Virtual Soldering Environment Using Touch and Gesture for Engineering Labs Education

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Abstract— **Labs form a central component especially in engineering education. The objective of our current work is to enhance the possibility of teaching, learning and experiencing engineering lab targeted towards teachers and students of various disciplines in engineering. This is achieved by developing virtual computer based lab environments. The experience of these environments is enriched with touch based technology. This paper talks about creation of virtual soldering environment. We have successfully implemented a working prototype which would enable the end user to get a feel for real time soldering. This approach of 'virtual' computer based training environment has great potential that stimulates self-learning process of soldering.**

Keywords— **Virtual Soldering, Touch based technology, Virtual training environment, Touch Sensitive, Haptics, PCB, Engineering Labs**

I. INTRODUCTION

Teaching and student practice of virtual labs are getting central attention, with the numbers of students being on continuous rise and resources being limited [1]. This helps students to get more of practical experience without using actual resources. This not only helps students but also instructors to teach students effectively in a large environment. Recent technologies in computer graphics has helped to develop many such virtual lab applications such as E-Learning systems [2], virtual network systems [3] and many more. However, there is no virtual soldering application developed so far.

The focus of this work is to build a user friendly tool for soldering in the virtual environment that allows soldering to be performed with ease. It lets them feel the same, experience the same and have fun to the same extent as in real world. Compared to the traditional soldering methods that use soldering tools like the soldering gun, lead, flux, the haptic devices provide users with tactile information such as sense of touch [4]. This is achieved by capturing the input parameters such as pressure, forces etc and also by getting feedback on reaction forces [5]. This provides greater freedom in 'feeling' and interacting in the virtual space.

This work is unique as it integrates haptics [9] to improve human computer interaction to the specified audience.

II. THE STATE OF THE ART

This section presents background of touch based technologies with examples of a few historic and contemporary applications.

A. Touch based Technology – Overview

A touch-sensitive tablet (touch tablet for short) is a flat surface, usually mounted horizontally or nearly horizontally, that can sense the location of a stylus around its vicinity. It is a tablet that can sense touch and provide the location coordinates of the touch points. Touch tablets can vary greatly in size, from a few inches to several feet [4]. They can detect touch from a variety of devices such as styluses or pucks. A simple touch tablet senses only one point of contact. However, more sophisticated tablets allow detection of the degree or pressure of a single or multiple contact points. Thus the impact on several points of contact can be closely monitored to enhance the virtual effect of touch.

B. Applications

Touch and gesture based devices evolved historically from applications and devices which use a video screen and a light pen like Sketchpad [6]. A user of the sketchpad could draw lines by touching the screen with the pen and then modify them by typing instructions on a keyboard. Cutting edge technologies such as haptics also incorporates learning from these touch and gesture sensitive devices [5], [7], [8]. Recent applications of this technology are mobile phones (iPhones in particular) which recreate touch and texture through artificial stimuli. Touch based inputs also find wide applicative uses in the field of kiosks, banks and touch screens. It is also actively used in E-learning scenarios. Thus tablets are commonly used as teaching aids. This work brings out the use of tablets for the virtual soldering application.

III. TOOLS USED

In this section, we introduce the hardware and software used. The various specifications for these are also presented.

A. Hardware – WACOM Intuos3

Fig. 1 WACOM ® intuos3

WACOM Intuos3 Details: Intuos is marketed to professional graphic artists, and features the highest specifications of any Wacom device. Wacom® Intuos3 [10] is packaged with a cable to connect to the USB, customizable express keys, touch strip controls, status LED, a stylus, a puck, tablet work surface. Fig.1 shows the Wacom® Tablet with stylus and mouse.

Intuos3 tools have unique IDs for each tool and are cordless and battery free. This enables usage of multiple tools and customization of each tool. The Intuos3 grip pen is a sensitive to pressure which is helpful during soldering process.

B. Software

1. Wintab [12] and JTablet [11] API
2. NetBeans IDE for Java and JavaFX

WinTab ® [12] is a standard interface for using digitizers. JTablet [11] plug-in is a simple and easy-to-use API designed to give us the bare essentials required to support tablet features in java applications or applets. The user interface has been developed using Java and JavaFX.

IV. SYSTEM OVERVIEW

In this section, the proposed soldering application will be presented from a system point of view.

A. Layered view of the system

As shown in Fig 2. the Wacom tablet captures the events from the stylus used for drawing. The internal functioning of the system can be categorized as follows:

1. Packets sent by tablet to JTablet when stylus is active. (stylus in contact with the tablet)

2. Two way communication between JTablet API and the back end wrappers.

3. Two way communication between the back end wrappers and the interface.
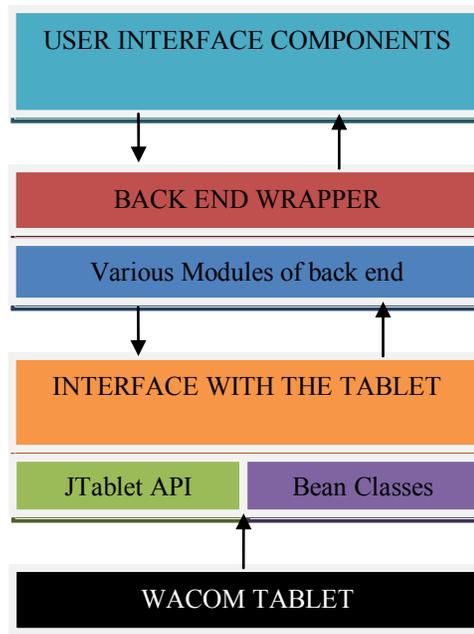

Fig. 2 Four Tier Architecture

Using this layered architecture the entire back end of the application is developed using java 1.6. This layering encapsulates all the functionalities providing services to the front end, which can be developed in any of the available technologies. The user interface of our application is developed using JavaFX which uses the services provided by the back end. The application is made modular enabling the developer to add plug-ins for further development. This eases the migration of the front end from one technology to another without actually manipulating the core back end of the application.

B. System Description

The soldering interface has a PCB, control indicators and a component kit. The PCB module is divided into sub parts namely the spring board, general purpose printed circuit board and a PCB with an etched circuit. There are control indicators for pressure, tilt, temperature, time and azimuth. The component kit contains resistors with various resistance values, various types of capacitors and diodes. The interface has an option for turning the soldering gun on or off. The stylus is used as a soldering gun and the tablet as the printed circuit board.

V. SOLDERING MODULES

A. Spring Board

In the Springboard subsystem, the user gets a feel for placing the components on the board and check for its working. There is no soldering involved here. The user can select various components and place it on this board using the stylus and get a feel for the interface just like how traditional spring board works.

B. General Purpose Printed Circuit Board

When the user feels comfortable using the interface, he proceeds with the Circuit Board where he solders the components on the circuit board. We have designed a general purpose board. The user is free to solder the components at random points. This is provided to mimic a real soldering experience to the user.

C. PCB with a circuit

When the user is comfortable soldering components on a PCB he would advance to soldering a circuit where the component specifications are given. Users are not allowed to place any other components other than the ones specified.

This way of organizing the soldering process helps the user to learn soldering using this interface easily and comfortably.

VI. PRESSURE DETECTION

The Pressure Detection module is activated to ensure the right pressure to be applied during soldering. The JTablet API is invoked for capturing pressure. The direct pressure applied by the user using the stylus on the tablet is translated as the pressure applied on the PCB. The variation of pressure is according to the formula given below:

$$Pressure = \begin{cases} 0 & \text{if } 0 < getPressure < 20 \\ PressureValue & \text{if } getPressure > 20 \end{cases}$$

where,
"PressureValue" is the pressure applied on the PCB while soldering.
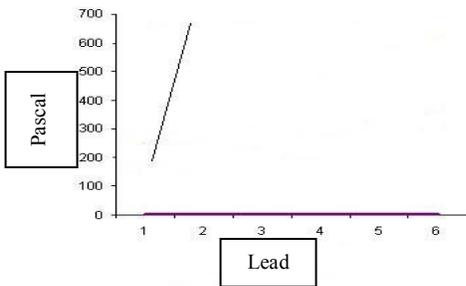"getPressure" returns the pressure value applied on the tablet by the user.

Fig. 3 Pressure Variation

VII. TILT DETECTION

Soldering is accomplished by placing the stylus in the range of 30 to 60 degrees with respect to the tablet. If the tilt is not in the right range, soldering will not take place. Once, the pressure applied is greater than zero, the tilt detection module gets activated. This module checks for tilt. Just like the pressure detection, the tilt is also captured using the tilt gauge where in the indicator lies in the green region if the tilt is appropriate. If not, the indicator lies in the red region.
The calculation of the tilt is based on the following formula:

TiltValue = 0 if getPressure = 0
TiltValue = 200<getTilt<600
where TiltValue is in the range 23° to 70° for the specified getTilt value.

VIII. TEMPERATURE DETECTION [14]

Temperature plays a crucial role during soldering. Hence it is mandatory that we have a temperature detection system to check the amount of time the soldering iron is in contact with the circuit board. . This module is activated for this purpose. There is a time gauge which indicates the temperature variation with time.
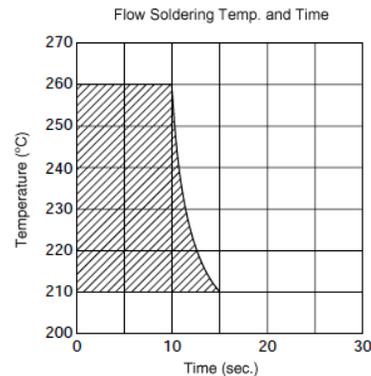

Fig. 4 Temperature Variation

IX. SOLDERING [13]

This is the phase where soldering is done when all the parameters are in the acceptable range. The lead is assumed to be held very close to the soldering iron and heat is assumed to have been applied. The stylus is kept in contact with the board for a while when solder is being done. Once, the red points turn silver in color, soldering is said to have been accomplished successfully. Soldering is done in accordance to the formula:

**Lead = Lead + 0.1
[If the temperature < 210,
Pressure>0, time gauge NOT IN red area
and Tilt i.e. 200 < getTilt < 600
i.e. around 23° to 70°]**

Lead=1 [if 210< temperature > 260]

Lead=0 [if Pressure<0 or Tilt<23° or Tilt>70°]

X.   RESULTS

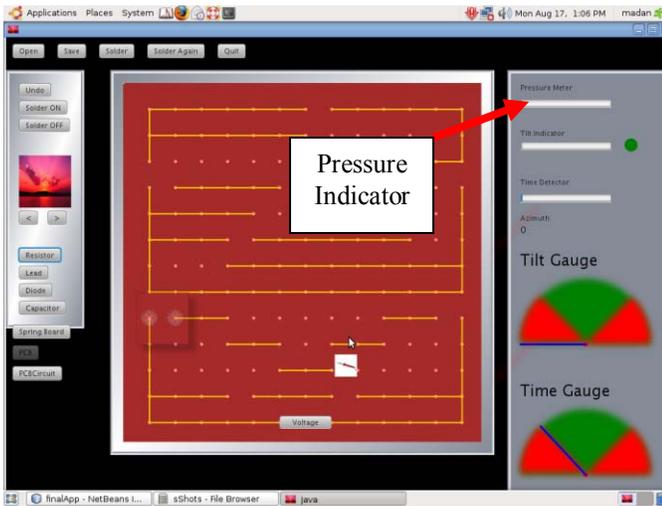The following are the snapshots of the soldering application for the already mentioned modules

Fig. 5: Screenshot of Soldering Application when pressure is applied.

The screenshot in Figure 5 depicts the pressure applied during soldering. This is shown as a progress bar whose progress is translated to the direct pressure applied by the user.
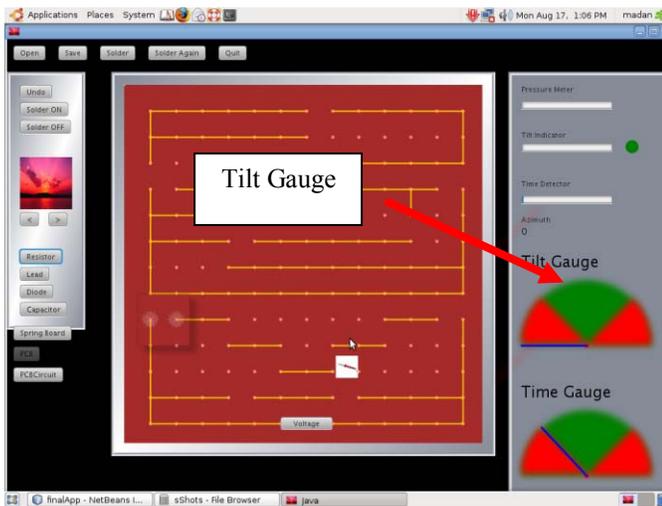

Fig. 6: Screenshot of Soldering Application when correct tilt is not applied

The screenshot in Figure 6 shows the tilt gauge in the inactive state as correct tilt is not applied.
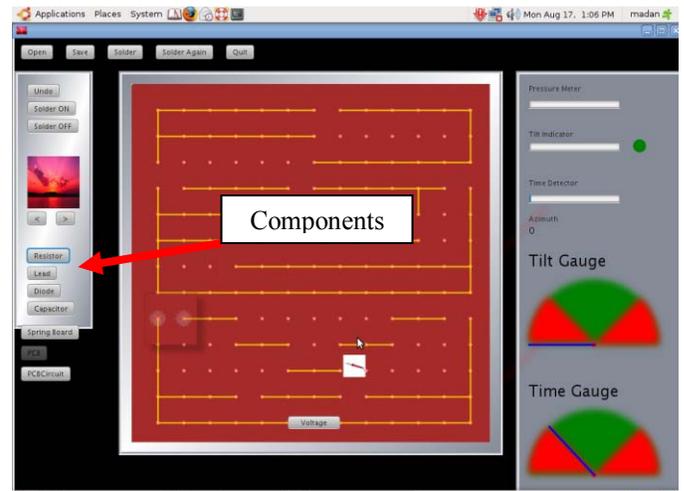

Fig.7: Screenshot of Soldering Application when the PCB is kept for correct time.

The snapshot in the Figure 7 shows the components present in the soldering application (resistors, lead, capacitors and diodes)
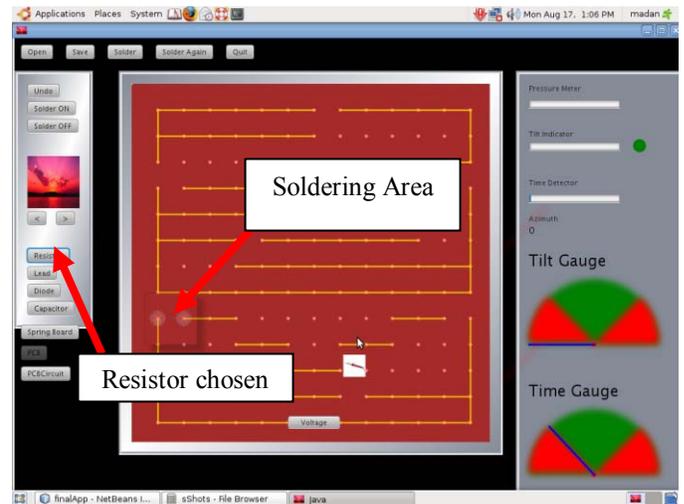We plan to add more components to the kit in the next version.

Fig. 8: Snapshot of the soldering application when soldering is started

The snapshot in the figure 8 shows the active area for soldering when soldering is about to be done when resistor is placed (indicated by the BLUE color of the resistor button)

XI.   USER STUDY

An extensive study of users and their perception, and grasp of this application was done. A set of users between 15 to 35 years of age (students and teachers) were used for this pilot study. All of them had known the concept of soldering. All of them were digitally literates. The response from this team has been very encouraging. The users were able to use the stylus

as the soldering gun quite effectively. However, we found out that some basic training was needed for the users to understand the interface.

We carried out similar study on a group of students who had theoretical knowledge of soldering. Around 50% of them were actually motivated to carry out the soldering in the real environment.

The results from the electrical and electronics lecturers were quite different from what we expected. They felt that physical soldering was much more realistic compared to our application. But that is the trade off over less real equipments, physical damage etc. which will not happen with our application. However, their views were positive on the concepts used in this application and gave feedbacks on making it more realistic in the next version.

XII. CONCLUSION

This application can be used effectively to teach a student the concepts behind soldering and to implement soldering virtually. In this paper we have portrayed a simple soldering application which captures the required parameters of soldering process. This application is under further development to bring in more reality (like the dual stylus for lead, UI enhancement etc.).

The User Interface enhancements that are added will make the users understand the concepts and get a good feel for soldering, virtually.

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