Magic Touch — A Simple Object Location Tracking System Enabling Physical-Virtual Artefacts in Office Environments

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ABSTRACT

This video demonstration illustrates a method for tracking location changes of large sets of real-world objects unobtrusively and cost-effectively based on the assumption that all object movements are caused by users themselves, and can be tracked using wearable sensor technology placed on human hands.

Keywords

Ubiquitous Computing, Context Awareness, Tangible User Interfaces, Augmented Reality, Wearable Computers.

1. TRACKING OBJECTS

Although the information gathered about human activity is limited by tracking location changes of objects only, we believe that it is a good starting point for further improvements.

1.1. Some Available Technology and Methods

One obvious solution is to let all objects in the environment carry position transmitters, giving both parameters accurately and continuously. Drawbacks are that the system is expensive if you want to track many objects, and the identification tags can be fairly large. Another method is to put a camera in the ceiling and to attach visual tags onto the objects. These tags and their location are interpreted and calculated through analysis of the camera image [8]. In this case the tags are considerably cheaper compared to the other approach since it is possible to print them out on an ordinary printer. Drawbacks include the necessity of free line-of-sight between the camera and the tagged objects and that the tags themselves could become fairly large when tracking many objects.

2. A MORE INDIRECT METHOD

While searching for a suitable tracking method we discovered that objects in office environments move only when they are moved by users' hands. Based on this insight, we developed another object location tracking method which at least for our purposes is more suitable than the other two mentioned tracking approaches.

As illustrated in Figure 1, the object location tracking system consists of (1) an office environment containing RF/ID- tagged artefacts, (2) wearable tag readers, placed on each of the user's hands, identifying any tagged object the user takes in her/his hand, and (3) a location transmitter always aware of the positions of the user's hands. The advantage of using RF/ID tags for our kind of application instead of other similar solutions like bar-codes is thoroughly discussed by Want et al. [10].

As soon as the user's hand comes close to a tagged object, it is identified. If the user moves her/his hand and the reader still can read the tag it means that the user has grabbed the tagged object. When the tag is no longer readable, the user must have dropped the object, and the location of the user's hand at the point when the tag was last readable is regarded as the new location of the object.

2.1. Most Evident Limitations

- All objects that are to be tracked have to be tagged.
- No tagged object is allowed to change its position on its own.
- The user does not drop an artefact “in the air”. If so, the system will store an incorrect height location.
- The user moves only one artefact at a time unless object collections are placed in designated container objects first.
- The user always moves artefacts directly with the hands and does not use arbitrary tools to push or carry the artefacts
- Only users that carry the wearable system equipment are allowed to move artefacts in the environment.
- To treat tag position as object position is a reasonable approximation only for small objects.

3. PHYSICAL SPACE MODEL

The system maintains a structural model of the physical environment based on containment relationships between “active volumes” defined by the user: invisible boxes aligned with real-world entities (such as bookshelves; desktops; drawers) that potentially can hold the objects of interest. Additionally, the system recognises explicit and implicit grouping of physical objects through tagged containers and object piles.

4. PHYSICAL-VIRTUAL ARTEFACTS

The main purpose of the system is to provide an infrastructure for creation and maintenance of Physical-Virtual Artefacts (PVAs): objects that have a representation in both the physical and the virtual worlds having the potential of bridging the gap between the physical and the virtual world [6]. Currently, only basic manipulation of physical PVA manifestations (e.g. paper documents) is captured and mediated to the virtual world but more advanced

PVA synchronisation is planned using "electronic ink" and handwriting tracking technology.

5. ADDED-VALUE FUNCTIONALITY

The system provides added-value functionalities to users based on the PVA infrastructure such as:

- the possibility of locating PVAs if the corresponding PVA is identified (e.g. finding out where that old report ended up),
- the possibility of automatic retrieval of corresponding PVAs if the PVA is indicated by the human agent (e.g. to view additional information about the coffee cup by putting it in the dedicated PVA inspection area of the desktop),
- and the possibility of visualizing the monitored physical environment as hierarchies allowing a view of the physical space from an alternative perspective.

6. RELATED WORK

Since Wellner's DigitalDesk [11] there has been a continuous interest in merging the physical and virtual worlds in office environments and in more specialised settings, e. g. [1, 5]. Compared to the DigitalDesk, the proposed system covers a whole office rather than a desk. More recent sources of inspiration to the present work have been work 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 objects (common terms are "Bricks", "mediaBlocks" or "Phicons") are identified. While in the former systems they are identified by tag readers mounted on 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. This difference also holds for Want et al. [10] where they, although using RF/ID tags, attach the readers on portable computing devices rather than hands and furthermore don't combine the identification mechanism with motion tracking of these devices as in Magic Touch. Schmidt et al. [9] place an RF/ID reader on the hand but without tracking the location of it.

7. CONCLUSIONS

By tracking simple office actions like the changing of artefacts' locations we believe that we can integrate and enrich the working environment as a whole. By tracking user hands only, and by tagging physical objects, the system potentially becomes more affordable than systems based on other known approaches.

8. ACKNOWLEDGMENTS

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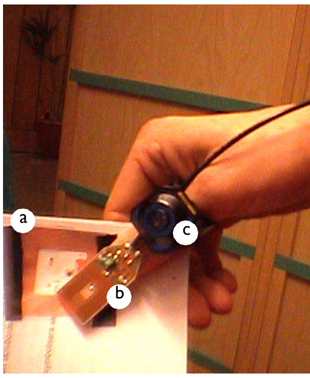

Fig. 1. Magic Touch PVA Manipulation Tracker v.0.51 in action. The photo shows (a) an RF/ID tag attached to a paper document, (b) a stiff antenna, and (c) position transmitter [7]

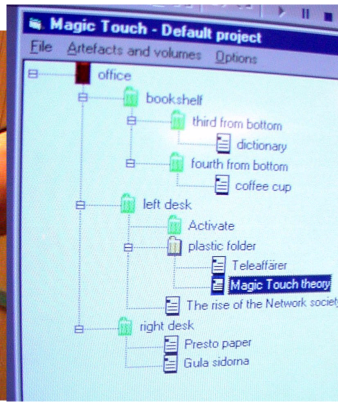

Fig. 2. Parts of the PVA Configuration UI of Magic Touch 1.0 showing a hierarchical virtual representation of objects in a physical environment based on containment relationships [6]

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