Exploiting Heterogeneity in Ubiquitous Computing Environments for Robust Positioning and Localization

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POSITION STATEMENT

An essential prerequisite to location aware computing is the ability to gather information about the current location or position of users and their mobile devices.

Various systems for positioning and localization have been proposed for ubiquitous computing [3]. Something these systems have in common is the fact that they are all based on a limited set of underlying sensing technologies.

We advocate the intensification of research in the direction of exploiting the heterogeneity of ubiquitous computing infrastructures. Instead of relying on dedicated hardware, systems for positioning and localization should take advantage of the full spectrum of sources of location information that are – often as a side-effect – implicitly provided by the infrastructure and readily available.

We argue that by fusing the various sources of location information that are available over time, the robustness and accuracy of the positioning process can be increased considerably:

First, location systems that rely on a specific technology are prone to service disruption and interferences, because the unavailability or failure of the single underlying technology leads to a complete failure of the service as a whole. However, if the system takes advantage of as many sources of location information as possible so that at it can draw upon different sources of location information, a higher level of redundancy and fault tolerance can be achieved. One benefit is the increased robustness of the provided service in so far that the failure of single technologies can be tolerated. The absence of certain sensors only affects the quality of the positioning, but as long as there is some sensory input available, the positioning system stays "alive", thus leading to a graceful service degradation, maximizing the availability of the service.

Second, the quality of the positioning or localization process can be improved by fusing the data of multiple independent sources of location information. A higher number of sources of location information will typically improve both the spatial coverage and the rate at which location information is available, which should increase the accuracy and precision of position calculations.

We think that data fusion algorithms [2] are particularly suited to merge multiple sources of location information. We have devised and prototypically implemented a stand-alone positioning system for mobile devices which combines the location information extracted from an arbitrary number of sensors by means of high-level sensor fusion and map-knowledge (two-dimensional map model) [1]. The heart of the system is a probabilistic data fusion algorithm that processes location information gained from various sources, such as signal strength analysis of Wireless LAN access points, visibility of Bluetooth hotspots, and active or passive radio frequency identification (RFID) tags. We are currently performing practical experiments to evaluate the benefits of our prototypical system.

A further interesting option is to integrate similar data fusion algorithms into existing location frameworks, such as the Location Stack model [4] by Hightower et al., which provides a multi-layered design abstraction for location-aware ubiquitous computing systems.

CURRENT RESEARCH INTERESTS AND ACTIVITIES

The author's main research interests are in the field of reliable service infrastructures for ubiquitous computing, including robust location systems, reliable pervasive medical healthcare systems, and the roles of redundancy and connectivity.

BIOGRAPHY

Jürgen Bohn received a master's degree in computer science from the University of Karlsruhe (TH), Germany, in March 2000. Since May 2000 he is a research assistant in the Distributed Systems Group at the Institute for Pervasive Computing, ETH Zürich, Switzerland.

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