Olfactory Interaction Zones

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Abstract. Spontaneous interaction among humans and things in pervasive computing systems is often based on the spatial outreach to which an entity can interact with another entity, often referred to as "zone of interaction". Usually technological sensors for proximity and distance, like radio, ultrasound or microwave, are used to perceive and track the presence, activity and utterance of entities in the vicinity. This paper proposes the exploitation of the "natural" zone of interaction based on the dispersed odor of entities. Much like the emission of radio signals with spatial decay from the center of radiation, the evaporation of natural (perspiration) or artificial (perfume) odors spawn spatial zones of interaction with spatial, but also temporal decay. Gas sensors or electronic noses can serve as the technological means for the olfactory perception of zones of interaction. We introduce "Olfactory Interaction Zones" and outline how olfactory perception enriches the design space for spontaneous interaction in pervasive computing.

1 Motivation

Social interaction refers to the protocols, dynamics, and mutual expression of action and reaction among individuals. Such actions can be preplanned or regulated, like the everyday coming to work or the gathering for a meeting. They can, however, also be occasional or accidental, like the spontaneous interaction with someone we meet for the first time. Spontaneous social interactions among humans is often controlled by social interaction territories, i.e. spatial bodily boundaries defining zones of acceptable or uncomfortable closeness. The "private sphere" or the esoteric "aura" are examples of such social interaction territories. Correspondingly for the interaction among humans and things, interaction design [1] has established notions of space and range to enable, guide, steer, support and even to suggest styles of interaction (*"affordance"*). As for the "interaction" of things among things, spatial abstractions have been introduces to model the interaction outreach of a physical object wrt. to the perception of another physical object [2]. The *interaction* zone, the *notification* zone or the *ambient* zone [3] of an object are examples of such qualitative abstractions of the space within which interaction is engaged. With our previous work [2] we have proposed the *Zone-of-Influence (ZoI)* of an individual or physical object to represent the nimbus of its interaction. A ZoI in a geometrical way describes the spatial vicinity of a person or an entity, namely the subspace within which it can perceive the presence of another entity, or be perceived by others. Technological

sensors for distance (like microwave, ultrasound or radio based sensors), and orientation (like compasses, accelerometers or gyroscopes) allow a spatially aware entity to scan its vicinity for other entities. Based on the concept of ZoIs, and the respective sensor technology, things can become aware about other things in their vicinity, they can build up knowledge about where other things are, how far or close they are, and reason about their orientation.

The original concept of ZoIs is based on geometric shapes and the algorithmic verification of their mutual relations based on spatial proximity sensors. The limitations posed by this approach are caused by the quality and accuracy of the engaged sensors, but also by the dichotomy of the verification (either ZoI_1 *intersects* ZoI_2, or ZoI_1 *does not intersect* ZoI_2). Many spontaneous interaction scenarios, however, would be better grounded on a more approximate, vague or fuzzy verification of relations (ZoI_1 *"intensively" / "loosely" / "marginally" intersects* ZoI_2). Furthermore, in many situations the ZoI (and its presence and verifiability) is just limited in time, and declines in its degree of verifiability until it has totally disappeared.

A natural approach to implement ZoIs and their verification at such a qualitative level are olfactory ZoIs, i.e. ZoIs represented by odor, the creation or spawning of ZoIs by (artificially) vaporizing odor, and the detection of and verification of ZoIs by gas sensors or artificial noses. What intrigues to be a "shortcoming" of olfactory ZoIs in the first place, namely to be ephemeral, appears to be a "feature" for particular situations: the odor of an individual -depending on environmental factors like temperature, humidity, airflow, etc.- can even be verified after the individual has already disappeared. In this sense, olfactory ZoIs, by the nature of odors (intense, whiff, commingled, straight, ephemeral, vanishing, etc.) introduce a whole new quality of information representation and interaction design.

2 Olfactory Interaction Zones

Odor as a means to encode information receives more and more attention in human-computer-interaction. While visual and acoustic information representation has populated the communication channel to such a high extent, that individuals suffer from "information overload", the olfactory channel due to its subtle (and imprecise) perception remains a developing research topic [4][5]. Contemporary research tries to understand the connection between the olfactory organ and the emotional system (limbic system) and the long-term memory of the human brain as a promising source for interaction design [6]. As for examples from the literature, an ambient olfactory reminder system is reported in [5]. An integration of an augmented reality application with an odor machine to improve on the the reality experience is presented in [7]. NTT Communications have developed a smell machine called *Aroma Geur*, laying the path to the first olfactory emails in 2004 [8]. This device was also used to create an ambient smell when listening to Tokio FM. In 2005 TriSenx launched their *ScentDome* to enable websites emitting scents[9]. In the meantime, telecommunication industries have also

found the olfactory information channel as useful medium and market the first scenting mobile phones [10][11]. The special smoothness of olfactory interaction spaces was the central subject of the *Space-of-Scent*-project realized by Haque Design & Research in 2002. Not only the output of olfactory information is an increasing subject for information technology research, but also using volatile substances as input for digital communication becomes increasingly useful. Gas sensor arrays and electronic noses are used especially in forensic investigation for the detection of explosives and medical science to diagnose diseases like cancer. But now they are also used to control digital systems. E.g. the japanese *Hanahana*-installation allows manipulating flower-animations by ten different perfumes. Researches of the Austrian Konrad-Lorenz-Institute are currently developing a system to recognize individuals by their body odor which represents the individual DNA like a volatile fingerprint [12]. Such installations and developments reflect a coming up olfactory human-computer-interaction, in which conventional zones of interaction are inapplicable.

Each odor-emitting human or thing is surrounded by a definite waft of scent like an olfactory aura, which extents to a space within it is perceivable. It specifies an *Olfactory Interaction Zone (OIZ)*. The dimension and form of OIZs are specified by the occupied space and the odor intensity. The intensity of olfactory information depends on the ratio of odor molecules to air molecules and smoothly decreases with the distance to the emitter. Air flows dynamically manipulate the OIZ. Therefore an OIZ specifies a gradient and dynamical interaction space which allows approximate states of communication between two entities. The smooth transition between environment and interaction space is useful to define time-, position- or importances-related information. High intensive odor presence can be mapped to *recent*, *near* or *relevant*, low odor presence would mean *long-ago*, *far* or *irrelevant*.

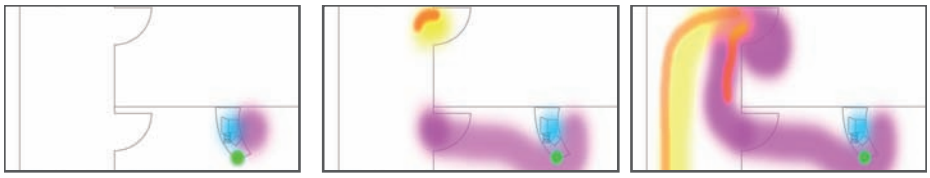

Fig. 1. Dynamic OIZs of two persons in floor plan

On the one hand odors volatilize fast and are inapplicable as constant data input, on the other hand they persistently stay a period of time at one place. Therefore odor emitting objects or humans leave an individual mark at every place they visited and define an OIZ which need not refer to their current position. OIZs also qualifies for digital tracking system as scents for a dog's snout. Figure 1 shows five dynamic OIZs of persons and things on a floor plan, which continuously change their form, dimension and position corresponding to the

odor emitter. Inactive humans or things have an nearly static OIZ with minimum change of dimension and intensity (Fig. 1a). If they alter position or intensify odor emission the zone change form and dimension (Fig. 1b, c).

3 Conclusion

Olfactory information can support approximate spatial reasoning among two or more entities in pervasive environments. Natural or artificial oders, emitted by humans or things, spawn an olfactory interaction zone (OIZ) which can be verified using olfactory sensing technologies. Based on this principle of "spawning" and "verifying" odors we have proposed OIZs as a potentially effective means for the spontaneous interaction among humans, humans and things, and things among things. As compared to the Zone-of-Influence framework based on space sensor technologies like radar, lidar, ultrasound or microwave in our previous work, OIZs open up a whole new dimension in the design space of spontaneous interaction: OIZs decay in time (gradually thins out until it has disappeared) and in space (gradually extends in space until it is omnipresent). At the same time, OIZs can be recognized by humans and machines at the same time, which is not the case e.g. for ZoIs based on radar signals.

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