Egocentric Interaction

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ABSTRACT

This position paper for the CHI2006 workshop "What is the Next Generation of Human-Computer Interaction?" presents our emerging conceptual framework for modelling and designing everyday activity support systems. The proposed framework is based on the assumption that a suitable wearable computing and sensing platform will be feasable in 5-10 years from now.

INTRODUCTION

Looking back on the HCI work made during the period 1950-1975 and comparing it to the work performed during the 25 years after that it seems that while the first period was about finding and defining a working interaction paradigm for non-specialist computer use, the past 25 years has mainly been about polishing it. Why it is so is of course an open question. From a more balanced and less cynical viewpoint one might say that the reason that PC/WIMP is still the ruling computing paradigm is because all other tried alternatives (although few have actually been proposed) have been less suitable for the tasks at hand. The PC/WIMP paradigm was simply a great design from the start. Another reason might be that there has been no series of inventions in the field of electronics (corresponding to the ones in the early days) that could inspire new ways of interaction. Another important factor is the enormous "paradigm polishing" industry that has evolved during the mentioned time period and doing everything it can in order to ensure that the (for them) very lucrative paradigm stays.

The end of the PC/WIMP polishing era?

Although the PC/WIMP interaction paradigm probably will continue to be the focus for the major part of the HCI community for another few years, recent advances in hardware technology and standardisation (in particular electronics miniaturisation, battery improvements, new sensor technology, and ubiquitous wireless network access) might soon trigger a paradigm shift just similar to how in the past the electronics development played an important role in determining the interaction paradigm of the early days of HCI research.

In fact, as portable/wearable computers, wireless networks and the new possibilities for making computers aware of events in the physical world emerged during the 1990's, a growing number of academics within the HCI community left their "paradigm polishing" activities and began searching for an interaction paradigm that could better embrace the interaction possibilities enabled by this new hardware. Meanwhile, the established PC industry of course has continued to push for the use of the PC/WIMP paradigm also in this new technological context.

If the state-of the art hardware technology of today is enough for driving the paradigm shift, or if one or two more electronics inventions have to arrive first, is an open question. The increased interest in alternative interaction devices is an indication that the shift is at least approaching. There is of course also a slight possibility that the existing WIMP paradigm could be adapted and work well enough also for controlling computing in the new technological and social context as well. It is however unlikely, considering the basic assumptions of the WIMP paradigm such as

- the assumption that the human agent can dedicate all attention to the interaction with the virtual environment provided by the computer (e.g. does not bike or drive a car)
- the assumption that the real world environment in which the interaction takes place is always the same (quiet, in the shadow, etc.)
- the assumption that input and output devices are few, and the same, at all times (i.e. screen, keyboard, and mouse)

As acknowledged widely by researchers in proactive HCI areas (e.g. Augmented/Mixed Reality, Ubiquitous/Pervasive Computing, Graspable/Tangible User Interfaces, Wearable Computing, and Context Awareness) these assumptions do in general not hold, or severely limit interaction possibilities, in non-WIMP paradigm contexts.

EGOCENTRIC INTERACTION CORNER STONES

Our general aim is to design computer systems that facilitate everyday activities no matter if they take place in the physical world, the virtual world (mediated by some interactive computing device) or — which we believe will become increasingly common in the future — somewhere inbetween (Pederson, 2003). The technology advancements and increased interest in sensing and actuation technologies throughout the past 15 years makes this aim not only an

interesting academical challenge but also a realistic one from a more pragmatical perspective.

The egocentric view on interaction we propose differs from more classical HCI models by building on the following corner stones:

1. **A physical-virtual design perspective.** Objects of interest to a particular human agent are modelled uniformly no matter if manifested in physical space, virtual space, or physical-virtual space.

2. **One human, no user interface.** Focus is on interaction between a single human agent and objects of interest to that human agent, specifically ignoring infrastructure that mediates virtual objects, such as personal computers.

3. **Strengthening connections between physical and virtual artefacts.** Focus is on the role of potentially automatic interplay between a) physical and virtual objects [residing in] b) physical and virtual environments [making up] c) the physical and the virtual world.

4. **"Applications" emerging by doing.** Modelled and infrastructurally supported physical-virtual environments ("applications") are just as likely to emerge through everyday egocentric interaction by specific human agents, as being pre-defined by external physical-virtual environment designers.

5. **Support for living rather than just work activities.** The aim is to support personal everyday activity 24 hours, 7 days a week, without drawing the classical border between work and leasure, home and out.

The term 'egocentric' has been chosen to signal that it is the human body and mind of a specific human individual that (sometimes literally) acts as a centre of reference to which all interaction modelling and activity support is anchored.

Motivation for Corner Stones 1 & 2

What matters for human agents when manipulating objects for the purpose of performing well-known activities is the changes made to objects of interest (henceforth called *domain* objects), whether it is about calculating next years project budget in a spreadsheet application or knitting a pullover. What does *not* matter is the way the domain objects are accessed. E.g., expert PC users do not have to pay attention to how the physical mouse corresponds to the virtual arrow. Instead, they pay attention to the effects of their virtual activities as if they were inside the virtual environment themselves. Dragging a virtual document to the virtual trash can is as natural as throwing the corresponding paper document in the physical trash can below the desk. Based on observations such as these, the physical-virtual design perspective [2] suggests that physical and virtual domain objects should be as central for physical-virtual designers as they are for the users of those designs and that many classical HCI user interface concerns are of less importance if not completely ignorable.

Motivation for 3

One dimenson of the physical-virtual gap has to do with the lack of causality crossing the divide [2] . State changes of an object in the physical world typically does not have any effect on a corresponding object in the virtual world, or vice versa. Infrastructure keeping corresponding physical and virtual artefacts in synch would bring the two worlds closer to each other.

Motivation for 4 & 5

The space of possible activities is much larger in the physical (real) world compared to in the virtual world. It is harder as environment designer to have detailed control over human activity (and the way it is performed) in the physical world compared to the almost complete control offered when designing environments and behaviour in the virtual world.

The dynamics of "physical-virtual applications" caused by the extreme mobility (in physical space) of virtual environments, compared to the immobility of physical environments. The extreme mobility of virtual environments, paired with ever cheaper virtual environment providers (computing devices) makes it technically possible to provide virtual environments in almost any physical situation, not just the typical office setting. Thus, the design space for activity support more or less automatically expands from classical work settings to include just about any kind of human activity thinkable.

THE PHYSICAL-VIRTUAL DESIGN PERSPECTIVE

Computers, embedded in the "background" as well as more obtrusive artefacts (e.g. PCs, PDAs, cellular phones), play an increasingly important role in human activity. However, there are still things that most people would prefer to do "off-screen" in the physical (real) world, such as having parties, reading long text documents, or spending vacation. I argue that there exists a class of activities that are neither physical or virtual, but "physical-virtual" [2]. People frequently do parts of an activity in the physical world (e.g. proof-reading a text document under construction) and parts in the virtual world (e.g. adjusting paragraphs within "the same" document in a word processing environment). This behaviour is likely to become more common. Hence, future environments should be designed with such *physical-virtual activities* in mind.

The Classical User Interface Can Be Ignored

The proposed physical-virtual perspective is a way to deal with the gap between the physical and the virtual world[1], and to facilitate the exploration of designing information technology for helping human agents bridging it. The assumption is that a reduced physical-virtual gap means less "friction" for physical-virtual activities. Physical and virtual space is modelled together, and automatic mechanisms for synchronising related phenomena in both worlds are imagined to be offered by systems that have been developed with the physical-virtual perspective in mind. By viewing the physical and virtual worlds as one, we believe the chance to *make* them one increases.

Adopting the physical-virtual perspective involves abstracting away the classical HCI concepts of input and output devices, giving them a background role as Inter-World Event Mediators (IWEMs). Fig. 1 and 2 illustrate the basic

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1. Dimensions of the gap between the physical and virtual worlds are explored in [2].

cases of physical and virtual human action (object manipulation). IWEMs are shown as white squares.
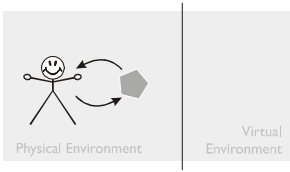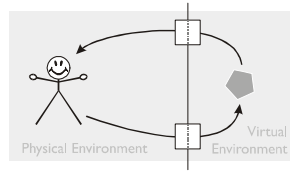

Fig. 1. Physical action [2]

Fig. 2. Virtual action [2]

In order to arrive at a definition of physical-virtual activity I have found it useful to define human border-bridging activity on a lower level of abstraction first:

Definition 1: A *physical-virtual action pair* consists of two actions belonging to the same activity and often time-wise adjacent, where the first action is constrained (by lack of action support in the current environment) or chosen (e.g. based on individual preferences) to be performed in the physical world and the other action is constrained/chosen to be performed in the virtual world, or vice versa. [2]

Physical-Virtual Artefacts

Among physical-virtual action pairs we can sometimes identify one or several information-mediating objects that are subject to indirect or direct human manipulation in *both* actions, objects that transcend the physical-virtual border by being present in both worlds. Such objects are referred to as *Physical-Virtual Artefacts* (PVAs) and for denoting the presentations of them in the two different worlds, the term PVA *manifestation* is used. A text document presented in both the physical (e.g. printed on paper) and the virtual world (e.g. within a word processing environment) would serve as a good example of a PVA, where each manifestation affords different kinds of manipulation.

Definition 2: A *physical-virtual action* is an action on a PVA where both the physical and virtual manifestations are directly controlled and/or monitored by the agent. [2]
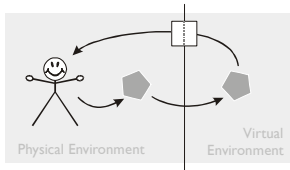

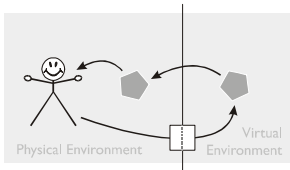**Fig. 3.** Physical→ virtual action [2]

Fig. 4. Virtual→physical action [2]

Fig. 3 and 4 illustrate two possible kinds of physical-virtual actions. Finally, the concept of physical-virtual activity is defined as follows:

Definition 3: A *physical-virtual activity* is an activity consisting of a sequence of actions containing a) at least one physical-virtual action pair or b) at least one physical-virtual action. [2]

One Space, One Magnifying Glass

By viewing the physical and the virtual worlds as equally important for human activity, the proposed physical-virtual perspective makes terms tied to an implicit virtual-world bias such as "context awareness" obsolete. It also expands the meaning of "location tracking" (currently having an implicit physical-world bias) to include also space and place in the virtual world. It invites the viewing of the relationship between physical and virtual environments from unconventional angles. For instance, why should not the current (local) state of the virtual world influence how activity in the physical world is interpreted? Could it not be of use for physical-world "applications" to be aware of their virtual-world context? And why is virtual-world location tracking (e.g. web pages browsed by a human agent) not considered when designing interactive environments?

EGOCENTRIC INTERACTION

The egocentric interaction perspective is based on a situative model of what a specific human agent can see and not see, reach and not reach at any given moment in time (Fig. 5). The model is based on the physical-virtual design per-
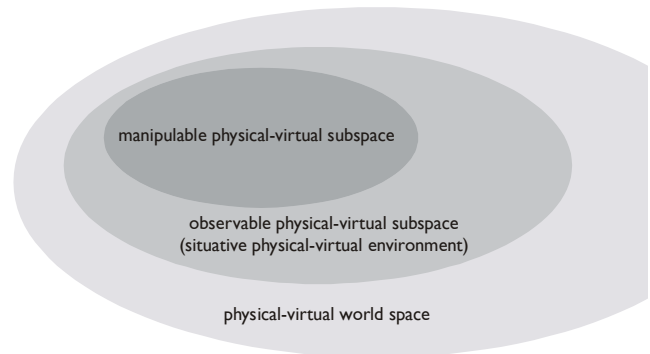

Fig. 5. A situative physical-virtual space model [2].

spective briefly outlined in the previous section. Thus, physical and virtual domain objects are treated as being located in the same space. As a specific human agent changes physical and/or virtual location, objects come into and leave the observable physical-virtual subspace in a dynamic fashion. Somewhat simplified, one can say that it is the borders of the observable subspace which defines the set of objects that can possibly be part of a physical-virtual "application" at any given time-instant for the specific human agent.

The idea of using computers for assisting individual human agents in everyday life is not new but has gotten increased relevance in the last 5-10 years because of increased capacity of mobile and wearable devices. One example is the research performed at Georgia Tech investigating the possibilities in creating an always present, context- aware "digital assistant" [6]. The egocentric view differs from their and most other similar "intelligent assistant" approaches, by focusing on detecting presence of physical (and virtual) objects rather than places or persons, for detecting and contextualizing human activity. The approaches are, of course, complementary in this respect. However, as mentioned earlier, by taking a world-neutral physical-virtual design stance, the egocentric view on interaction differs from most existing HCI modelling approaches by not seeing the state of the real world as merely *context* to virtual activity but an *inseparable part* of it.

Computing Infrastructure for Egocentric Interaction

The egocentric approach follows the current HCI trend, breaking with classical Task Analysis that assume human agents to perform all actions based on rational decisions for reaching well-defined goals most efficiently. Egocentric

computing systems do not necessarily have to actually *know* what the modelled activity is about but rather what the human agent seems to need (in time and space) in order to perform it, mainly based on historical data of object use. Thus, *emerging* individualised physical-virtual "applications" rather than traditional *pre-defined* general-purpose ditto designed by application designers.

Being a relatively abstract perspective on future HCI, the egocentric view does not assume the use of any particular kind of technology for supporting interaction between the human agent and the physical-virtual world. For instance, computing and sensing technology for tracking physical activity of a specific human agent could be imagined to be either worn by the human agent herself, or be situated in the surrounding physical environment. The same goes for virtual environment providers (computing devices providing access to the virtual world) which could be both worn by their user or ubiquitously distributed throughout the physical environment like in Mark Weiser's vision [7].

For reasons of privacy, efficiency, design complexity, feasibility, and cost, we have found an implementation approach based on wearable sensing and computing power most attractive. The basic idea is to make the wearable egocentric computing system as self-sufficient as possible, reducing the problem of "uneven conditioning" [4]. Information about activities perfomed using devices external to the wearable egocentric interaction system (e.g. in the case when the human agent is using a desktop PC) need to be transmitted through some standard wireless commmunication protocol to the wearable egocentric interaction device for analysis. Complemented with real-world object manipulation information from sensors, the egocentric interaction system would (at least in theory) be able to gracefully model activities across the physical-virtual gap.

As an example of a useful application, wearable egocentric interaction technology has the potential of ensuring that human agents always have the necessary physical and virtual objects at hand for successfully performing the activities they like to. Such systems can act in the conscious "foreground", reminding the wearer to bring this or that physical object along when changing physical location, or in the "background" by setting up physical-virtual environments prior to the human agent's arrival, making the emerging physical-virtual world a slightly smoother place to be in.

APPLYING THE FRAMEWORK

As is common in the explorative branches of HCI, the interaction theory presented in this paper has been and will continue to be developed hand in hand with prototype systems. The aspects of the egocentric interaction framework related to the physical-virtual design perspective have inspired and been inspired by the development of the Magic Touch system [3; 1] which among other things provided limited support for end-user design of Physical-Virtual Artefacts based on wearable position and object identification sensors.

easyADL

A more extensive application of the egocentric interaction framework is currently undertaken within the easyADL project where the focus lies on recognition and support of everyday activities based on the situative physical-virtual space model (Fig. 5). easyADL is a two-year research project started in June 2005 investigating new forms of computer technology for facilitating everyday life of individuals suffering dementia disease[1]. The goal is to develop a wearable computer-based "cognitive prosthesis" which to some extent could compensate for mild cognitive impairments when performing everyday tasks such as getting dressed, preparing dinner, and going to the bathroom.

In order to speed up the design process, and in order to compensate for limitations with currently available sensing technologies, Virtual Reality models are used to simulate wearable real-world sensors, feeding "clean" data to the activity modelling algorithms under investigation. The method also facilitates the experimentation and comparison between different wearable sensor configurations for successful recognition of activities based on a set of objects nearby and/or manipulated by the human agent within a given time span.

CONCLUSION

This position paper has presented an everyday activity modelling framework (under development) based on automatic recognition of basic object manipulation performed by a specific human agent in a joint physical-virtual space.

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