Natural User Interfaces

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ABSTRACT

In this report I have discuss the works of 6 papers in the field of natural user interfaces. They all discuss different interaction techniques and how effective they are. Most of the current literatures, within 4-5 years discuss techniques for touch screens or movement based interaction, so I will be focusing on these topics.

Fitts's Law is a huge part in all Human Computer Interaction. Fitts's Law states that completion time is proportional to distance and size of the target[7]. This is important when trying to make user interfaces natural, as we can apply applications of Fitts's Law to make the user interfaces easier to use.

When creating a natural user interface we need to decide what type of interaction techniques we should use. We need to decide on bimanual versus unimanual input. Bimanual is faster than unimanual, but it is not always possible to have bimanual input.

There is a lot of literature on touch screens and wall displays. This report covers many types of these interactions. It covers physical navigation, tactile feedback and many gestures. It seems that tactile feedback is not a natural form of output as it tends to distract the user. Physical navigation is a great way of helping the user navigate a virtual space.

Introduction

Natural User Interfaces are interfaces which are natural to use. This means that the user is able to use the interface with little to no training. This is important as it reduces the cost of using the software, you do not need to train all the users to use it. It also means that the users will enjoy using the interface.

User interfaces are being developed all the time. We try to create interfaces in many ways. One way we create interfaces is to design an interface so that users can perform tasks quickly. Another way we create interfaces is to design an interface that users will prefer to use.

Natural user interfaces are intuitive. This is a desirable quality in user interfaces. Natural user interfaces allow a user to use an interface with very little training, as they can draw from experiences from other activities or interfaces.

Natural user interfaces are usually flexible. This allows a user to customize their interface to better suit their needs, allowing the user to use the interface more efficiently. This is a desirable quality for natural user interfaces.

Natural user interfaces are fluid. They allow the user to use the interface without realizing they are using one. This allows the user to use the interface without any interruption. This leads to better performance when using a natural user interface.

Fitts's Law

In many studies in the literature Fitts's Law is tested against the question: "Does this interaction fit Fitts's Law?" Fitts's Law states that the time of completion is a function of distance and size of the target[7]. More precisely, it states that $T = a + b\log_2(1+D/W)$, where T is time, a and b are constants, D is the distance from the starting point to the target and W is the width of the target.

Fitts's Law is very important in Human Computer Interaction (HCI). Fitts's Law is used as one method to validate any data obtained. If we can prove that our data fits Fitts's Law then we can apply many findings based on other works. These include size of buttons being a reasonable size to reduce times, putting common functionality together to make it faster to access them as well as many other practices.

When designing user interfaces completion time is very important. Users are very impatient and do not want interfaces that take forever to navigate. Fitts's Law gives us some guidelines when creating these interfaces to make them easier to use. If they are easy to use they will seem more natural and thus will be used more.

Most of the literature in this report has Fitts's Law analysis, with most concluding a Fitts's Law relationship. This means most of the techniques described here can use derivations from Fitts's Law.

Bimanual versus Unimanual input

Our interactions with computers use both bimanual and unimanual input. When we are using a laptop or a desktop, we use bimanual input most of the time. We have learnt over time to use two hands, one on the keyboard and one on the mouse. This seems like quite a natural interaction

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technique.

When we use touch screens it seems more natural to use two hands. It is certainly a lot faster, and more efficient. This is not always possible as one hand is usually needed to hold the device in the air (phones, etc). It is more natural for users to use bimanual input whenever possible.

In 1986 Buxton and Myers wrote a paper called "A study in two-handed input"[5]. Buxton and Myers's paper discussed bimanual versus unimanual input. They created two experiments. In the first experiment the participants were shown how to do two separate tasks, positioning and scaling an object. They showed the participants that they could move the object, and they could also scale it. They made sure that it was not shown to the participants that they could do both together. The results were shocking at the time, as all the participants but one used bimanual input. The one participant who did not use both at the same time said that he did not know that it was allowed in the study.

This experiment proves that it is quite natural for users to use bimanual input. The authours' second experiment showed that bimanual input was faster than unimanual input. They showed that for experts, bimanual input was 15% faster and that for novices bimanual input was 25% faster.

Buxton and Myers's paper is cited in many articles. Nancel, Wagner, Pietriga, Chapuis, and Mackey's[1] paper shows very similar results for bimanual versus unimanual input. This demonstrates that it is quite natural and fast. Whenever one has an application with possible parallelism one should use bimanual input as it is faster and more natural.

Interaction types

The literature shows many types of interaction types. I will be discussing a few of the interaction types in the literature. Please note that this is not a definitive list of interaction techniques, but merely a few of the recent ones.

Interaction techniques are important because there is a risk that users will become impatient with an unintuitive, unnatural interface and they will simply not use it. Thus developers have to design user interfaces that are natural and easy to use.

Pan and Zoom on wall displays

Nancel, Wagner, Pietriga, Chapuis, and Mackey's[1] paper tests interaction techniques on wall displays. Since wall displays are very large, different interaction techniques have to be used. It is interesting which techniques are the fastest and which are the slowest.

The paper identifies three main factors that were tested. These are Hands, Gestures and Degrees of Freedom. All twelve combinations were tested.

Hands were identified to have two main modes, unimanual (using one hand) and bimanual (using both hands). Since pan and zoom can be performed in parallel, in general, as stated earlier, bimanual techniques performed better.

Gestures were identified to have 2 main modes, linear and circular. Scrollbars are a good example of a linear gesture. This gesture is best carried out with a mouse wheel or a touchpad. The circular gesture is the gesture used in most Apple products, like the iPod, to scroll through music. This is a nice alternative to the linear gesture but in general performs worse as it is less intuitive.

Degrees of Freedom (DOF) were identified to have three main modes. These are 1DPath, 2DSurface and 3DFree. In general the less Degrees of Freedom, the faster the task is performed.

The slowest combinations are both unimanual and circular. They also used 2DSurface or 3DFree. The tasks took around 14 seconds to complete. There may be times where these techniques can be used; however these combinations are very slow. They are also less natural to use

The fastest combinations are both bimanual and linear. They also used 1DPath or 2DSurface. The tasks took around 8 seconds to complete. This makes sense and these techniques should be used whenever possible, they are intuitive and fast.

To make user interfaces better for the user, we need to know what interaction techniques are more natural. One way of determining this is to test the performance of different techniques. It was found out that bimanual, linear gestures performed better. It is possible to hypothesize that this is because these techniques are more natural to the user.

Rubbing and Tapping on touch screens

Olwal, Feiner and Heyman's paper[4] tests two techniques for interaction with touch screens, rubbing and tapping. These techniques both resize or zoom objects on the screen but use different gestures to achieve this. They also test these two techniques with two other well-known techniques, Take-Off and Zoom-Pointing.

The paper defines rubbing and tapping. Rubbing is a gesture where you touch the screen and move your finger up or down. This gesture is quite natural and is used in many recent touch devices. It is not used to zoom data; it is usually used to scroll between menus or lists. It is a nice gesture and very intuitive and easy to use. Rubbing is a unimanual gesture.

Tapping is a gesture where you tap on the object you want to zoom or resize and move your other finger up or down to resize it. This gesture is quite a good gesture as it uses bimanual input, which has a shorter completion time with a high degree of parallelism.

The interesting thing about rubbing and tapping is that the time of completion for using each gesture is quite similar (within 0.25ms) with no gesture being definitively better than another. Another interesting thing is that rubbing had a greater perceived speed. Rubbing had one disadvantage, the fatigue due to the friction between the user’s finger and the touch screen.

Binmanual input should have a smaller completion time. However due to the lack of parallelism in the tasks it had a similar time of completion. The tasks used are tasks that users commonly perform on a touch screen.

It seems from the data given that rubbing is more natural, since it has a perceived smaller completion time as well as being more intuitive. This is likely the reason that this gesture is used extremely often in recent touch screen based devices. Tapping is still a useful and fast gesture and should not be discounted. This paper points out that touch screens should use different gestures compared to other devices.

Physical Navigation on Large Displays

Ball, North and Bowman's paper[2] tests if physical navigation is a interaction technique that can be used. They focused on large displays. The resolution they used is 10240 X 3072 which is much larger than desktop, laptop or phone screens. This allows testing of a different type of interaction.

The paper tests whether physical navigation helps when using large displays. Physical navigation allows a user to visualize the space they are navigating in better. As long as the physical navigation is set up correctly, it is preferred over just virtual navigation.

To set up a good physical navigation space there are a few general rules that should be followed:

1. Use a wireless device for the interaction. This allows the user more freedom to move about the room. Being tied down to wired devices, or a desk, hinders performance a lot.

2. Have a clear room with a large screen for the information. Users that are not fearful of tripping up on objects perform much better. Also having a large screen means that more information can be shown, allowing the user to make use of the physical navigation allowed.

3. Have the room make sense with regards to the virtual one. If the physical room matches the virtual one then the user will treat the virtual interface as part of the physical space, making them feel more comfortable.

Physical interaction is a well discussed topic in user interface design. With systems like the Wii, Kinect and Move it is becoming more and more important to discover what is more natural to the user. The paper tests how physical navigation works with large displays.

It was found that physical navigation helps with user performance, and allows them to visualize a problem better. Users also preferred using physical navigation 100% of the time; it is more natural to move around to view the data they are interested in.

Tactile feedback for large displays

Foehrenback, König, Gerkin, and Reiterer's paper[3] did a similar experiment to Ball, North and Bowman's paper[2]. Instead of using physical feedback Foehrenback, König, Gerkin, and Reiterer focused on tactile feedback. Their definition of tactile feedback is "Tactile feedback, sensed as an ongoing vibration on the fingertips, was given when a collision of a virtual object and a finger occurred."[3]

The paper tests whether tactile feedback increases user performance with big monitors. An interaction technique was created which can use tactile feedback. They hypothesized that tactile feedback will increase the performance of users, as it is quite natural for humans. This hypothesis was proved to be wrong; the performance was identical for tactile and non-tactile feedback.

Another note in this paper is that the error rate went up by about 10% when tactile feedback was used. This can be because the tactile feedback was ignored and/or interfered with the task they had to do. Since participants were not used to having tactile feedback, it seemed to be getting in the way, leading to mistakes.

User satisfaction was quite even, with a third of the study liking tactile feedback, a third disliking tactile feedback and a third undecided. There was no correlation between satisfaction and performance.

The non-tactile version was liked. This means that the tactile feedback did not improve performance or satisfaction, while increasing error-rates. The tactile feedback was a failure.

Tactile feedback is more natural to humans; we use it all the time. It would make sense for it to be natural for users to have tactile feedback when navigating virtual spaces. It would provide extra information to the user and allow them to interpret the data better.

However this does not seem to be the case, having tactile feedback seems to confuse the user, making them more prone to errors. It does not increase performance. Also not having tactile feedback was preferred over having tactile feedback.

Direct and indirect input using a stylus

Forlines, and Balakrishnan's paper[6] tests direct versus indirect input using a stylus. They have tactile feedback and non-tactile feedback in the stylus different to the way Foehrenback, König, Gerkin, and Reiterer did their tactile feedback.

Direct input is where the stylus is directly touching the user interface. Indirect input is where the stylus is touching a touch screen, but the user interface is on another screen. This is a very interesting technique to test as it tests whether the touch screen should contain the user interface.

An interesting thing to note is that tactile feedback seemed to outperform non-tactile feedback for direct input. There is a difference of about 100 milliseconds. This is probably due to the fact that the user can identify if the stylus is touching the object.

Tactile feedback seemed to not make a difference in the completion time when using indirect feedback. This seems to be similar to what Foehrenback, König, Gerkin, and Reiterer[3] found out. This is due to the same reasons, it was more of a distraction and did not provide any more information, and users still had to look up at the screen to confirm their input.

Direct input had a shorter completion time than indirect completion time. Direct with no tactile feedback had a completion time of 1100 milliseconds while indirect feedback has a completion time of 1200 milliseconds. This is a 100 milliseconds difference which is very small.

The reason direct input is faster is because the user does not need to look at another screen. It is more natural to be working directly on the user interface, which the completion time shows. It is however important to note that indirect input was not that much slower, so it can still be used where it makes showing information better, like a meeting on a wall screen.

Summary

In conclusion, bimanual interaction is more natural than unimanual. It makes sense for us to use two hands to complete tasks, since we do this for other tasks. Bimanual is best suited for tasks that have a high degree of parallelism, for instance pan and zoom tasks.

Different interaction techniques need to be used when dealing with large screens. Large screens allow the information to be viewed better. It makes sense for the user to move around and look at the data from different angles. This physical interaction needs different conditions to a desktop, laptop or phone. Physical interaction needs a large space with wireless devices to control the screen.

Tactile feedback works for touch screens with direct input, but not much else. It also seems to increase error rates while providing little or no benefit. It does not seem natural to use tactile feedback as a form of output.

Future work

There has been much work on finding out how to present users with interfaces that are natural, easy and fast to use. While this is great and there will always be new interaction techniques to test, it is worth noting that other factors can be tested as well. These factors could include, color, position of interface objects and layout. It is also possible to test current software to see if it is natural and easy to use or if users have just adapted.

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