
Self-Description and -Management of Orientation-Aware Artefacts

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Abstract

The topic of this PhD thesis is the composition and aggregation of physical artefacts in a generic way, where the focus is on the utilization of spatial orientation for both context acquisition and interaction. It also involves the construction of real-world user interfaces from a collective of orientation-aware artefacts, as well as means for inferring context information from orientation at different levels of complexity. The basis is a software framework that implements life-cycles of such artefacts which are able to describe themselves to their environment. In addition, the framework can be extended with tools for visual composition and aggregation to ensembles of artefacts.

Keywords

Context awareness, interaction modalities, orientation sensing, self-description and -management, tangible user interfaces.

Problem Statement and Research Question

The focus of my research is on the utilization of **spatial orientation** of physical artefacts, which is valuable information for both context acquisition and interaction. In this respect, the research mainly contributes to two fields.

The first one is the field of **tangible user interfaces**, where the use of spatial orientation opens up novel interaction modalities. For example, simple and intuitive manipulations and gestures performed with one or more orientation-aware artefacts can be used for controlling the environment. In this respect, orientation information is useful for both selecting and controlling multiple devices as well as services in a natural way.

The second research field is **context computing**, namely the utilization of information about the situation of an entity. Low-level data from orientation sensors like information about the manipulation of an artefact or its static orientation, metrics like angular acceleration or all kinds of statistical numbers calculated from a time-series of orientation-values, and high-level information like activities and gestures inferred from both sensor data and metrics, provide a rich source of context information.

For both fields, the ability of artefacts to **describe themselves** to other artefacts and the environment, as well as their **self-management**, namely the management of their interactions and activities in a decentralized manner, are central issues. This is of value as the respective artefacts should coordinate themselves or provide suggestions to the user about how they can be used in combination, in order to unburden humans from configuring and managing these environments.

My **central research interests** are (1) to develop novel interaction modalities and to identify high-level context information based on spatial orientation, (2) to find simple and generic means for self-description and -management of artefacts with a focus on orientation information, and (3) to develop a flexible and extensi-

ble software framework which implements the life-cycles of self-describing artefacts on the one hand, and allows their composition to ensembles for interaction and context acquisition on the other hand.

Further aspects I intend to address in my research are **design guidelines** and **process models** for the development of interfaces with multiple self-describing physical artefacts.

Approach and Methodology

The research is both experimental and theoretical. The **theoretical** parts comprise the development of new interaction modalities and the identification of context information based on spatial orientation, the development of a generic self-description for artefacts as well as a framework that executes their life-cycles and provides means for composing them, and an analysis and comparison of approaches for self-management. On the other hand, the research is **experimental** with respect to implementing a software framework and evaluating it with application scenarios.

The **validation and evaluation** of the quality of my research is primarily based on reviews and feedback to related publications and presentations, respectively. I think that sharing ideas with an international group of experts is appropriate in the context of my work, as it is evaluated from many different viewpoints thereby. Moreover, a survey of recent literature and discussions with my supervisor as well as colleagues working on similar topics helps me keeping up to date and getting early feedback about my work.

Related Work

This section explains in short **important publications** that had a major impact on my research field. First, K. P. Fishkin proposes a definition of and taxonomy for **tangible user interfaces** in [2], along the dimensions embodiment and metaphor. An early related work of H. Ishii et.al. about TUIs can be found in [3]. Another relevant paper written by S. Greenberg et.al. introduces the concept of "phidgets" [4], which are to **physical user interfaces** basically what widgets are to GUIs. Additional work related to physical user interfaces can be found in [5], [6] and [9]. A comprehensive overview of **context computing** is given in the PhD thesis of A. Dey [7] and A. Schmidt [8].

Preliminary Results

In comparison with the related work mentioned above, I see the **contribution of my thesis** in the composition of ensembles from physical artefacts which **describe themselves** to others and have a **controllable life-cycle**, where both the life-cycle and the self-description depend on their current **context**. In this respect, the general focus is on the use of **spatial orientation**. The **composition of artefacts** as well as automatic code-generation and -deployment are planned to be supported by a graphical user interface, allowing a rapid development of real-world user interfaces.

The **preliminary ideas and results** are:

- Survey and taxonomy of orientation sensing systems (from a technological viewpoint) as well as concepts for using spatial orientation

- Interaction modalities using cubes (change services and their parameters by flipping and turning the cube, respectively) and knobs (connect to devices in close proximity and control them in continuous or discrete ways)
- Development of an architecture for gesture-based control with orientation-aware artefacts
- Interaction paradigm for orientation-based selection and control of multiple arbitrary devices as well as services (browse devices and services with rotary movements and select/deselect them with tilt movements)
- Architectural ideas for the lifecycle control of artefacts, their self-descriptions and composition to ensembles by visual means
- Five-phase design-process for building real-world interfaces

Conclusions and Future Steps

My **next steps** are planned to be as follows. First, I will develop an XML-based **self-description** for artefacts (with PML [1] as starting point), which also allows their linkage to ensembles as well as the embedding of inline code. Related with the self-description of artefacts is the description of whole ensembles of artefacts (similar to graphical user interfaces, which can also be described with XML-based languages).

Second, I intend to implement a **plug-in framework** based on OSGi that supports the lifecycle control of self-describing artefacts for context acquisition or interaction. In this respect, an interesting issue is the inves-

tigation of context-dependent adaptation of life-cycles as well as the artefacts' self-descriptions. In addition, an Eclipse-Plugin for composing artefacts by visual means as well as automatic code generation and deployment is planned to be developed.

In parallel to the first two steps, I will think about **application domains** and develop **scenarios** for such self-describing and -managing artefacts that are aware of their spatial orientation. From my viewpoint, this is not only important with regard to building prototypes for evaluation purposes, but also for getting new ideas.

Further issues are the investigation of feedback mechanisms for controlling real-world interfaces with everyday objects as well as the systematic combination of orientation data with other contexts like identity and location.

I would like to **cooperate with others** in the discussion of novel interaction modalities, the investigation of application scenarios for self-describing and -managing artefacts, as well as the development of a software framework as outlined above.

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