Human Hands as a Link between Physical and Virtual

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INTRODUCTION

Money in my wallet means that it is my money. Exactly the same money in your wallet would mean that it is your money. The location of artefacts sometimes determines very important properties of the artefacts themselves, properties that until recently have been very hard for computer systems to capture. Since humans are still performing many tasks in the physical world, often involving the change of an artefact's physical location, the inability of computer systems to support and be aware of these activities is a weakness.

Merging the Physical and Virtual

This weakness becomes even more evident when studying activities in knowledge work environments such as offices where humans continuously alternate between activities in the physical and the virtual environment. Although humans might consider work objects like documents as the same artefact no matter physical or virtual, there is currently very weak *technological* support for establishing and maintaining such views. This lack of support manifests a physical-virtual environment gap that in various ways decreases productivity[1], forcing knowledge workers to either conceptually merge the two environments in their heads rather than with their hands, or, to bridge the gap by explicit actions like for instance re-typing parts of a received fax which should be e-mailed to a third person.

Physical-Virtual Artefacts

As designers of knowledge work environments, in our research group we address the problem of bridging the physical-virtual environment gap problem by developing physical-virtual artefacts (PVA). [7]

Definition: A physical-virtual artefact is an abstract artefact that (1) is instantiated in both the physical and virtual environment, where (2) these instantiations to a large extent utilize the unique affordances and constraints that the two different environments facilitate, and finally (3) where one instantiation of a specific physical-virtual artefact is easily identified if an equivalent instantiation in the other environment is known.

1. Although hard to measure, the extent of the physical-virtual environment gap is currently investigated in a field study of knowledge workers in Swedish industry.

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In contrast to many other Augmented Reality approaches for bridging the gap, it is not based on visual integration but on plain machine-supported linking of artefact instantiations in the two different environments.

VISION

We are envisioning a future where physical and virtual artefacts are strongly intertwined and where an increased number of physical actions can be used implicitly or explicitly to perform tasks that today call for "purely virtual activities" through a few designated input devices like keyboards and mice. Eventually, technology decreasing the gap will also give rise to integrated physical-virtual activities that have no correspondence to activities existing today.

Tracking Position of All Artefacts, Always, Worldwide

Ambitious as it might seem, we believe that it could be economically and technically possible to track everything, always and everywhere, with certain reservations of course. On the simplified assumption that artefacts don't move unless *moved* by human hands, all that is needed is to track hand movements and identify artefacts that are picked up/held/dropped along the way.

For several reasons, society, industry and technology is yet not ready for a universal tracking system such as this. In the mean time, we intend to investigate the same object tracking approach but on a smaller scale (see Figure 1).

MAGIC TOUCH

Partially illustrated in Figure 2, Magic Touch consists of (1) an office environment containing tagged artefacts, (2) wearable wireless tag readers, placed on each of the user's hands, identifying any tagged artefact the user takes in her/his hand, and (3) a wireless location transmitter always aware of the positions of the user's hands. A system component not shown is (4) the PVA database linking PVA-instantiations together.

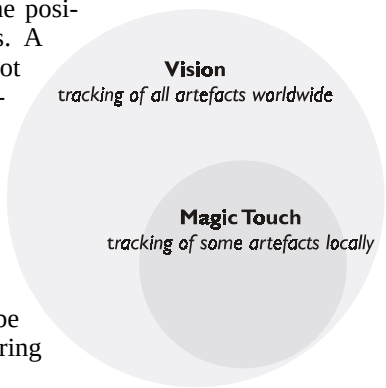

Figure 1: *The Magic Touch system in relationship to the vision.*

Some limitations

- All artefacts that are to be tracked have to be tagged.
- Artefacts are only to be moved by hands wearing tag readers.
- Users move only one artefact at a time.

- The position of an artefact is based on the tag position, i.e. one point in space. For large artefacts this is imprecise.

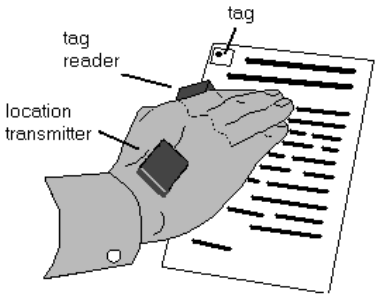

Figure 2: *One of the user's hands holding a tagged paper document.*

USER MODELLING

Apart from the fact that the proposed system could serve as a tool for researchers interested in physical behaviour of office people, *automatised* user modelling could of course be used to enhance the performance of the system itself. We believe that the system can extend the set of possible activities to be modelled.

SOME APPLICATION IDEAS

- A Physical-virtual (PV) search engine enabling search for both virtual and physical artefact instantiations.
- A PV mail box handling both physical and virtual mail.
- A PV paper basket handling and synchronising the discarding of PV documents.
- Tele-presence. By visualising the PVA database and enabling the access to the visualisation through the Internet, users can visit Virtual Reality versions of physical offices.
- PV containers. Physical instantiations of PV containers (e.g. document folders) can be linked to sets of virtual artefact instantiations and vice versa, making it possible to "keep" both physical and virtual artefact instantiations in the same container, physical or virtual.
- PV Stacks. The user can explicitly define, or the system can implicitly infer (see the previous section) stacks or piles of artefacts that can later be referred to as a physical instantiation of a PV container.
- Active volumes — physical space that the user explicitly has assigned some "meaning". The user could for instance define one part of the physical desktop as being a mail outbox or a paper basket.
- "Magic memory" allowing backtracking of past user actions, and limited UNDO facilities.
- "Virtually filled" physical artefact instantiations. If the proposed system is combined with a motion tracked Head Mounted Display (HMD), users can handle blank papers while the actual paper contents is projected virtually.

RELATED WORK

Seeing Wellner's DigitalDesk [9] as a starting point, there has been a continuous interest in merging the physical and virtual worlds in office environments and in more specialised settings [1, 5]. Compared to the DigitalDesk, the proposed system Magic Touch covers a whole office rather than a desk. More recent sources of inspiration to the present work have been the research done on Graspable [2], Tangible [4] and Manipulative User Interfaces [3]. One major difference between these systems and the proposed one regards how or rather *where* the physical artefacts (common terms are "Bricks", "mediaBlocks" or "Phicons") are identified. While in the former systems they are identified by tag readers mounted on a set of designated "physical-virtual docking stations", the number of tag readers needed in Magic Touch is never more than two, both attached as wearable wireless devices on the user's hands. The support for searching artefacts in physical environments, which is one of the possible applications of the proposed system, has some similarities with the InfoClip [6] solution. However, InfoClip does not involve any centralised knowledge database for where artefacts are located. The advantage of using RF/ID tags for our kind of application instead of other tag solutions like bar-codes is thoroughly discussed by Want et al. [8].

CURRENT DEVELOPMENT STATUS

A wearable wireless radio-based (RF/ID) tag reader is being developed at the time of writing. A complete Magic Touch physical-virtual knowledge work environment including a wireless motion tracker and a local PVA-DBMS is planned to be set up and developed during spring 2000. Evaluation is planned to take place during autumn 2000.

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