

Bootstrapping Sensor Networks in Ubiquitous Tracking Environments

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January 30, 2004

Introduction

Augmented Reality (AR) applications are highly dependent from accurate and precise tracking data. Since current tracking technologies do not always provide such information everywhere in real-time application developer must combine certain trackers together to minimize the disadvantage of one tracker by another. These sensor networks can then be used to deliver positional relation information of objects to the application which then can be evaluated.

Currently most AR application bring along their own customized solution of this problem. However these solutions are hardly reusable in other systems. This inhibits the development of large-scale sensor networks because there are no standard interfaces between these technologies. By introducing the *Ubitrack framework*¹

it is possible to form ubiquitous tracking environments which may consist of several sensor networks.

The Bootstrapping Problem

One of the main problem in the Ubitrack framework is the question how to set up the system for new participating users when they are using Ubitrack themselves. Or in other words: how do you identify new objects in the *spatial relationship graph* in Ubitrack?

Consider the following situation: Bob is a computer science student at the TU München. He is currently working in the AR lab at the software engineering chair of Prof. Brügge. His friend Alice is at the bus station and wants to know where he is at the moment. So she asks this to her mobile Ubitrack system.

The problem now is how we can integrate the Ubitrack system of Alice into the whole system. Her client does not know anything about the existing tracking

¹See our project homepage for details

environment at the bus station. This is the same problem which all peer-to-peer systems have: where to find potential partners without a central coordination facility and how to form a network with these partners.

Another problem is the identification of objects in the combined graph. Alice is tracked by her mobile setup and possibly by the tracker setup at the bus station. When both are combined the system must know that the two tracked objects are the same person.

Challenges

1. Setting up Ubitrack systems without initial knowledge of their environment

- **Problem:** Finding existing Ubitrack system to forming the sensor network

Example: Alice wears a mobile Ubitrack system. When she exits at the bus station she should be able to connect to the station's Ubitrack environment.

Solution: Use DWARF

- **Problem:** For inferring new spatial relationships from scratch it is necessary to traverse the whole graph. Are there solutions to limit the graph search by getting additional information from other context sources?

Example: Alice asks her system where Bob is. Is the fact that Bob is a computer science student relevant to start the search in the FMI building subgraph?

2. Identify new tracked objects in the graphs

- **Problem:** Objects can be tracked by different trackers at the same time. They also can be registered as different nodes in independent Ubitrack systems. When these system merge together the two nodes must be matched on exactly one node because in reality it is one object.

Example: Alice is tracked by a wireless LAN tracker at the bus station. Additionally she is a registered object in her own mobile Ubitrack system. When both are combined how is it possible to match the two objects together?

Basic approach

The first step is the evaluation of literature concerning P2P architectures, especially efficient ways to build ad-hoc P2P networks. The results of the literature

search is then used to modify DWARF to suit the needs mentioned in the project's description². This can be done either by finding attributes which can be used to model the bootstrapping protocol or by introducing new components to the current middleware.

The purpose of the new model in DWARF is to detect new edges which combine several subgraphs together. This includes the fusion of all available context sources to defer the spatial relationship between two graph nodes. The problem thereby is the identification of newly created objects (see above). Possible solutions are to find similarities in the movement of current objects by motion estimation.

Project Schedule

Until workshop	List of abstracts of all relevant papers concerning: <ul style="list-style-type: none"> • P2P architectures • Forming P2P sensor networks • Routing through these networks • Motion estimation (together with Daniel) Post the list in the TWiki web.
Ubitrack workshop	Present results of literature search Define hardware API with project members
February – march	Implement needed extensions to the middleware Simulate P2P system in simulator
March – april	Form real SR graph over subnetwork boundaries <i>Fallback:</i> Use a only one subnet where all nodes reside Realize parts of the scenario in a first demo
April – may	Integration with the components of Dagmar and Daniel Final Demo !
May	Write thesis

²see the Ubitrack homepage.