Slant Menu: Novel GUI Widget with Ergonomic Design

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Abstract
In this paper, we propose a new GUI design method based on ergonomics and describe our new menu widget named Slant Menu. Natural human hand movements on a table are reflected in this menu, which appears in an inclined direction with a curved form, rather than a conventional vertical, linear GUI menu. We have developed the prototype and conducted usability testing.

Keywords
Graphical user interfaces (GUI); menu; Slant Menu; ergonomic design

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces - Graphical user interfaces (GUI)

General Terms
Human Factors.

Introduction
In recent years, ergonomically designed products have been made available to fit the shape of human hands (Figs. 1 and 2). We consider a Graphical User Interface (GUI) that will also be more comfortable and natural by designing it in a similar way to reflect the

characteristics of human hand and arm movements. Thus, we propose an Ergonomic GUI that we designed from the perspective of ergonomically designed products. In this study, we developed a pull-down menu as a typical GUI widget (Fig. 3).

Background

In this section, we will explain the background that led to our proposed Ergonomic GUI from the following three perspectives.

The movement of human hands and arms

It is not easy to move our hands, fingers, and fingertips in a straight orientation such as the vertical or horizontal planes found on a desk. When we try to move our hands in a straight orientation on a desk, the movement affects many parts of our hand and body detrimentally. These parts mainly consist of joints and bones, which generally move by drawing arcs around their joints. Examples include the following: fixing the position of the shoulder joint lets the elbow draw an arc; fixing the position of the elbow joint lets the wrist draw an arc; fixing the position of the wrist joint lets the fingers draw an arc; fixing the position of the palm lets the fingers draw an arc. Thus, the basis of human movement is rotation and combinations of rotations make the movements of reaching out or pulling back the hand in a straight line.

When we execute a combination of rotations to make a movement in a straight line, our brain must perform a series of highly complex controlled movements. It has to control all the moving parts and move them to their appropriate positions gradually [1].

Figure 1. Left: General keyboard. Right: Ergonomically designed keyboard.

Figure 2. Left: The first mouse in the world. Right: ergonomically designed mouse.

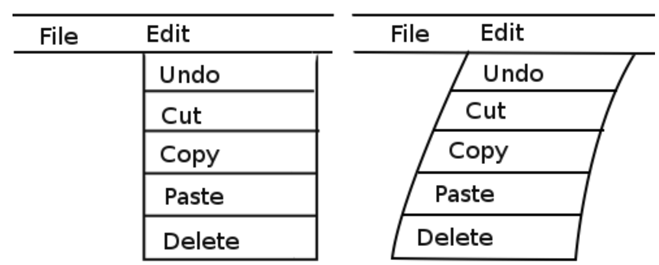

Figure 3. Left: Conventional GUI. Right: Ergonomic GUI

When we want to execute the straight movement of bringing a hand from one position to another position, our brain has to control the position of the parts of the human body simultaneously.

Numerous studies have demonstrated the difficulty of moving the hands in a straight line. For example, De Graaf investigated subjects who are asked to draw a straight line slowly using the hand [2]. When subjects tried to move their hands in a straight line they typically had a misdirection of 5–10 degrees. De Graaf argued that movement from point to point with a hand in unrestricted conditions normally forms a gently curved line.

Square GUI widgets

Current GUI widgets such as desktops, windows, menus, icons, and buttons, are based on quadrangle design with horizontal and vertical directions, where the arrangement utilizes straight lines. However, the human hand must operate these linear GUI widgets. Although a curved motion is natural and comfortable for humans, these GUI widgets force users to move their hand in a straight line.

Ergonomically designed products

One of objectives of ergonomics is to design a machine that a human can manipulate it without feeling tiredness or stress. Ergonomic design is the result of ergonomic studies of human shape, size, movement, cognition, and psychological aspects. Based on this viewpoint, many products with ergonomic benefits have appeared on global markets.

In the information field, products that incorporate ergonomics are also increasing in number, especially input/output devices such as keyboards and computer mice that humans can use comfortably. User interface devices such as common keyboards and early computer mice are designed with a square conformation, mainly to reduce production costs. However, some modern user interface devices have been designed with a curved shape to reduce human tiredness and stress. For example, standard keyboards have a straight arrangement of the keys, whereas some modern keyboards have the keys arranged in curved lines to better fit the movement of the human fingertips (Fig. 1). The first mouse in the world was a square wooden box, whereas many modern mice are designed with a curved shape to fit in human hands (Fig. 2). These physical devices are designed to fit human body parts and motions, but GUI widgets such as menus remain square on the computer screen (Fig. 3 left).

Ergonomic GUI

Based on these considerations, we propose an ergonomics GUI (ergonomically designed GUI) that can be operated easily by human hands. In this proposal, we aimed to develop a GUI that will not force us to manipulate our hands in a stressful manner. We also felt that it was important for our new design not to spoil the look and feel of conventional GUI widgets. In the following sections, we will describe our ergonomic GUI prototype pull-down menu and its evaluation.

Slant Menu

We propose a slanting menu as an ergonomic GUI widget that facilitates human hand-friendly menu manipulation. Conventional GUI menus contain selection items that are arranged in perpendicular straight line directions. In contrast, our slanting menu arranges the selection items in a curved arc that fits the natural curved movement of human hands. The shape of the curved arrangement is adapted according to the past menu selection trajectories made by the user.

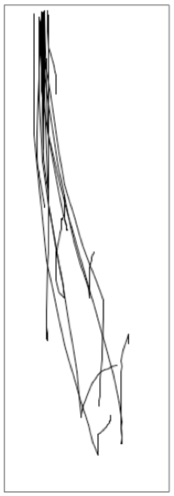

Figure 4. Traces of the pointer

Figure 5. Snapshot of the Slant Menu prototype

Preliminary Experiments

Before developing the Slant Menu prototype, preliminary experiments were conducted to observe mouse pointer movements when a user selected pull-down menu items.

Method

We asked 10 subjects (female computer science students aged 21 years to 24 years) to select pull-down menu items. In this experiment, we developed a simulator program that randomly generated pull-down menus containing 10, 20, or 30 items. The target menu item that we asked subjects to select, was chosen randomly and it was highlighted with a yellow background. The locus of the mouse pointer was recorded as menu items were pulled down until the target was clicked. Four kinds of pointing device were used, i.e., a mouse, a note PC touchpad, a pen tablet, and pen tablet PC. A touchpad is a device that detects the user's fingertip position on its sensing plate. Pen tablet and tablet PCs detects the pen position on their sensing surface, although later this is combined with a built-in display. The subjects were asked to select 14 menu items per device.

Results and Analysis

All the loci of the pointers were not straight and many of them drew curves (Fig. 4). This shows that a curved slanting menu would be useful for reducing the user's stress in tracking menu items. However, the amount of curvature depended on the subjects and the devices used. This shows that one fixed shape of slanting menu would not fit all. Thus, we designed our menu item arrangement to reflect a user's previous trajectories when selecting menu items.

Prototype Slant Menu

We created a program that simulated a slanting menu. Although, the slanting menu method is applicable to context menus or pop-up menus, our current prototype is based on pull-down menus with a menu bar. A curved slanting menu dropped down when a user clicked one of the menu bar items, as shown in Fig. 5. The shape of the pull-down menu varied to reflect the mouse pointer loci that a user had drawn in previous menu manipulations. Other than its curved appearance, this menu performed in the same way as a conventional pull-down menu during user interactions.

Method for producing the Slant Menu

The Slant Menu uses a quadratic Bezier curve with three control points to arrange the menu items. The three control points C1, C2, and C3 of the Bezier curve were determined as follows (Fig. 6).

C1 is located at the center of the lower end of the menu item of the menu bar. Points C2 and C3 were determined based on the previous loci of menu item selections made by a user.

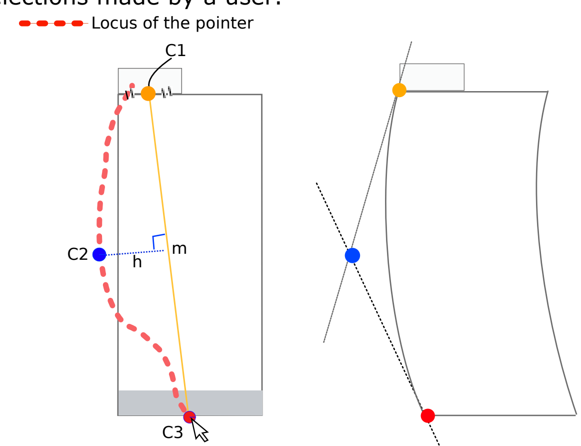

Figure 6. Method for producing the Slant Menu.

Figure 6 shows the determination method with a typical example of the locus of a mouse pointer selecting the bottom item from the menu (shown as a red dotted line). The control point of C2 is the point that deviated most from a straight line among the coordinates of the locus (i.e., the most "swollen"). Point C3 was roughly the terminal point of the locus. In fact, it was the intersection of C1 and the terminal point of the locus and the lower end of the bottom menu item.

To adjust C2 and C3 for different users and devices, our Slant Menu program obtained the weighted average of the loci from previous records of the menu selections made by a user. A user did not always choose the bottom menu item, so the following parameters were obtained and averaged with previous averages:

(1) the angle of line C1-C3; (2) the ratio of line C1-m to m-C3; and (3) the value of the "swell" h (deviation from a straight line connecting C1 to C3) divided by n when a user selected the n-th menu item from the top. The averaged locus for selecting the bottom menu item was obtained from the angle (1), the position of the most swollen or deviant point (2), and the swell value per menu item (3) multiplied by the number of all menu items.

Subjective Evaluation Experiment

We performed a subjective evaluation of our Slant Menu prototype using a questionnaire.

Method

We asked 10 subjects (female computer science students aged 21 years to 24 years) to use our menu prototype. Four types of pointing device were used, i.e., a mouse, a note PC touchpad, a pen tablet, and a pen tablet PC.

The subjects were asked to select 14 menu items that appear randomly in the pull-down menu with yellow highlighting, for each style of menu and each device.

Finally, they were asked to complete a questionnaire.

The questionnaire asked the subjects to compare the two types of menus in terms of six criteria, i.e., readability of items, speed of selection, ease of pointing, selection failure, comfort of selection, and selection problems. Subjects were asked to rate these 6 categories using seven levels (-3, -2, -1, 0, 1, 2, 3), where a score of 0 represented “no difference” compared with the conventional pull-down menu. Minus scores were negative and plus scores were positive evaluation of the Slant Menu.

Results and Analysis

Figure 7 shows the average ratings from the questionnaire. The graph shows that the Slant Menu was rated comparatively highly compared with a conventional pull-down menu. Overall, a touchpad scored highly whereas the mouse had a low score. There was almost no difference between the tablet PC and the pen tablet. Subjects scored "readability of items" low when compared with other elements. Some of them felt that menu items displayed in a curved line appeared somewhat strange and they were difficult to recognize.

The touchpad scored high on many criteria. This may be because many of the subjects were familiar with a touchpad and they were sensitive to the difference.

We asked subjects about their most familiar pointing devices and 9/10 subjects were using note PC touchpads more than six days a week.

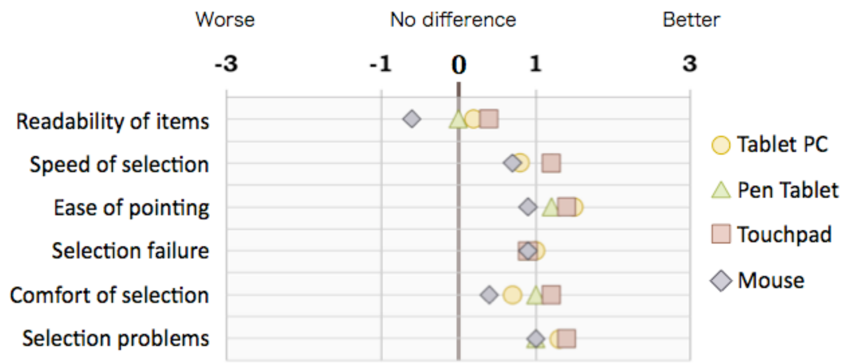

Figure 7: Subject evaluations of the Slant Menu compared with a conventional linear menu.

One of the subjects, who was familiar with a pen tablet, suggested that the Slant Menu was most suitable for a pen tablet. We think that our ergonomically designed GUI was most effective when a user chose their most familiar pointing device.

Related work

Techniques have been introduced to improve user experience of selecting a menu item. Force enhanced menus [3] augment pull-down menu with invisible "force fields" that reinforces the mouse pointer movement to the center of menu items. While the force enhanced menu preserves visual appearance of menus, our approach tries to provide uniform control-display gain over the GUI desktop, and it is also applicable to direct pointing device such as touch-screen. In the user-drawn path menu [4], menu items appear along a path drawn by a user to avoid occlusions with physical objects on a digital tabletop display. Although the user-drawn path menu requires additional action of creating a path, it has potential effect of reducing user's menu-selecting load in non-occluded situations. Fan Stack is used by Dock in Mac OS X and it is a technique for arranging icons on a curved line. This function allows an icon that resembles a fan to be opened. With this display function, a user can search through icons that are fanned out like playing cards. Our object is not to improve visualization but to reduce the burden of human hands when manipulating a GUI.

Future Work

Further evaluation experiments will be conducted with our slanting menu. In addition to a pull-down menu, we are developing other GUI widgets including curved sliders, curved scrollbars, and check boxes arranged on a curved line.

Acknowledgments

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