Visceral Interaction

Masitah Ghazali and Alan Dix
Computing Department, Infolab21, Lancaster University, Lancaster, UK
{masitah, dixa}@comp.lancs.ac.uk
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This paper introduces visceral interaction, which we believe complements the vision of creating more natural and intuitive interfaces. We re-emphasise the importance of the detailed physical aspects of devices and the way in which these can recruit our natural human abilities. We describe a study that highlights this in physical manipulation so long as devices possess key features of physicality - in this case the 'natural inverse' property. The device, a Cubicle, controls a media application, but the mapping between the device and its effects were deliberately manipulated. Despite a lack of understanding of the mappings, the participants were able to react appropriately to feedback and successfully complete tasks, and moreover enjoy the experience. We attribute this to the fact that the device preserves key properties of visceral interaction that allow a momentary tacit mapping. We hope that this understanding of physical interaction will help improve future human-centred interaction.

Physical interaction, tangible interfaces, user experience, mapping, calibration, fun, playful interaction.

1. INTRODUCTION

Our everyday interaction with the real world requires perceptual, cognitive and motor abilities in order for us to comprehend the world and for us to take any action based on that understanding. Our interactions with computer systems leverage these same abilities and theoretical analysis over many years has tried to make sense of this adoption of natural abilities in electronic environments.

Some research has focused on more richly exploiting inter-personal aspects of human abilities. In general however, direct manipulation interfaces use metaphors and natural skills related to physical manipulation: picking up, moving around, putting down, albeit at an indirect level using the mouse or other pointer. In contrast virtual reality and mixed reality interfaces from early system such as the DigitalDesk [8] onwards have used hands directly to manipulate virtual 'physical' objects. More recently, interest in tangible interfaces has allowed actual physical objects to be used tapping more directly into our 'real world' manipulative abilities and has highlighted the importance of the precise physical form of interactive devices.

Strangely, in the early days of the GUI, Buxton [2] argued strongly that physical devices used in graphical interactions should not be simplistically reduced to abstract devices for pointing, text input and selection. He used children's drawing toys to emphasise the subtle differences between, for example, using a joystick to draw as opposed to the multiple knobs of Etch-a-Sketch. However, whilst there is a line of research that has preserved his vision; the broad thrust of GUI practice has elided the differences between mouse, trackpad, or joystick and followed blindly the path of abstraction. It is only now with both tangible interfaces and greater links to industrial design that the importance of fine details of physical devices are beginning once again to be understood.

In this paper we want to re-emphasise the importance of the detailed physical aspects of devices and the way in which these can recruit our natural human bodily abilities. We call this *visceral interaction*. This will be exemplified by observations made during a short study of the Cubicle, small cubic devices proposed by others as a tangible input device [1, 6]. In this study, despite the often complete breakdown in explicit and tacit understanding of the device–system mappings, the users were able to successfully complete tasks and moreover enjoy the experience. We attribute this to the fact that the device did preserve key properties of visceral interaction that allowed *momentary* tacit mappings.

2. VISCERAL INTERACTION

If you have ever driven a car in reverse using mirrors you may have experienced something like the following:

(a) you look in the mirrors and try to turn the wheel in the 'right' direction but you keep getting it wrong – it is the opposite way round to what you are expecting
(b) you then stop and perhaps work out which way the wheels will go as you turn the steering wheel
(c) you then very fitfully move the car small turn by small turn in the right direction
(d) suddenly you find yourself just driving effortlessly backwards
(e) then something goes wrong, you over steer slightly, go too fast, an odd angle in the road, and it collapses – you are back to stage (a)

Our interactions with the physical world operate at many different levels from explicit concrete reasoning "if I put a long stick under the rock I will be able to move it" to instinctive motor feedback: hand jumps back from sharp point. Between these we have tacit knowledge, for example, if a cup begins to fall we move our hands beneath it to catch it because of gravity, but without thinking explicitly about it.

Note how the stages in the above car reversing task are operating at these different levels. Steps (b) and (c) are at an explicit reasoning level. In order to do this the car has to reveal enough of its operations for you to be able to infer the mapping between actions and their effects on the car. Your ability to do this with the car, and with a device in general, depends on your own mechanical understanding and also on the extent to which the device reveals its mapping to you; that is its affordances [5], or in the case where information may be deliberately exposed to augment this is called *feedforward* by Wensveen et al. [9].

Step (a) is addressing something a little 'lower level' in our mental functioning. If you were an experienced truck driver or used to reversing using mirrors something about the situation of sitting, looking in the mirrors would trigger learnt reactions and you would simply drive backwards without thinking about it. This happens in all types of motor learning: when a user chooses to use a mouse upside down, in the classic experiments where people wore left–right reversing glasses, or when you practice a finger sequence on a guitar or a move in martial arts. Our human ability to achieve this for technologically enhanced interactions, such as mouse–screen, is amazing and it has been suggested this has its origins in the skills needed for very early tool use [3].

So what is happening at stage (d)? Clearly, this is more complex than a pain–withdrawal response as it involves hand–eye feedback. However, neither is it a sign that the 'driving backwards' action has become learnt as the breakdown in stage (e) tends to be pretty much back to the beginning. At this point a more generic behaviour seems to be in play: "if you do something and the response is 'the wrong way', just do the opposite". Even though when reversing using mirrors the action–effect mapping is the opposite to driving looking over your shoulder, still it preserves a crucial property: opposite actions have opposite effects. We have previously called this property the *natural inverse* [4] and have identified it as one of the ways in which our natural responses to the physical world can be exploited in 'fluid' interaction design.

Note that during the tight loop of hand–eye interaction in stage (d) in some way you 'know' the directional mapping. However, this is a momentary knowledge and embedded within the flow of interaction. As soon as the interaction breaks down the 'knowledge' is lost.

3. CUBICLE EXPERIMENT

An experiment was designed to study the Cubicle's performance as an input device in terms of ease of user calibration and manipulation. Several conditions were used corresponding to more or less natural mappings (in the Norman sense), but the details of these are not important for this paper except in that they created breakdowns in the users' ability to create explicit mappings. In addition the protocol included observations and questions intended to study the user experience and playful behaviour.

We used a Cubicle application [1] intended as an input device for playfully changing between different TV-channels. In particular, the Cubicle was used to select movie trailers. The Cubicle itself is constructed of wood with sides approximately 3 in (7.5 cm) (see Figure 1). It was augmented with accelerometers hidden within the wooden case. The sides were numbered 1 to 6, but without any images of the movies or other indications of meaning. This meant that the mapping between the cube's movements and its digital effects could be 'soft' and reprogrammable. In order to help the user to understand the effects of the Cubicle, it also has an on-screen representation of itself (see Figure 2). In this digital representation the sides each display a title image for the associated movie.

FIGURE 1. The Cubicle used in the study

FIGURE 2. A user exploring the cube interface by interacting with a large screen

In order for the study to be semi-exploratory, the instructions given to the participants included not only some prescriptive tasks, but also space for exploration. Out of 14 participants, eight came from Computing, three from Psychology, and one from Accounting Finance departments, whilst two participants were taking their A-Levels. There were nine male participants, and five female participants. Five participants had prior experience of using alternative input devices, such as haptic gloves, and two of them had used the Cubicle interface before.

Participants were first given time to familiarize themselves with the Cubicle interface. The next two steps were to give participants the idea of selecting a movie trailer by carefully rotating the Cubicle. The rest of the instructions/tasks were carefully designed to observe how participants manipulate the Cubicle, i.e. the calibration (if any) and to observe their facial expressions as they selected the requested movie trailers. However, because of the novel nature of the Cubicle and the limitations of the technology, we realized that these tasks were more likely to explore the limits of interaction rather than to provide solid quantitative data.

Various conditions were used to represent the different mappings between the physical cube and on-screen representation. Because the sensors used in the cube (accelerometers) could not uniquely sense the cubes rotation, the participants needed to establish some calibration between the on-screen representation and the physical cube in order for there to be a consistent mapping. However, the participants were not given coaching on how to obtain this calibration as one aim was to see whether this could be inferred during exploratory interactions.

4. OBSERVATIONS AND FEEDBACK

The participants all followed the same general pattern during the experiment. They commenced the first few steps of each condition with an attempt to establish a correct mapping between the physical movement and its effect on the screen. But this exploration did not last long. We could see the participants struggled trying to match their movement with the movement of the virtual cube on the screen, and consistently failed, even when there were numberings on the sides of the on-screen representation that were intended to help. On a few occasions they were able to briefly establish calibration, but they were not able to maintain this. The participants were clearly quite frustrated. Eventually the participants abandoned their attempts to calibrate and understand the cube mappings and then proceeded to successfully accomplish further steps. Over subsequent trials, independent of the order of conditions, each participant's attempts to calibrate became progressively shorter before abandoning the attempt. However, despite all this, they still managed to successfully complete tasks, and enjoyed it at the same time.

In a post-experiment questionnaire of ten criteria using 7 point Likert scales six of the criteria (smoothness, mental effort, reaction time, overall operation, frustration and reliability) obtained average ratings between 3 and 4 giving a baseline. The two ratings for physical effort and fatigue were much lower (2.07 & 1.36), reflecting the fact that the fact the cube had to be held in the air during much of the experiment. However, the ratings for general comfort and, importantly, fun were substantially higher (4.97 & 5.00), demonstrating an overall appreciation of the device, despite its frustrating aspects! In addition to the questionnaire answers, we observed participants enjoying their interaction with the Cubicle and this resulted in a playful, fun experience. Several of the participants commented on this: "good fun :-)", "great device, enjoyable experience (would like to use again!)". These participants also spent a longer time watching the trailers.

Why is it that despite failure to establish a mapping the participants were able to successfully and enjoyably manipulate the Cubicle? As previously mentioned in the introduction, we believe this is due to *visceral interaction*, the physical aspect of device which recruits our natural human abilities. In particular, the Cubicle had *natural inverses*. At any moment the participants did not know how a physical rotation of the Cubicle would translate into rotations of the virtual cube. In fact, not only did they not explicitly know, but because of the lack of calibration there was no stable mapping. However, it was always true that the reverse of a particular rotation moved the cube in the opposite screen direction – a *natural inverse*. This means that without explicit conscious deliberation 'errors' would be corrected in a sort of constant exploration of the *momentary mapping*. This is exactly like the car reversing during stage (d) and likewise recruits our natural abilities for physical object manipulations.

From our observations, participants preferred not to dwell on understanding the mapping, especially when their attempts never seem to make any differences. They, rather remarkably, found it easier to manipulate the Cubicle by just paying attention to the visceral interaction. By doing so, the participants didn't need to plan their action; all they had to do was respond to feedback in a very direct perceptual–motor cycle with apparently little explicit cognitive understanding. Even though the mapping established was strange and ever changing, it was impressive to see how the mind and body works in unconsciously comprehending the physical and virtual movements in order to complete the tasks. This 'carefree' and intuitive act seemed to shape their attitudes towards the Cubicle.

5. SUMMARY AND ONGOING WORK

Turk and Robertson characterise Perceptual User Interfaces (PUI) as perceptive (rich sensing of users by computers), multimodal and multimedia interfaces; the integration of these would no doubt create more natural and intuitive interfaces [7]. We share the same vision, which is to seek and to achieve far more general and intuitive ways of interacting with technology. However, the broad thrust of perceptual user interfaces is towards rich capture of physical data and deep processing within the computer, whilst visceral interaction recruits deep-seated human abilities to manipulate physical objects.

From the Cubicle study, we have discovered that despite 'failure' in calibrating the mapping of the physical cube with the virtual cube, participants were still able to complete tasks, and enjoy it! Normally in user interfaces a poor mapping between action and effect would be regarded as bad design and would give poor usability, but visceral interaction has enabled participants to overcome the cognitive complexity of the 'impossible' mappings. The intuitiveness of natural inverses enabled successful task completion, and the participants had fun.

Whilst the observations here are suggestive of the role of visceral interaction and are consistent with day-to-day experience, devices tend to either have or not have properties such as natural inverses. It is thus hard to explore rigorously the properties of visceral interaction. However, in the coming months we are planning Fitts' Law-style experiments where we will be able to 'turn on and off' the natural inverse property in highly constrained circumstances allowing factorial designs with good/bad cognitive mappings and good/bad visceral interaction.

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