The Intuitiveness of Bimanual, Mid-air, Gesture-based Input Methods which provide Haptic Feedback

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ABSTRACT

In order to allow a person to intuitively make effective use of it, a digital device should support input methods which mimic the way in which people manipulate the physical world around them, instead of requiring people to learn a whole new set of input techniques before they can make use of the device. A common way in which people intuitively provide "input" to the world around them is by using both hands to affect their surroundings, while receiving feedback through their hands' sense of touch (haptic means). By allowing bimanual (two handed) input through the use of hand gestures which aren't tied to a particular location, and providing tactile feedback, a digital device can make use of this method of interaction which a user is already adept at. The interfaces of both emerging and existing digital technologies can be made more usable and user-friendly by integrating with people's natural methods of interacting the world around them, instead of requiring the use of input techniques which – from a human perspective – are unintuitive, restrictive, unresponsive and limited.

Author Keywords

Natural User Interface; Bimanual Input; Mid-air Input; Gesture-based Input; Haptic Feedback.

ACM Classification Keywords

H.5.2 Haptic I/O, Interaction styles, User-centered design.

General Terms

Human Factors.

INTRODUCTION

A way in which people naturally interact with the world around them is by using their two hands to both physically manipulate it, and receive haptic feedback about it [6]. Because of this, one way to design a digital device which people will intuitively be able to make effective use of – in other words, without having to learn and use interaction techniques which don't come naturally to them – is to make it accept bimanual, mid-air, gesture-based input, and provide haptic feedback based on this input.

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INPUT METHODS

Bimanual Input

Leganchuk et al. [5] point out that many digital devices utilise methods of input which engage both of a user's hands in a complementary way in order to complete tasks. The reason this is an efficient and effective method of input compared to a one-handed approach is because there are both manual and cognitive advantages to these two-handed methods. The manual advantages are due to the possibility of being able to perform two input functions at once – in other words, due to an increase in the level of parallelism – while the cognitive advantages are caused by a reduced mental workload from not having to perform with one hand a task that would "naturally" be done with two.

Based on the findings of Myers and Buxton [7], Latulipe et al. [4] and Nancel et al. [8], Banerjee et al. [1] chose to incorporate bimanual input into Pointable – their remote target acquisition and manipulation system for tabletop displays – in order to increase the level of parallelism while a user is providing input, and therefore reduce the amount of time it takes a user to complete the integrated task of both acquiring and manipulating a target.

The advantages gained from bimanual input are also demonstrated by Leganchuk et al. [5] in an experiment involving both one and two handed methods of selecting objects in a graphics program by sweeping a boundary box around them. Even though this paper was published fourteen years ago (in 1998), it is notable that a one-handed approach is still the prevalent way in which this task is performed on digital devices. Overall, the task was performed significantly faster with a two-handed approach, with this advantage becoming more pronounced as task difficulty increased, supporting their hypothesis that there are both manual and cognitive advantages to using input methods which involve both hands.

Nancel et al. [8] investigated the relative merits of accepting one or two handed input with their mid-air pan-zoom virtual navigation system designed for very-high-resolution wall-sized displays. One of the findings derived from their experimentation – which involved twelve participants performing a total of 2592 trials – was that two-handed methods were consistently faster than one-handed methods when all other considerations were equal.

Mid-air, Gesture-based Input

The Pointable system – a mid-air, gesture and position based technique for bimanual input – was developed by Banerjee et al. [1] as an alternative to touch input for interactive tabletop displays. Two of Pointable's design goals were to enable the in-place manipulation of remote targets, and to minimise intrusion into the personal space of others in collaborative settings.

While the development of a mid-air, gesture and position based input technique would enable the realisation of these two design goals, the speed at which input could be provided through the Pointable system was also a design concern, and was measured by conducting two experiments.

It has long been established that, in general, use of a mouse is one of the – if not the – fastest method of providing input [2]. More recently, touch input has been shown to provide similar speed performance to mouse input, with the relative performance of the two methods depending on usage context [3].

The two experiments conducted by Banerjee et al. [1] resulted in the finding that the speed at which input can be provided through the Pointable system is similar to the input speeds provided by both the touch and mouse interfaces.

They also conducted an experiment in which it was found that, when given a choice while completing a set task on an interactive tabletop display, over three quarters of participants preferred using the bimanual, mid-air, gesture and position based input of the Pointable system over the more established multi-touch input system.

This supports a hypothesis that, when the speed of performance isn't a factor, people prefer to provide input to digital devices via a method they find more natural and intuitive – in this case the method provided by the Pointable system.

For Nancel et al. [8], providing input from a fixed point – such as a conventional desk-based keyboard and mouse set-up – was not a viable option when designing their mid-air pan-zoom virtual navigation system for very-high-resolution wall-sized displays. Given the huge size of the displays in question, the ability to move freely in front of them is paramount – which also rules out the use of cumbersome input devices.

Because of this, Nancel et al. [8] concentrate on determining which particular implementation – or implementations – of mid-air, gesture-based input are most effective when performing the task of pan-zoom virtual navigation on very-high-resolution wall-sized displays. The effectiveness of a particular implementation is determined by the amount of time it takes experimental participants to perform set tasks.

One finding of theirs which they did not expect was that input was more effectively provided through linear gestures than circular ones – it was expected the clutching (having to return the hand or finger to a more comfortable posture) involved with repetitive linear gestures would produce the opposite outcome.

HAPTIC FEEDBACK

Nancel et al. [8] found that – generally speaking – the more guidance people received through passive haptic feedback, the quicker they were able to provide bimanual, mid-air, gesture-based input to a digital device. In their experiments, this haptic feedback was provided by the user holding a wireless input device upon which their hand was allowed freedom of movement in either one or two dimensions. For freedom of movement in one dimension, either the wheel of a mouse, or an input device featuring a dial, were used. An iPod Touch was used for freedom of movement in two dimensions.

A user who received tactile feedback through such a device was able to control their hand movements much more accurately than a user who was given freedom of movement in all three dimensions – and who then had to rely solely on proprioception (their internal awareness of the position of their hand) in order to regulate their hand's movement.

SUMMARY

While Nancel et al. [8] did find that some other combinations of handedness, gesture type and guidance level offer a reasonable level of performance, they found that bimanual input, using mid-air, linear gestures, and with a high level of guidance through passive haptic feedback, was best suited to the task they wished to accomplish.

Banerjee et al. [1] also found that, when people are given a choice between providing input through a multi-touch system, or through a bimanual, mid-air, gesture-based system, they generally prefer using the latter system.

Given that both of these selected input methods mimic the natural, intuitive way in which people manipulate the physical world around them, these findings should come as no surprise. When digital devices fit in with human ways of doing things – instead of the other way around – they become a lot more usable and user friendly.

FUTURE WORK

Banerjee et al. [1] identify two areas in the study of natural user interfaces which would benefit from further research. The first is the advantage which could be afforded to the area of collocated, synchronous (same place, same time) computer-supported cooperative work by the integration of bimanual, mid-air, gesture-based input. Instead of several users running the risk of obstructing each while providing input to a common device such as a multi-touch display, research in this area offers the possibility of each user being able to provide input in an unobstructed and unobtrusive way.

The second area which Banerjee et al. [1] state could benefit from further research is the development of accurate mid-air, gesture-based input methods which do not require users to wear equipment. The Pointable system they present requires users to wear both gloves and an eyeglass frame, and they state that this input method's rate of use would benefit from users being unencumbered by such devices.

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