (as of 1 November 2009). Depending on the choice of the projector, the cost may considerably vary.

Table 1: Hardware cost needed to develop a Wiimote-based Multi-touch teaching station

Components	Price (RM)
Wiimote	200
Projector	2000
Bluetooth dongle	50
Mirror	50
Table	250
Infrared pen	25
Total	2575

RESULTS

A prototype of the Wiimote-based multi-touch teaching station has been implemented in Multimedia University as shown in Fig. 3. The teaching station has a 32-inch horizontal table display and operates with IR rings or pens as the input device. The teaching station, when operates with the Multi-touch Teaching Module and Classroom presenter, allows instructor to handle the teaching materials more interactively and naturally by touching directly and manipulating the content with gesture controls such as zooming in and out, panning, rotating etc. while at the same time allows instructor to augment typical slide-based lecture to:

- Enable the flexibility to control the flow of slides during a class
- Easily add extra notes or diagrams on the slides
- Promote participations from the students during a class
- Allow the instructors to monitor their students' level of understanding

Figure 4a shows an instructor applying gesture control via fingers to zoom in the desire teaching slide when conducting a class using the Wiimote-based Multi-touch teaching station with the Multi-touch Teaching Module. The teaching module allows instructor the flexibility to control the flow of teaching slide depending

Fig. 3: Prototyping of the Wiimote-based multi-touch teaching station

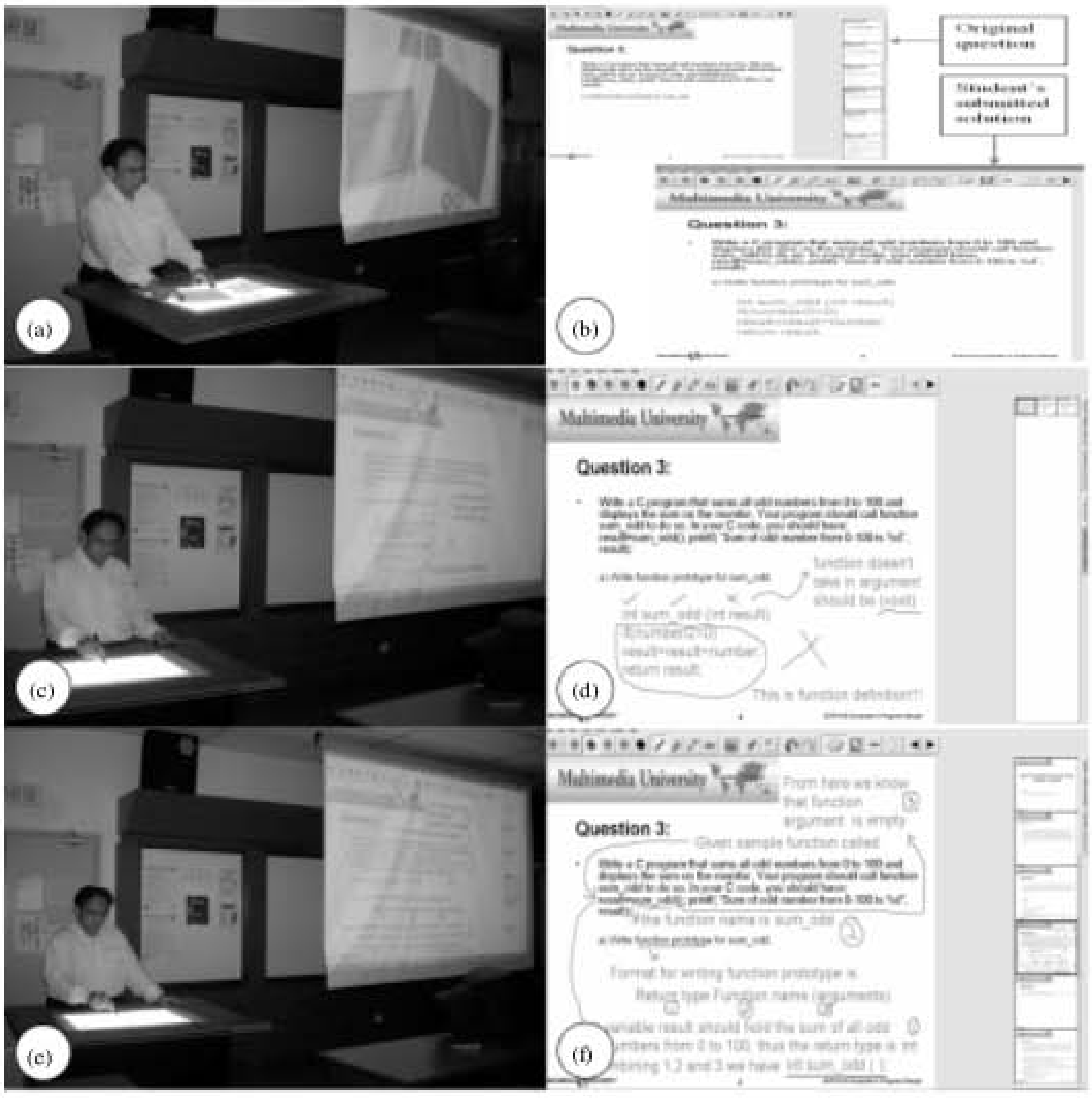

Fig. 4: (a-f) Application of multi-touch teaching station in a programming class

on the needs during the class, by selecting and zooming in the desire slide in a non-linear format. The multi-touch teaching station when use with Classroom presenter will enhance the participation from the students by enabling them to submit their solution to the instructor during the class. Figure 4b shows the original question used in the class and one of the solutions submitted by a student. Instructor can use the teaching station and an IR pen to write comments on the solution as shown in Fig. 4c and d for further discussion. By reviewing the students' solution, the instructor can monitor closely the performance of the class. To facilitate a better understanding for the student on the problem, the instructor can provide digital solution on the slide in a step-by-step manner as shown in Fig. 4e and f. Generally, the instructors are satisfied with the usage of the Wiimote-based multi-touch teaching station in a classroom, as it provides a larger display screen and an easier method to add digital content to the teaching slide during a class as compared to the use of a standard PC or a tablet PC. However, some instructors feel uncomfortable wearing IR rings when using the teaching station initially. They felt that the response time for the touch was slow as compare to mouse. The slower response time was due to the extra processing needed to track the touches, converts them to the proper screen coordinates and associates the gestures to the appropriate actions. However, after using the teaching station for some time, the instructors were able to use the teaching station comfortably.

CONCLUSION

The design and implementation of a cost effective universal Wiimote-based multi-touch teaching station that is able to operate with standard educational collaborative software as well as customized Multi-touch Teaching Module is presented in this study. The teaching station allows the instructor to easily add digital inks on teaching slides while conducting a class. When the teaching station is used together with the Multi-touch Teaching Module, instructors are able to manipulate the slides more naturally with gesture-based interaction and are given more flexibility to control the flow of teaching slides during a class. Instructor can use the teaching station to write and discuss students' solution when it is used together with Classroom presenter to improve the interaction between instructor and students. At the same time students can view and save instructor's comments on their computer for future reference. The archive of classroom lessons can help students especially those from weaker group and the absent students in catching up easily. In short, the Wiimote-based multi-touch teaching station provides an alternative solution to the functionality of the advanced modern computer such as stylus input feature from tablet PC, but with a large input display and multi-touch gesture controls, to enhance the delivery of teaching materials to students with a minimum upgrading cost. As the current system is only at the prototyping stage, full scale evaluation of the teaching station in different classrooms for both instructors and students will be realized in the near future.

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