Creating Affinities between paper and digital resources

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1. INTRODUCTION

When considering the uses of mundane artefacts there appears to be one that perhaps deserves to receive more attention than most. The humble paper document pervades our ordinary lives - at work, in the home and almost everywhere else. Despite insightful research delineating the significance of the artefact (e.g. Sellen and Harper 2002, Luff et al, 1992, Harper 1997) – the social sciences have so far mostly disregarded its status as a fundamental resource for many human activities and forms of collaboration, whilst technical innovations still tend to attempt to refashion, reshape or even replace paper, without regard to its critical capacities.

In this presentation we will revisit the long-standing interest in system design with paper. Rather than drawing on the appearance of paper to inform the design of an interface or to suggest the functionality of a technology from the capabilities of paper we will consider a development that sought to maintain the material qualities of paper whilst providing people with ways of establishing simple affinities with a computer system. The technological approach considered was innovative, drawing upon the properties of innovative inks and coatings. Severe technical challenges emerged, however, in trying to develop a working solution. A simple observation of the uses of paper did suggest a way in which some of these difficulties could be overcome, informing quite fundamental aspects of its design. This enabled the production of a system which we could test and assess.

We will briefly consider a quasi-naturalistic experiment we undertook with the technology. By analysing the activities of participants in the experiment we consider the appropriateness of our initial observations for the use of the technology, and suggest how when designing even the simplest of systems it may be worth understanding the fine details of activities in interaction.

2. BACKGROUND

A number of researchers in CSCW, HCI and Ubiquitous Computing have considered the critical properties of paper, or the 'affordances' of paper, and how we might develop new technologies that might replicate these or make use of them (e.g. Sellen and Harper 2002, Heath and Luff 1992). From what is now quite a considerable corpus of studies of paper use in settings as diverse as classrooms, control rooms and design practices it is apparent how activities with and around paper are embodied activities. For example, references to features of a document are often animated through gestures not only with the hand and fingers but with pens and other artefacts. Paper documents can be tilted, rotated or slid along a desk to provide another person with better access to details, or moved to encourage participation or invite a response from another. Writing, as another example, can require the whole body frequently requiring the second hand to steady the paper or the body as writing takes place (see Figure 1).

Figure 1: Two-handed writing

This latter and apparently simple observation has informed the development of a technology in quite a curious way. In aiming to provide individuals with a simple way of interrelating paper and digital documents a technique had been proposed using innovations in conductive polymers. By a combination of coating the conductive polymer on conventional paper and lacquering this to protect it the surface could be coated with a barely visible pattern. This could then used to encode locations as x-y (and page) positions in the document. With such a technique a very simple contact – principally two electrodes – could when swiped across the page detect the changes between conductive and the non-conductive parts of the pattern. If this pattern was similar to a barcode and encoded locations, a piece of paper could operate in a similar way to a simple graphics tablet or touch screen. When a location is detected, the 'swiper' could transmit this (via, say, the Bluetooth protocol) to another device such as a computer and an appropriate action invoked, such as playing a sound, video or changing an image on a screen. The envisaged advantages of this approach was that it was simple, and on account of this, cheap. The additional costs of producing the coating could be very small and the swiper could be very inexpensive (see Luff et al 2004, for a description). Furthermore, as only information is encoded about locations, all other relationships being defined through software. Given a pre-printed paper product, like a text book, this should make it easier to update or tailor for particular users. One could envisage applications where updates, additional resources and customised information would only be provided in the digital domain (see Figure 2).

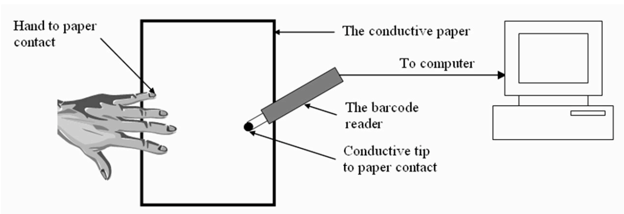


Figure 2: The technology

There are quite complex technical issues in trying to develop this approach. Firstly, the only conductive polymer that seemed suitable Poly(3 4)-ethylenedioxythiophene (or 'Pedot') although transparent when applied to plastic surfaces had never been printed on a paper surface before. Initial experiments showed when applied to paper it was blue and no longer unobtrusive. Secondly, when a way was devised to coat the conductive pattern on a flexible (glossy) surface where this was less visible we found it hard to print standard inks on top of it: any device, such as the swiper, that touched the surface would take portions of the printed artwork with it. We had to develop a way of coating the paper with Pedot and then printing a lacquer with 'holes' in it for the pattern, where the conductive ink could be detected. Although a complex arrangement, this would for a process where printed materials could be produced in large qualities using standard printing techniques. Thirdly, it was difficult to design a reader that robustly detected changes in electrical conductivity, in particular the design of the nib. The electronic engineers tried a number of configurations for arranging the two electrodes, one simple approach was similar to an ink fountain pen where the nib was split to form the two electrodes that were needed, another was similar to a ballpoint pen where the two nibs were concentric. In both cases it was possible to develop a 'swiper' that could, when run over the pattern detect the appropriate signals, but it was hard to do so without scratching the surface. As was raised in design discussions these technical issues emerged because what we were trying to develop was something different from a conventional printing process and using something that was different to a standard pen or a swiping device such as a barcode reader. We were trying to print something that was invisible (but that had an effect) and trying to detect an electronic signal through contact with paper. Colour printing, developed over centuries, has emerged to produce highly distinctive marks: pens can run smoothly over paper, because the ink acts as a lubricant not only producing a continuous mark but also serving to clean the nib.

By a combination of innovation and systematic assessment we did manage to develop a printing process so we could produce artwork with a conductive pattern that could only be seen when a page was held against the light in certain directions. The eventual solution for the detector emerged through discussion between the engineers and social scientists regarding their observations of pen use. If indeed writing was embodied and a second hand was used when writing this could inform the design of the detector. It may be possible to develop a much simpler nib arrangement that would be less abrasive if it had only one point of contact where the page and the circuit was effectively 'closed' by the second hand being in held on the desk or another surface.

A system was developed based on this observation. After technical trials with this system which produced positive results we undertook a small-scale study of the technology where individuals used it to perform a simple presentational task. These experiments involved using the swiper and augmented paper technology to control a PowerPoint presentation through an application called PaperPoint (Signer and Norrie 2007). By a simple addition to the PowerPoint application handouts can be printed on augmented paper where they also have PaperPoint controls. In its simplest operation the handout can be used to control the presentation by just selecting the image of the slide (or thumbnail) on the page. This application also proved to be an effective way of demonstrating the principles behind augmenting paper, being quite simple, but also one where the combination of the paper and electronic resources seemed to offer a great deal of flexibility and overcome some of the problems that arise when such presentations are controlled just through a computer system (cf. Tufte 19xx, Schnettler and Knoblauch 2003). Users had an easy means to move between slides and select their own order of a presentation. In our experiment 11 groups of students and administrative staff from University Departments (each with three members) undertook a simple presentation task with a paper handout containing six slides. We recorded the experiment using four cameras.

3. THE SECOND HAND: ONLY TOUCHING THE SURFACE

In the recordings it is apparent that when using the system the participants do use their second hand when selecting slides; even though our observation was made with regard to writing and not the rather specialised action of swiping.

Indeed, swiping over the paper seems to require the participants holding the paper so that it remains stable. When participants do attempt to use the technology single-handedly, and there is no response, they take remedial action, bringing the second hand up to stabilise the page. The users' handling of the technology in the experimental setting not only confirms our mundane observations on writing practices, but also suggests that swiping with the reader requires the use of two hands.

However, there are aspects of the design that make it possible for the circuit through the body not to be completed correctly. To get the best results the second hand needs to touch those areas of the page that are conductive, that is all those parts of the page that are not covered by the lacquer that masks the conductive layer and thereby creates the pattern. In the design of the PowerPoint handout there is in effect a relatively large space for 'correctly' touching the surface, and the page layout we chose seems to match the users' preference for touching the paper at its margins when swiping, whether this is on the left or the right of the page.

When stabilising the page some combinations of hands seem to work better than others. Very occasionally users – although using all five fingers – manage to place them in such a way that they are all positioned on non-conductive areas (while the palm of the hand is in the air). Here, the electrical circuit is not closed and the slide will not be selected.

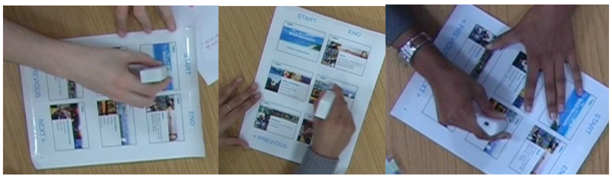


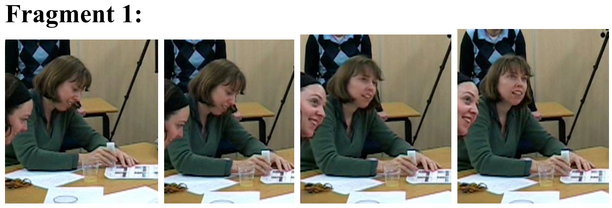
Figure 3: (a) left side swipe; (b) right side swipe; (c) all five fingers on non-conductive parts of the page

4. GIVING A POWEROINT PRESENTATION: UNPACKING THE SWIPE

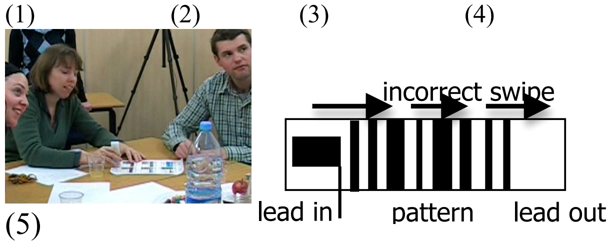
When considering how to link paper with digital materials through a conductive surface various options were discussed regarding what action the 'user' needs to take. The action needs to be simple, but not constrained by the capabilities of the conductive materials, the kind of pattern to be used or the nib of the device that detects the electronic signals. The engineers required the pattern incorporated a 'lead in' and 'lead out' space. This would allow for the swiper to be positioned before or after a barcode and for the individual's swiping motion to accelerate before reaching the barcode, and decelerate after it. This would mean that the user would need to swipe over the area of the code encoding the location information. These technical constraints seem to match the design and layout of a PowerPoint handout where each thumbnail could be augmented with the (more or less) invisible pattern, so that by swiping over a thumbnail a relevant location would be detected and the corresponding slide displayed. Indeed, the users seem to make use of the geography of the page to accomplish the swiping action successfully.

However, a seemingly simple action such as swiping across a pattern turns out, when undertaken by participants, to be a more complex activity than expected. Although most users intuitively use the boundaries of the thumbnails as relevant demarcations for their swiping, this activity varies in a number of ways. Some users, for example, need several attempts to swipe a thumbnail: they might initially position the swiper in the middle of the thumbnail image, thus missing the beginning of the pattern and thus produce an incorrect swipe. Users – when trying to activate a slide – might also shift their gaze between the paper where they were swiping and the screen where they expect a new slide to be displayed. Although it is possible to interleave these actions whilst swiping, it can be more difficult than it might seem. In the following fragment, Anna is presenting whilst Alex and Marc, sitting either side of her, watch the presentation. Anna brings the swiper down to the page (1) and begins to swipe (2) while gazing down to the paper. Then, when she looks up to the screen (3), her swiping motion comes to a short halt, then restarts and continues (4) before halting again (5). Anna's swiping motion is interrupted and thus transmitted to the computer in parts, resulting in an unsuccessful swipe.

Fragment 1:



(1) (2) (3) (4)



(5)

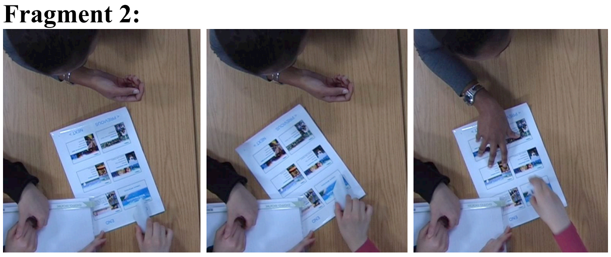
It transpires that in order to perform the swiping action, the participants need to look at the paper to determine where to swipe and, at the same time, monitor the screen to observe the consequences of their actions. While such changes in orientation might not affect the performance of short activities, such as tapping on a page, they do affect ones of longer duration, such as swiping – resulting in the system not appearing to work. In some other cases, users run the swiper – while gazing back and forth – over the boundaries of the thumbnail image and into the next slide; again producing an unexpected result and the system appearing not to work.

What seems to be a single action, swiping, turns out to be broken apart and interleaved with others – such as looking at the screen or gazing towards co-participants. A technology that requires what seems to be a single, simple action, a ‘gesture’, to link materials on paper to those on screen, when used by participants in conjunction with other devices, can become fragmented.

5. COLLABORATIVE USE

The simple action of swiping can be more complex in other ways. Consider the following fragment, in which three users in an early phase of the experiment gather around the PowerPoint handout and take turns in manipulating the device. The woman (at the bottom-left of the image) takes the swiper and begins to swipe along the thumbnails, firstly top down with the swiper’s metal tip touching the paper surface, then with the swiper being held flat above the sheet (1). As she stabilises the paper with the tip of one finger (positioned at the left topmost edge of the page), and begins the second action, the paper begins to slide across the table spinning around the tip of her finger (2).

Fragment 2:



(1) (2) (3)

A colleague sitting opposite her comes to help, not only moving the paper back into its original position, but also offering her right hand to stabilise the paper for a further swiping action (3). When resuming her actions, the first user repositions the tip of her left index finger at the left topmost edge for stabilising the page. The paper is now held by two participants. Unfortunately, although this serves to allow for an apparently appropriate swiping action it does not complete the circuit. On the one hand, the user who is manipulating the reader does not touch the PowerPoint handout but touches the transparent cover of the document. On the other, to close the circuit the same person needs to swipe as place their hand on the desk. This collaborative effort does not achieve its aim.

6. DISCUSSION

In this paper we follow what is now a long tradition in ubiquitous computing and elsewhere of seeking ways of drawing from studies of everyday behaviour to enhance a mundane artefact. The development of a conductive paper technology was motivated by the recurrent observation that paper continues to be ubiquitous and rather than seeking to replace it, it may be worth considering ways of better interweaving paper and digital resources. The PaperPoint system accessed through a simple piece of paper and a wireless swiper is an apparently simple way of interrelating the use of a mundane object, paper, with an apparently complex one, a computer. The technical solution, however, is not that simple, requiring innovative developments in organic chemistry, printing processes and device design, drawing on resources not usually considered in ubiquitous computing, HCI and CSCW. Perhaps unusually a rather specific observation made about everyday conduct with a mundane artefact seemed to offer a way of resolving what seemed an intractable problem: how to design a device that could detect very low electronic signals printed on a paper substrate. The observation that writing is a two-handed activity offered both a way of solving a technical problem but also making the device simpler.

This observation has proved to be surprisingly robust, given the activity undertaken, swiping, is quite different to writing; being more transient and not needing to be so precise. However, where the use of the technology does become more problematic, is when we consider the use of the artefact in concert with other devices and in collaboration with other people. By developing the technology and undertaking a naturalistic experiment we find working with pen and paper to be even more complex than we have previously considered. An apparently simple action on the page may be segmented into different components but might also be produced collaboratively, from moment-to-moment in interaction with others. It is with little doubt that naturalistic observations of everyday conduct, whether this is with mundane technologies or complex ones, can be useful for design, but in seeking to enhance mundane objects we may have to understand the behaviour with and around them in much finer detail. We need to consider how even the simplest of actions with mundane artefacts are articulated with regard to local circumstances and are shaped by the conduct of others. Such analysis may have implications for design but also suggest how we might enhance and transform the methods we utilise for understanding everyday, mundane behaviour.

7. REFERENCES

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