A new way to make multi touch using the idea of Persistence of Vision

R.Sriranjan
infibit@gmail.com
dt: Jan 30 : 2010

Abstract
In this paper a new way for converting any single touch system to multi touch using persistence of vision concept is presented. Also discussed in this paper are builds of some of the existing multi-touch technologies to show how the current method used to make multi-touch is different.

Keywords
Multi-touch, Colored-markers.

Introduction:
Multi-touch has always been exciting than the conventional single touch. It enables the user to interact with the system in a more natural way as in the real world. Some of the applications like the picture browser in Apple's i-phone[15] where the user can zoom in and zoom out of a picture using two fingers or the Microsoft's Touch wall[9] where the user can use his hands to interact with more than a single object on the screen are more fun to use than the conventional way to use a mouse pointer to browse through the photos or interact with the icons on the computer's desktop by clicking. Multi-touch also gives the feel to

the user when dealing with the objects on the computer screen as if it was his real world office desk. Finding cost effective and new ways to make multi-touch devices is thus interesting. Also in many multi-touch devices developed include a large amount of modification of the existing embedded hardware, are of limited usage because they are just multi-touch emulated applications and some include costly hardware or custom developed hardware. So I feel converting a single touch device and a single touch operating system to multi touch using the components available off the shelf without using additional and expensive customized hardware or without much modification of the existing hardware is good. Here, the method, programming and the hardware used eliminate the need of customized hardware and are not costly and is truly multi-touch. I implemented this using a web camera and colored caps attached to the users fingers as Pranav mistry did in his Sixth sense device[3]. This way I was able to operate the computer without physically touching the keyboard or the mouse as well. All one needs is a PC with a web camera thus it doesn't cost anything.

Related work

Jeff han's [1] work on multi-touch has been the guiding source to many multi-touch enthusiasts and researchers. He used an IR-camera and a projector. The projector projects the data from a computer onto a glass plate. The user places his finger tips on the glass surface. There is an IR camera along with the projector beneath the glass surface .Even there can be an IR light source for illuminating the glass surface. The points on the glass surface where the user places his fingers help in reflecting back the IR light back to the camera and these are observed as illuminated blobs in the camera's image. These blobs can be tracked to make multi-touch gestures. In another project by Jhonny-Lee [2,5] a Wii mote with an array of IR LEDs is used. The Nintendo Wii-mote has an IR camera and a hardware level implementation to track IR-blobs. The IR blobs are formed when IR light is bounced of the user's fingers. To improve the reflectivity he used reflective tape attached to his fingers but in case of the Sixth sense device since a web-camera was used colored caps were used to track the fingers in visible spectrum. He also made a low-cost multi touch white board using a projector and IR pens. The IR LEDs were attached to a sketch pan and were tracked by the Wii-mote. Also he made a single touch projected white board based on the same software. His multi touch applications were emulations. The main limitation of emulated multi-touch is that the interaction is limited to objects in the emulated multi-touch application window. One cannot use the operating system like Windows Xp which is inherently single touch as multi-touch using the Wii mote based project. Some of the systems like Thinsight[11] and FLATIR[10] system uses an array of IR emitters along the periphery of the LCD screen and an array of IR sensors behind the LCD. Also an acrylic sheet is used which helps for the diffusion and uses frustrated total internal reflection [10]. This helps in forming better IR blobs and thus position tracking of finger tips is efficient. In another system TouchLight[12] there is a projector and an IR illuminator with a camera. The image is projected onto a holo-screen. Here also IR blobs formed by placing the hands on the screen are tracked. In some systems like C-Slate[16] stereo vision has also been used. The stereo camera is placed above the screen and based on depth measurement it was possible to track finger position to millimeter accuracy. Pranav Mistry[3] in his

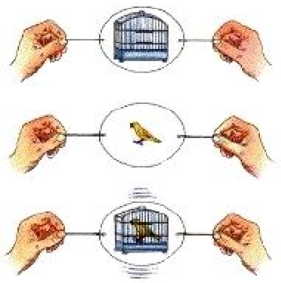

Figure 1.a Thaumatrope

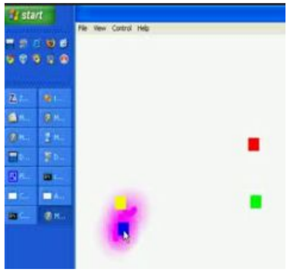

Figure 1.b Paint brush true multi touch

Figure 1.c Mobile projector and colored markers (red, green, blue, yellow) on the

sixth sense device used colored markers, a camera, a projector and a mobile computer. The colored markers are worn on the fingers and thus the finger motion is tracked. Some of the natural gestures based on intuitive hand movements are used for interacting with the system. The present system that I developed also uses colored markers but the methodology of multi-touch is different. Most of the systems have some mechanism for sensing the movements of hand in particular fingers and their motion is tracked and translated in a way so as to interact with the screen or the objects in the video output of a computer. Some variants of the multi touch projects by NUI group[4] use shadows formed by the finger. In one innovative design Mt-mini [8] there is an empty card board box with a camera at the bottom and a glass plate with a paper as the lid. Some spacing was left between the glass plate and the paper. When the user touches the paper the depression caused a shadow and this was used for tracking the finger tip. Microsoft's touch wall again uses IR light for illuminating the fingers, scanning cameras for observing and thus tracking the fingers. Generally most of the designers chose IR because it is invisible and it doesn't interfere with the light in the visible spectrum from the projector or the LCD screen. Resistive touch technology [14] measures the change in resistance between two thin layers of conductors which are transparent. Capacitive surface touch [14] is better than resistive touch because it allows for accurate location of finger tip and the clarity of the interactive surface here is much better than the resistive one. Projected capacitive surface is costlier to manufacture. The current method does not require custom fabrication of conductive plates as in case of capacitive or resistive screens. Also it does not hamper the screen clarity as no conductive layers are placed above the LCD screen.

Persistence of Vision

Thaumatrope [6] is a toy in which there is a card with a different image on each of its two faces. Two strings are attached to the card on either ends and the card is flipped at good speed and the observed effect is that the two images on either side appear to merge into a single image. It is because an afterimage of the eye is though to persist for about one twenty-fifth of a second and for the same reason if continuous frames of animated pictures or drawings are run at a speed greater than 25 frames per second they are perceived as a single moving image.

How is it applied here?

In the same way, say if the position of the mouse pointer can be swapped between two positions at very high frequency then the impression that there are two mouse pointers on the screen is created. Say positions are A and B. If at position A the mouse performs an independent action compared to that of B then the two action events say touch events can be considered as multi-touch. Consider some of the applications developed for multi-touch like paint or draw applications where the user can use each of his fingers as a paint brush. So the user can use more than a single brush to paint on the screen or a projected surface. Even consider the photo album application of developed showcased in Jeff's Hans multi touch work. He can hold one photo at a place and move the other around or move each of the photos independently on his projected surface.

As a test of the concept I wrote a program by which the mouse pointer's position is swapped between two positions at very high speed and each time the pointer is at a position the functions for mouse left button down and button up are called immediately. So in effect at a high frequency both the clicks at two different positions on the screen appear concurrent. To justify this further consider the paint brush example. In a single touch system say a laptop running Paint brush application in Windows Xp if the user has to draw two lines he has to draw each one of them in succession with respect to time, but if it was a multi touch the user can draw the two lines simultaneously each independent of the other with respect to time.

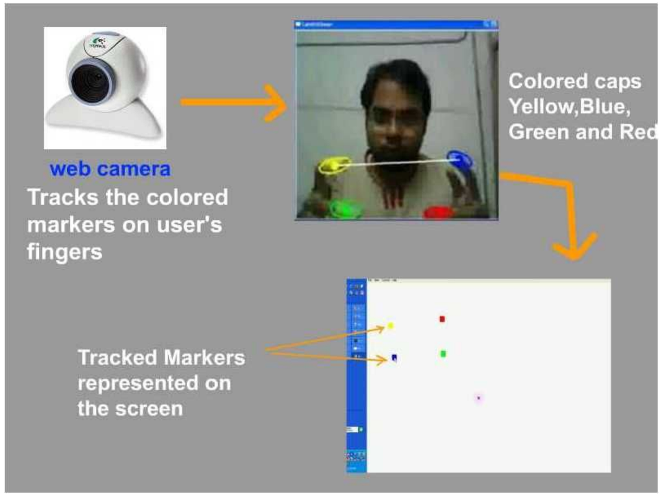

figure 2.The user with colored caps and the markers represented on the screen.

Also the hardware of the single touch system limits the positioning of the pointer to one location which is the single finger tip touching the mouse pad or the computer mouse .So to implement this idea I used a camera to track colored caps on the users finger (a pair each on each hand). Using image processing techniques like color filtering and connected components the center of gravity of each colored cap is determined in the camera reference frame. The position of one cap in each of the pair is used for positioning the mouse pointer at two independent locations on the screen. Each of the two positions can be controlled by the user's hands independently. Now the distance between the colored caps in each of the pair was used as a parameter to decide when to make a click (figure 2). If the distance is lesser than a certain threshold within the pair a click action was performed at that position (and the one can draw see fig 1.b). Thus using two pairs of colored caps in each hand the user can position the mouse at two different locations and perform two clicks independent to each other. Depending on the quality of the camera and ambient illumination the mouse pointer can be positioned at a frequency greater than 25 Hz. The coding was done in C using Opencv.I implemented this on a computer and also on a project surface using a wearable mobile projector (figure 1.c) similar to the sixth sense [3].

Also using this method of swapping the mouse pointers at high speeds between two positions any single touch system can be converted to multi-touch. The limitation of this method is the maximum frequency at which the pointer's position can be changed and this is governed by the single touch system's hardware. This method is quite different from emulated multi-touch applications since the default mouse pointer in the system is being made to do the multi-touch actions.

The generic algorithm to convert single touch to multi touch.

- Position mouse pointer at location A on the screen.
- Perform action (left click or right click) at location A.
- Quickly change to position B.
- Perform action (left click or right click) at location B
- Repeat the above steps in an infinite loop

Conclusions:

The existing single touch systems can be converted to multi touch with some hardware level programming. Using the above setup of a camera and colored markers one can make true multi-touch with out much hardware modifications.

References

[1] Perceptive Pixel http://www.perceptivepixel.com/

[2] Tracking your fingers using wii-mote http://johnnylee.net/projects/wii/

[3] Sixth sense http://www.pranavmistry.com/projects/sixthsense/

[4] Natural User Interface Group http://nuigroup.com/

[5] Low cost Multi-point Interactive white board using Wii-mote http://www.wiimoteproject.com/

[6] Persistence of Vision animated Toys http://en.wikipedia.org/wiki/Thaumatrope

http://anipedia.thebackalleys.com/index.php/Early_animation_devices

[7] Multi touch sensing through LED matrix displays http://cs.nyu.edu/~jhan/ledtouch/index.html

[8] Mt-Mini Multi touch http://sethsandler.com/multitouch/mtmini/

[9] Microsoft's Touch Wall http://www.officelabs.com/projects/touchwall/Pages/default.aspx#q02

[10] Ramon Hofer,Daniel Naeff, and Andreaz Kunz. FLATIR: FTIR Multi-touch Detection on a Discrete Distributed Sensor Array,TEI 2009

[11] Shahram Izadi, Steve Hodges, Alex Butler,A;ban Rsustemi abd Bill Buxton.ThinSight: Integrated Optical Multi-touch Sensing through Thin Form-factor Displays (Microsoft Research),EDT 2007,ACM Press (2007),

[12] Andrew D. Wilson TouchLight: An Imaging Touch Screen and Display for Gesture-Based Interaction, ICMI 2004, ACM Press (2004)

[13] Johaness Schoning,Peter Brandl, Florian Daiber,Florian Echtler,Otmar Hillinges, Jonathan Hook, Markus Lochtefeld, Nima Motamedi, Laurence Muller, Patrick Oliver,Tim Roth, Ulrich von Zadow .Multi-Touch Surfaces :A Technical Report (TUM-I0833)

[14] Apple's i-phone http://www.apple.com/iphone/

[15] Ankur Agarwal, Shahram Izadi, Manmohan Chandraker, Andrew Blake. High Precision Multi-touch Sensing on Surfaces using Overhead Cameras,2nd Annual IEEE Inernational Workshop on Horizontal Interactive Human-Computer System.