Relative Positioning

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Background and Motivation

Many ubiquitous computing applications rely upon location information describing the positions of people and devices. To date, location systems for ubiquitous computing have commonly supplied position data which has a single system-wide reference [1]. Examples include 3D coordinates inside a building, or public areas on a campus.

In order to provide statically-referenced data, such systems necessarily utilise marking or sensing units located at fixed positions in the environment. The units emit or sense signals via some physical medium (such as infrared light, ultrasound, or wireless LAN radio waves). These types of system tend to have two drawbacks.

1. *Infrastructure.* It is often the case that the marking or sensing units come in the form of active devices which must be deployed in the environment. Examples include an infrared sensor network, ceiling-mounted ultrasonic beacons, or wireless LAN access points.

2. *Topological survey.* The positions of the fixed environmental units must be known with respect to the system-wide reference.

There are a substantial number of applications which take place in unprepared environments, where infrastructure is not deployed and a survey of fixed unit positions is not available. Applications occurring in such scenarios are especially relevant to the fields of mobile computing, computer-supported collaborative work, and user interfaces. Applications include automatic device configuration [2], team-based creative design [3], and browsing geographic and informational spaces [4, 5].

In such applications, what is often needed is knowledge of the *relative* positions of devices with respect to one another. Thus, it is important to investigate relative positioning systems, in which mobile devices perform collaborative location sensing to support applications in unprepared environments.

Current Work

The Relate project is a one-year EC-funded collaboration between Lancaster University and the University of Karlsruhe. The aim of the project is to assess technology options for relative positioning systems. In this one-year assessment project, we have confined our study of the problem to 2D relative positioning for devices on surfaces. The study focuses on three important aspects of relative positioning systems.

1. *Sensor technologies.* The relative merits of different location sensing technologies should be assessed with regard to attributes such as accuracy, robustness, processing overhead, device size, and power consumption.

2. *Distributed systems.* Devices in a relative positioning system must be able to perform peer-to-peer organisation, sensing, and communication of measurements.

3. *Location algorithms.* After sensor data has been collected and shared among devices in the system, an algorithm must be used to produce relative positioning information. A given location algorithm can be centralised or distributed, and has associated with it a certain computational overhead, response to sensor measurement error, and capacity for estimating the error of its location results.

We have developed and tested objects which use infrared light intensity to estimate inter-object distance and orientation, and we have also designed an early prototype which performs ranging by measuring ultrasonic times-of-flight. Both the infrared and ultrasound–based objects interface with Smart-Its devices which provide wireless communication between objects in the distributed system. We have formulated several different location algorithms, and we are currently assessing their performance.

The 2D relative positioning systems we are developing are immediately relevant to applications such as surface-based user interfaces and collaborative planning. Much of the knowledge gained during this initial study can be expanded in future investigations to the more general problem of 3D relative positioning.

References

[1] Jeffrey Hightower and Gaetano Borriello. Location systems for ubiquitous computing. *IEEE Computer*, 34(8):57–66, August 2001.

[2] Tim Kindberg, John Barton, Jeff Morgan, Gene Becker, Debbie Caswell, Philippe Debaty, Gita Gopal, Marcos Frid, Venky Krishnan, Howard Morris, John Schettino, Bill Serra, and Mirjana Spasojevic. People, places, things: Web presence for the real world. In *Proceedings of WMCSA*, pages 19–28, Monterey, USA, December 2000.

[3] Norbert Streitz, Jörg Geißler, Torsten Holmer, Shin'ichi Konomi, Christian Müller-Tomfelde, Wolfgang Reischl, Petra Rexroth, Peter Seitz, and Ralf Steinmetz. i-LAND: An interactive landscape for creativity and innovation. In *Proceedings of CHI*, pages 120–127, Pittsburgh, USA, May 1999.

[4] John Underkoffler and Hiroshi Ishii. Urp: A luminous-tangible workbench for urban planning and design. In *Proceedings of CHI*, pages 386–393, Pittsburgh, USA, May 1999.

[5] Ken Camarata, Ellen Yi-Luen Do, Brian D. Johnson, and Mark D. Gross. Navigational blocks: Navigating information space with tangible media. In *Proceedings of IUI*, pages 31–38, San Francisco, USA, January 2002.