Multi-user Chorded Toolkit for Multi-touch Screens

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ABSTRACT
In this work, we present the design and implementation of a chorded menu for multiple users on a large multi-touch vertical display. Instead of selecting an item in a fixed menu by reaching for it, users make a selection by touching multiple fingers simultaneously on any place of the display. Previous research on multi-touch toolkits has provided basic access to touch events, but there is no support for advanced user interface widgets, such as chords. For this purpose, we extended the open-source PyMT toolkit with an architecture that supports alternative user interaction strategies with chorded menus. In addition, we built a multi-user extension that supports chords for two or more users. Chords could be used for having user-aware MT applications. Our toolkit is open source and has been designed as a widget that could be integrated into broader interaction frameworks for multi-touch screens.

Author Keywords: Multi-touch, toolkit, chord, large display, PyMT, multi-user, architecture.

ACM Classification Keywords: H5.m. Information interfaces and presentation: Miscellaneous.

General Terms: Design.

INTRODUCTION
In this work, we designed and implemented a chord selection technique, which is suitable for large multi-touch (MT) displays. The system was implemented with the PyMT programming framework [4]. In accordance to researchers who have highlighted the need for novel set of MT programming toolkits [9] being reusable [7], we found that the available MT programming toolkits support neither chorded interaction, nor multiple users. Thus, we developed a novel chorded selection interaction technique that leverages the unique characteristics of MT interaction. We have also found that most of the MT toolkits do not have support for multiple users. Although there have been some multi-user MT systems, some of them require the users to wear special receivers, which is not convenient.

The design and implementation process has been guided by a case study of a simple drawing application. The application provides a menu of four different shapes: an empty circle, a line, a rectangle and a full/painted circle as depicted in Figure 1. Every shape can be drawn with just two fingers, using only one hand or both of them. For example, when user wants to draw a circle he/she firstly selects the circle item from the menu. Then, he/she touches the MT display with the first finger and then with the second one. The center of the circle would be the middle point between the two fingers and the diameter of the circle would be equal to their distance. Lines are drawn with two fingers too. A line is drawn between each two touches when the line item is selected. Finally, defining two opposite corners draws the rectangle. In the next section, we describe the design process for replacing the fixed menu with a chorded one for the case of the above drawing application.

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INTERACTION DESIGN
During the process of designing a multiple-touch chorded menu for our drawing application, a number of different menus were designed and evaluated. (see Table 1)

Fixed selection
- needs more time than other methods - move to menu constantly
+ traditional menu, known to most users + novice users feel comfortable
Fixed area chorded selection
- using only one hand - restricted area - for menu selection
+ faster menu selections than traditional menu
Free chorded selection
- supports only one user
- select menu items from all over the multi-touch screen
+ fastest menu selection
Multi-user Chorded selection
- restricted interaction area - window manipulation policy is needed
+ supports multiple users

Table 1: Different types of selection techniques

Fixed selection
In almost every desktop computer, a mouse is an essential input device. Therefore, we considered a transition from the mouse click to the single-finger touch. The first implementation of a MT menu is the traditional menu with the four shapes (Figure 1). Users have to choose the shape they want to draw and just touch the appropriate button in the upper side of the screen. The system indicates their

selection and they are able to draw by touching their two fingers. In Figure 1.a the user has selected the line button and draws a single line. The drawing application shows two small circles for every touch as a feedback. Whenever the user lifts one finger the line is painted on the virtual canvas. Although the above scenario of menu selection is familiar, it does not leverage the benefits of multiple touches in the menu selection process. The next step was to create a menu that allows multi-finger selection.

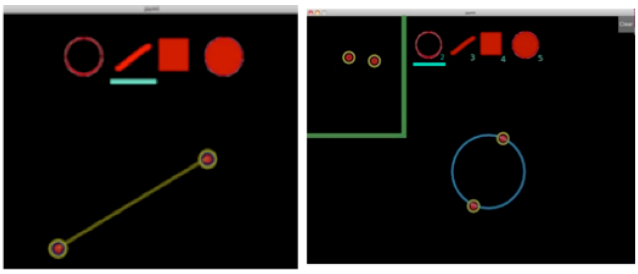

Figure 1: a) Traditional menu embedded in a MT environment. b) fixed are chords. In both cases, users draw a shape with two fingers.

Fixed area chorded selection

Although the above scenario of menu selection is familiar to desktop users, it does not leverage the benefit of multiple touches. In previous work, there have been chord keyboards that allow switching between modes (pressing the shift button by touching down a number of fingers in a MT display in order to write in capitals) [8] but these methods are used basically for improving user performance and they are not the main way of making ambiguous selections. The main objective is to empower the user to choose an item from the menu without touching the menu itself. For this purpose, a small portion of the MT display next to the menu was reserved. There, a user can touch the display with as many fingers as indicated in the status bar (Figure 1.b).

We placed the fixed chord area next to the status bar on the upper left part of the screen, in order to be accessible by the non-dominant hand of a right handed user (Figure 1.b). The design of this multi-finger menu was based on Guiard's Kinematic Chain (KC) model[2]. According to this model, the non-dominant hand sets the frame of reference in which the dominant hand works. In our drawing application, the non-dominant hand selects items from the menu and the dominant hand draws the relative shape. Such asymmetric movements are very common in our everyday life and that is because the non-dominant hand is considered to be coarser than the dominant hand. [5]

Even though the fixed area multi-finger menu selection technique keeps busy both hands and thus improves selection times, it has some limitations. First of all, the user has again to move his left hand to a specific area in the MT display. If he/she holds his hand above that area constantly in order to change his/her selections rapidly, he/she is obliged to draw with only one hand (his right one), which could be really difficult for larger shapes or for larger MT screens. For those reasons, another more flexible multi-finger menu selection technique emerged.

Free chorded selection

In large-scale vertical MT displays, the selection of items (e.g., on a fixed menu) requires excessive physical movement of hands, or even the body of the user, Instead of having a constantly reserved part of the screen as a MT selection area, users should be able to make direct contextual selections. In our new design, users can select the shape they want by just touching down the appropriate number of fingers wherever they want to draw on the screen (see Figure 2.a). Then, they are able to draw the shape with two fingers, as before. We also provided a status indicator, which allows the user to understand which shape has been chosen and how many fingers he/she has to touch on the display to change to another shape. In contrast to the traditional contextual menu, this technique is a one-step action and it has the affordances to support modes. Moreover, this technique affords a two-handed inter-changeable interaction [6], where user can interchange or use in parallel two hands to perform selections

For example, in the drawing application (Figure 2.b), the first two fingers are reserved for drawing the shapes. In order to draw a painted circle, the user has to touch six fingers somewhere in the screen firstly, (that is using his both hands), and then draw it with his two fingers.

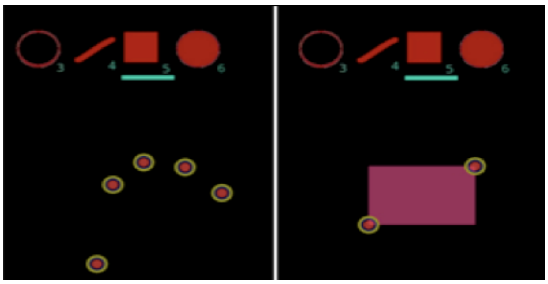

Figure 2: a) In this example, user chooses the rectangular by touching five fingers on the screen, b) rectangular is drawn

One other important aspect apart from the use of multiple fingers on a MT display is the simultaneous use of more than one user. In this condition, the menu techniques presented here do not work. Thus, the next step was to augment the multiple finger menu selection techniques to allow more than one user interactions.

Multi-user Chorded selection

On a collaborative framework for a large display, users should interact simultaneously with the MT screen. While a user is drawing in a window that popped-up another user could have touched the MT screen with his fingers to generate another pop-up window for another shape.

We realized that the free chord technique would not allow chorded modifiers for more than one user, because it regarded every finger to be part of the same chord. In order

to deal with this issue, we decided to go a backward step in the chorded modifiers design process. A modified version of fixed area multi-finger selection found to be the solution.

We have developed a multi-user MT component that allows users to touch multiple fingers on any place of the display just as before. Each time a user makes a selection of a shape a new pop-up window indicates the selected shape. In Figure 3 the interaction design of the system is presented.

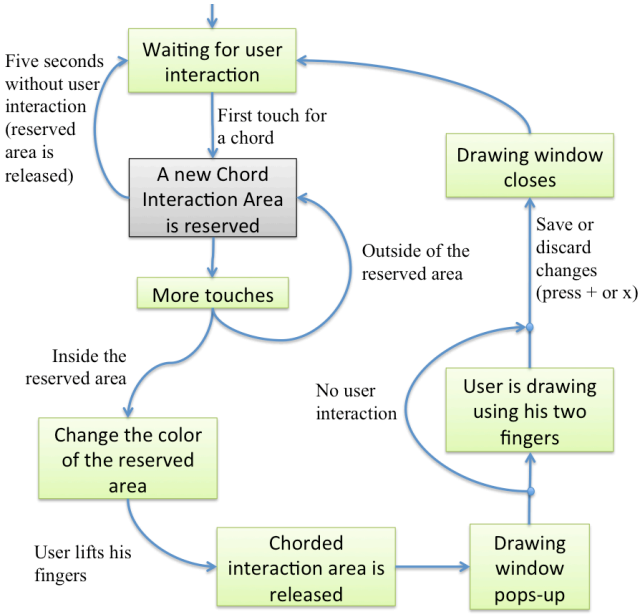

Figure 3: The interaction design of the system

The user, then, is able to draw that specific shape in that window only. The window has a close button (x button), an add button (+ button) and an undo button (Figure 4). The pop-up windows are dynamic: 1) they can be moved anywhere, and 2) users can change their sizes. For instance, if the user wants to draw a line, which is beyond the limits of the window, he/she must use the reversed pinch gesture to enlarge it and therefore becoming able to draw the line in it. In the same way, the chords are performed in a circular area around the first touch of the user, which is about the user's hand size. Chorded areas remain active for a specific period of time (e.g. 5 seconds)

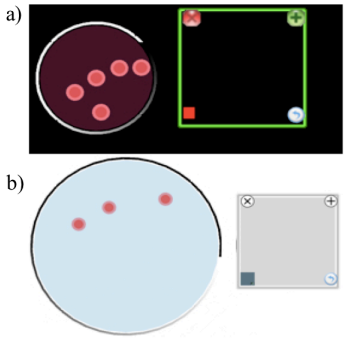

Figure 4: Chorded circular area and the respective drawing window. a) prototype, b) final version

In addition, a number of restrictions on the relationships between the pop-up windows should be applied. For example, the pop-up windows should not overlap or at least when this happens strict rules should apply, such as allowing drawing only in the front window. Moreover, those windows should be almost invisible in order to allow user to see the image of the background. If we would like to make them more MT oriented we could permit window moving among users or scaling.

SYSTEM DESIGN AND IMPLEMENTATION

The multi-user chorded selection technique has been built on top of the fixed chorded selection functions. In a multi-user environment, users dynamically reserve a small circular area, which is as large as ones palm (diameter is 15 cm). In the following subsections the architecture and the implementation of the system are described.

Architecture

The main architecture of the Toolkit presents three different levels (Figure 5). The system is based on the PyMT event engine. When the appropriate event is called a chorded event layer is created. Multiple chorded event layers are allowed since it's a multi-user Toolkit. If the chord is recognized then the respective Window event layer is created. Drawing, text, and images go up one level on the appropriate visualization layer.

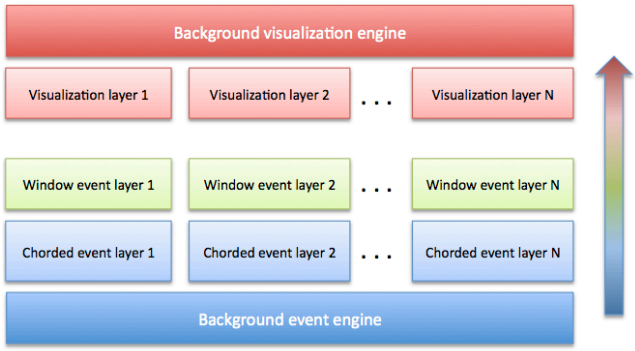

Figure 5: The architecture of the MT Toolkit for Multi-user interaction.

The different layers are represented with different classes. Each class takes parameters from the previous level. For instance a chorded event layer updates the window event layer with the event that three fingers touched the surface. Thus the window created will be accordingly chosen.

Implementation

In an effort to build upon other MT toolkits we implemented a system that is based on the architecture described in the previous subsection. A simple MT drawing application with the PyMT framework[4] was developed. We found that the PyMT framework is very suitable for quick prototyping, as well as for simulating MT with a variety of input devices, such as the track pad of Apple notebooks. In this way, our system is easy to demonstrate without the use of a full MT set-up. Nevertheless, an MT installation and field testing is required in order to adapt the

parameters of the system to the scale of users and their environment. For instance, in Figure 6 the system is being tested with two users in a vertical MT screen.

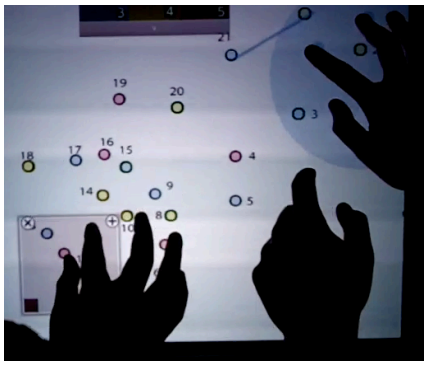

Figure 6: Two users working with the chorded Toolkit on a drawing task

Although PyMT has great support for basic touch, images, and windows, it lacks a set of window manipulation policies, which are necessary for multiple users interaction. For example, it is difficult to understand which window is on top or how many windows are occluded. In our implementation, both chorded interaction areas and drawing windows were MT widgets and thus we were able to count the number of touches, an important element of chorded interaction technique. Furthermore, we suggest that the buttons (exit, add, undo) used are an essential part of a multi-user collaborative application. In the current implementation, when the user has finished working, the changes are integrated in the Background visualization engine of PyMT. Thus, when the users finish their drawing and close the pop-up windows the shapes that they drew integrate in the same MT display. The next version will provide support for a screen object buffer.

DISCUSSION

Although the chorded menu is considered to be a "mouse impossible" application, an alternative design could be used for selection with a mouse. Menu items could be added in a right-click contextual menu that would pop-up at the point of interaction. Then, user would be able to select an item with his left-click. Nevertheless, the contextual menu is a two-step interaction, while the chord is an atomic action. One more limitation of our menu selection techniques is that they allow up to eight different menu items as long as we have ten fingers and we have to use our two fingers for drawing. But, as it is shown in [6] eight different items in a menu is an effective number of menu elements and as far as the depth of the menu is concerned, a MT application could reserve a suitable chord of fingers which could permit it.

CONCLUSION

In this research, we presented a toolkit for multi-user chorded selections on MT screens. The main contribution is the idea of using chords in a MT collaborative environment for menu selections, as well as a working toolkit and a set of example applications. Although a chording system was absent from MT Toolkits we believe that it would be integrated in future MT Toolkit updates for being simple, fast, atomic and essential for selection without the traditional buttons that overflow desktop applications (especially in larger MT installations). Finally, we suggest that MT screens demand fluid interaction techniques such as chording.

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