# Proximity as Key Property in the Egocentric Interaction Paradigm

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## Abstract
In this workshop position paper we briefly discuss the relationship between proxemics and Human-Computer Interaction (HCI), highlighting the fact that the former has a focus on social aspects of human behaviour while the latter (traditionally) has not. We also present our own proximity-based framework intended to help in the design of future interactive Ubiquitous Computing systems that optimize the use of locally available computing and interaction resources on the basis of human perception and action capabilities.

## Proxemics in HCI
Apart from within some specialized fields related to HCI (e.g. ergonomics; telepresence), spatial relationships among and between human agents and objects of interest have traditionally not been a major concern for the community. This has gradually changed with for instance the disseminatron of 2D Graphical User Interfaces in the 80's (e.g. Fitts's law; information visualization); Virtual and Augmented Reality in the 90's; mobile wireless computing in the 2000's. Note how focus has expanded from dealing with sub-meter scale in virtual (digital) space to super-meter scale in physical (real world) space. In fact, the structure of the local Eucledian space around computing devices and their users has become a core design factor in what is considered by many as being the future of HCI: Mobile

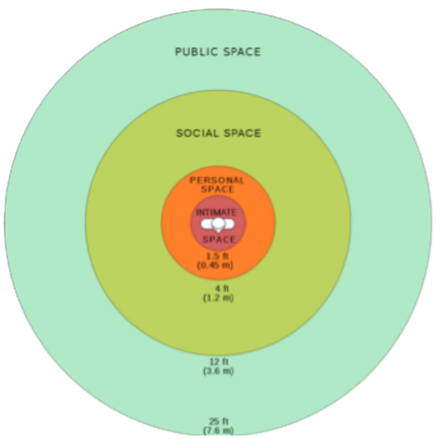
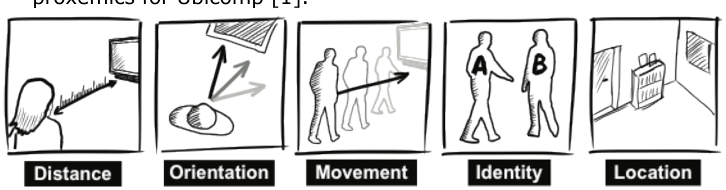



**Figure 1:** Hall's personal reaction bubbles [2].

**Figure 2:** The five dimensions of proxemics for Ubicomp [1].




and Ubiquitous Computing (Ubicomp). Tangible User Interfaces, Embodied Interaction, and Context-Aware Systems all represent and explore different aspects of this space. Yet, we are far from creating an overarching model for how future post-WIMP (Window, Icon, Menu, Pointing device) HCI dialogues should be influenced by properties of physical space.

Is proxemics [2] something we can learn from? Certainly. However, as always when borrowing terms from elsewhere, one needs to be aware of it's connotations. Hall coined and used the term primarily for describing social relationships. For some Ubicomp applications, i.e. those built to support collaborative activities or activities in public places, concepts from proxemics can probably be more or less directly transferred and used in system design. However, many Ubicomp efforts including most of what has been done within the field of context aware systems (e.g. multi-device user interfaces; location-based services) attempt to deal with aspects of physical space that have little or no direct association with social behaviour and more instead with trained and innate limitations of the single human body and mind. In other words, classical HCI design factors. For these systems, Hall's personal reaction bubbles model (see Fig. 1) will have less to say and we need to look elsewhere to define structures in space that can inform interaction design.

It is symptomatic that in the recent article by Greenberg et al. on the very potential use of proxemics in HCI [1], the examples used as illustrations are based on how human agent's perceive and act in physical environments largely *disregarding* social aspects (see Fig. 2)! When modeling this kind of applications, the term "proxemics" could be misleading and we should perhaps consider plain "proximity" until we find or define a better term for use in HCI. On the other hand, the benefit of using the term "proxemics" for describing our interaction design efforts could have the positive effect of increasing the focus on social aspects, something that is probably needed as digital computing continues to permeate our lives.

## Egocentric Interaction

In a short paper at NordiCHI 2010 [4], we listed five Ubicomp related aspects of HCI that have received increased attention in the past decade (see side bar) and which together point towards a new way of framing HCI, an emerging paradigm we refer to as Egocentric Interaction. Proximal relationship between human agent(s) and objects of interest (both physical and virtual) is at core in this interaction paradigm.

We have chosen the term "egocentric" to signal that it is the human body and mind of a specific human individual that (literally) acts as centre of reference to which all modeling is anchored in this interaction paradigm. In the context of this article, the term should not be taken as a synonym for "selfish" or other similar higher-level personality traits but instead as the lower-level approach which human agents in general are forced to adopt to perceive and act in the world based on their senses and cognitive abilities, even when working in groups and with shared goals.

The remaining parts of this position paper is a partial re-presentation of our NordiCHI 2010 short paper outlining an approach for modeling the physical space surrounding human agents, for better or worse, not on

**Egocentric Interaction [3]**

**1. Situatedness**: Acknowledges that the agent's bodily situation at each point in time determines what can be perceived as well as what can be performed.

**2. Attention to the complete local environment**: Makes it a point to consider the whole environment, not just a single artifact or system.

**3. The proximity principle**: Makes the assumption that proximity plays an important role in determining what can be done, what events signify, and what agents are up to.

**4. Changeability of environment and agent–environment relationship**: Takes into account agents' constant movements of head, hands, sense organs, and body, as well as agents' modifications of environment.

**5. The physical-virtual equity principle**: Both agent and system(s) pay attention and interact with both physical and virtual objects.

the basis of human social behaviour (proxemics) but on the limitations and capabilities of the human body and mind. It has been developed as a complement and reaction to the typical device-centric (as opposed to body-centric) context models proposed in the Ubicomp community for the past decade. Our model also differs from the majority of context models by striving for a common way of modeling both physical artefacts and virtual, avoiding any bias towards one or the other, with the motivation that human agents in the midst of activities have no problem seeing a mix of physical and virtual objects as belonging to the one and same environment and being potentially equally important for the task at hand.

## Achieving Physical-Virtual Equity

We believe the current physical-virtual gap [5] could be made easier to cross for human agents by introducing a mixed-reality infrastructure having an "interaction manager" as central component, responsible (in collaboration with the human agent) for channeling communication between human and system through the currently best available devices and modalities [5].

***Virtual Objects and Mediators instead of Interactive Devices***

Input and output devices can be viewed as *mediators* through which virtual objects are accessed. The purpose and function of mediators is that of expanding the action space and perception space of a given human agent (see Fig. 3).

*Action and Perception instead of Input and Output*

In the egocentric interaction paradigm, the modeled human individual needs to be viewed as an agent that can move about in a mixed-reality environment, not as a "user" performing a dialogue with a computer. If we take the physical-virtual equity principle seriously, also the classical HCI concepts of input and output need to be reconsidered. We suggest substituting the concepts of (device) "input" and "output" with (human agent) "action" and "perception". Note that we see object manipulation and perception as processes that can take place in any modality: tactile, visual, aural, etc.

## A Situative Space Model

The situative space model (SSM) is intended to capture what a specific human agent can perceive and not perceive, reach and not reach, at any given moment in time. This model is for the emerging egocentric interaction paradigm what the virtual desktop is for the PC/WIMP (Window, Icon, Menu, Pointing device) interaction paradigm: more or less everything of interest to a specific human agent is assumed to, and supposed to, happen here.

*Main Components of the Model*

The following definitions are agent centered but not subjective; they are principally aimed at allowing objective determination for automated tracking purposes. A more extensive description of the model can be found in [3].

**World Space (WS):** A space containing the set of all physical and virtual objects to be part of a specific model.

**Perception Space (PS):** The part of the space around the agent that can be perceived at each moment. Like all the spaces and sets defined below, it is agent-centered, varying continuously with the agent's movements of body and body parts. Different senses have differently shaped PS, with different operating

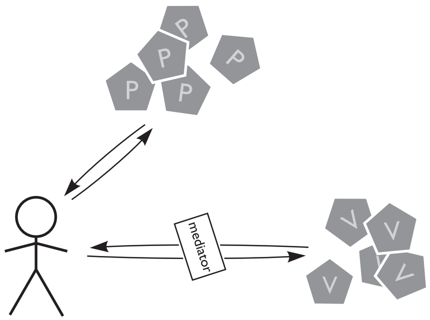



**Figure 3:** A human agent interacts with physical and virtual objects in the course of an activity. Virtual objects are manipulated and perceived through mediators.

requirements, range, and spatial and directional resolution with regard to the perceived sources of the sense data. Compare vision and hearing, e.g.

Within PS, an object may be too far away to be possible to recognize and identify. As the agent and the object come closer to each other (either by object movement, agent movement, or both) the agent will be able to identify it as X, where X is a certain *type* of object, or possibly a unique individual. For each type X, the predicate "perceptible-as-X" will cut out a sector of PS, the distance to the farthest part of which will be called *recognition distance*.

**Recognizable Set (RS):** The set of objects currently within PS that are within their recognition distances.

The kind of object types we are particularly interested in here are object types that can be directly associated with activities of the agent – ongoing activities, and activities potentially interesting to start up – which is related to what in folk-taxonomy studies is known as the basic level [6].

To perceive the status of a designed object with regard to its relevant (perceivable) states (operations and functions as defined by the designer of the artifact) it will often have to be closer to the agent than its recognition distance: the outer limit will be called *examination distance*.

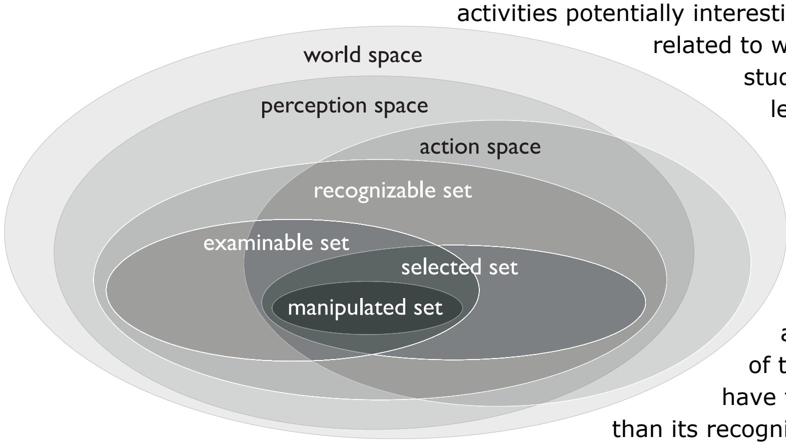



**Figure 4:** The Situative Space Model [6].

**Examinable Set (ES):** The set of objects currently within PS that are within their examination distances.

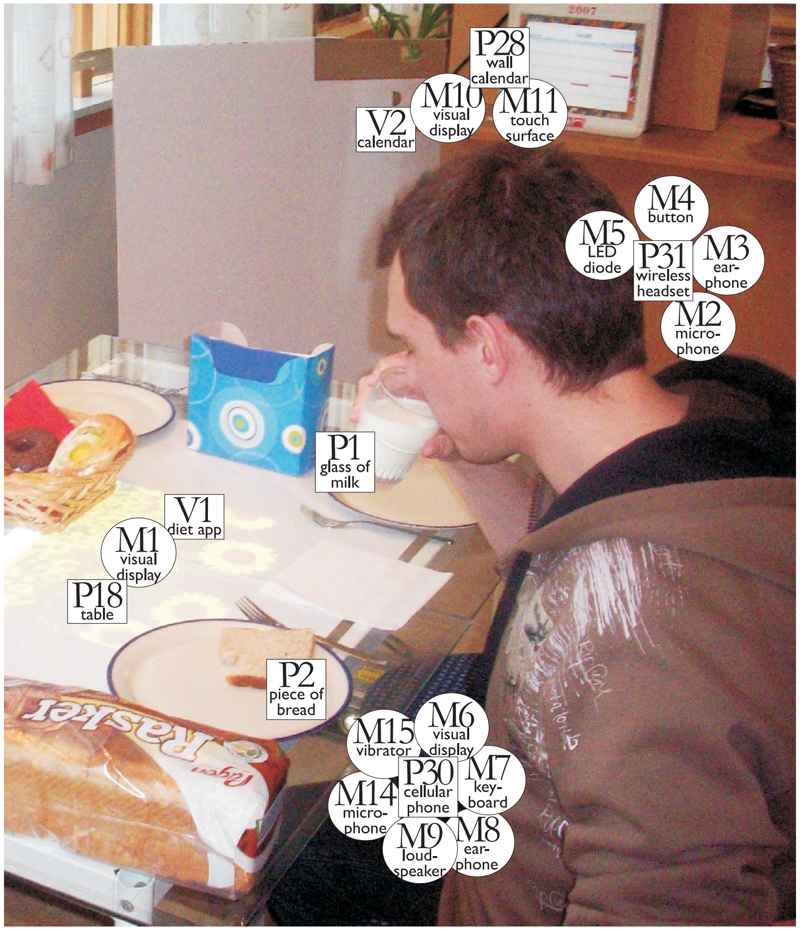
**Action Space (AS):** The part of the space around the agent that is currently accessible to the agent's physical actions. Objects within this space can be directly acted on. The outer range limit is less dependent on object type than PS, RS and ES, and is basically determined by the physical reach of the agent, but obviously depends qualitatively also on the type of action and the physical properties of objects involved; e.g., an object may be too heavy to handle with outstretched arms. Since many actions require perception to be efficient or even effective at all, AS is qualitatively affected also by the current shape of PS.

From the point of view of what can be relatively easily automatically tracked on a finer time scale, it will be useful to introduce a couple of narrowly focused and highly dynamic sets within AS (real and mediated).

**Selected Set (SdS):** The set of objects currently being physically or virtually handled (touched, gripped; or selected in the virtual sense) by the agent.

**Manipulated Set (MdS):** The set of objects whose states (external as well as internal) are currently in the process of being changed by the agent.

All these spaces and sets, with the obvious exception of the SdS and the MdS, primarily provide data on what is *potentially* involved in the agent's current activities. Cf. the virtual desktop in the WIMP interaction paradigm.



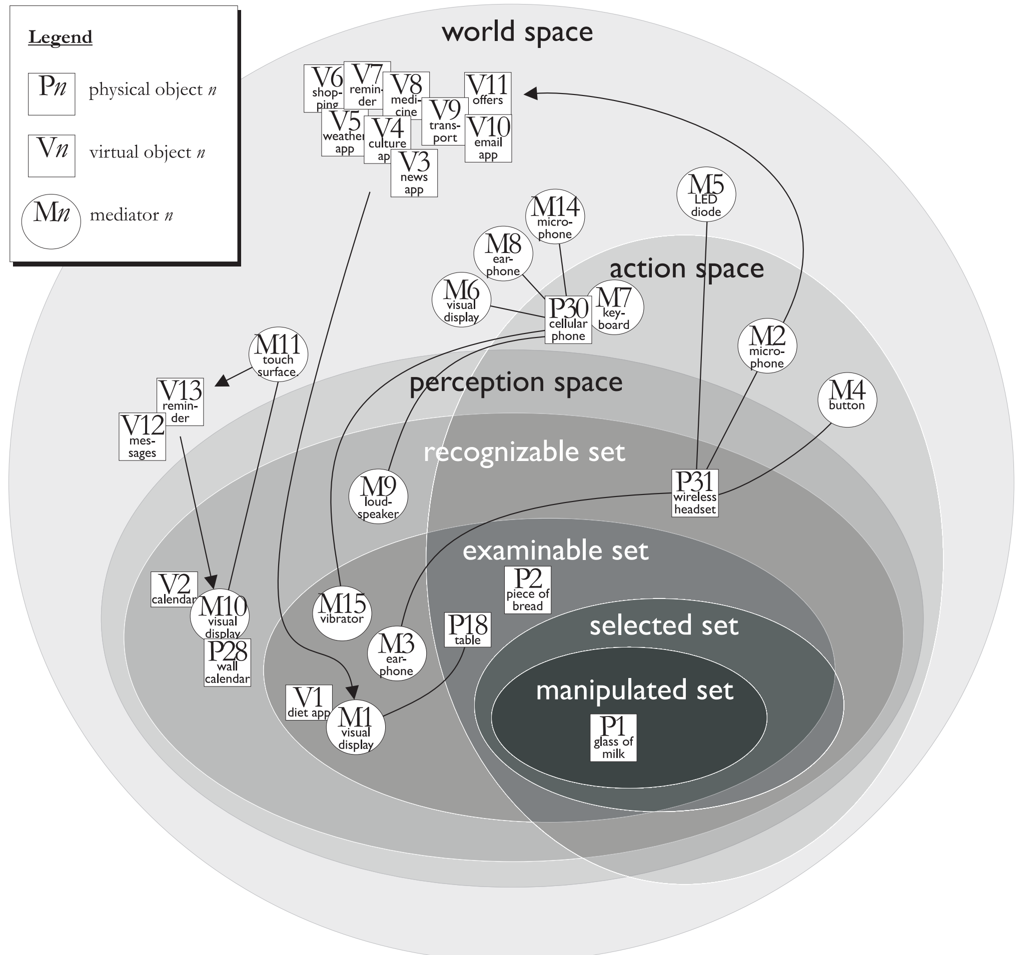




**Figure 5 (above):** Human agent O having breakfast in a mixed-reality environment.

**Figure 6 (upper right)**: The breakfast situation of Fig. 5 as viewed through the situative space model. Some virtual objects (V3-V13) not visible in Fig. 2 are shown here in the world space, ready to be made accessible to agent O through mediators in the perception and action spaces. Some potential flows of interaction – specifically, manipulation of virtual objects and perception of the results – are illustrated by arrows. [5]

## Example Situation: Having Breakfast

This section demonstrates the use of the SSM as a tool for analysis with the aim of identifying mediators suitable for HCI. The human agent O sits down at the kitchen table (P18) in order to have breakfast. The kitchen table is fitted with a visual display (M1) in the centre of the tabletop. In his pocket he has a cellular phone (P30) and on his right ear a wireless headset (P31). A wall calendar (P28) two meters away has an embedded touch screen (M10, M11). Various software applications (V1-V10) are running on a server ready to interact with agent O through these mediators. Fig. 5 illustrates this scenario with the mediators and a few objects highlighted. Fig. 6 shows the situative space model applied to the same situation. For a detailed account of this situation we refer to [3].

## Use of the Framework and Model

The egocentric perspective on HCI has enabled us to approach a recent design task (prototyping a wearable device offering everyday activity support for people suffering early dementia) in a very different way compared to if we would have taken a device-centric approach [7]. The situative space model (SSM) has proven both to be useful for activity recognition [8] and for providing data to a multimodal interaction manager in an intelligent home application [7]. As real-world sensing technology matures (e.g. allowing for accurate capturing of eye-gaze, body posture, and detailed object manipulation) we believe the SSM will become an increasingly powerful tool and system component.

## Conclusions and Future Work

We have briefly presented some characteristics of an emerging egocentric interaction paradigm and our approach in designing for it based on a situative space model. Future practical efforts include the improvement of our current real-world sensor infrastructure (for details, see [3]) as well as expanding the model to more explicitly cover collaborative activities.

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