A Location System based on Sensor Fusion: Research Areas and Software Architecture

2. GI/ITG KuVS Fachgespräch “Ortsbezogene Anwendungen und Dienste”

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Motivation

- various applications require location information
  - mobile ad-hoc routing: position based routing
  - mobile business: context-aware applications

- various location systems are around

- no highly accurate, easy-to-use indoor location systems is available
Motivation

- various applications require location information
  - mobile ad-hoc routing: position based routing
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- various location systems are around

- no highly accurate, easy-to-use indoor location systems is available

⇒ we investigate sensor fusion based location systems
Outline

- Categorization
- Existing Work
- Current Research
- Conclusion
Categorization

Location Systems

- Existing Infrastructure
  - Television
  - Bluetooth
  - Wireless LAN
  - FM Radio
- Satellite Based
  - GPS
- Satellite Independent
  - Sonar
  - Ultrasonic

Sensor Fusion

- RADAR
- RightSPOT
- Active Badge
- Cricket
Categorization

Location Systems

- Use Existing Infrastructure
- Use Dedicated Infrastructure

Existing Infrastructure
- Television
- Bluetooth
- Wireless LAN
- FM Radio

Dedicated Infrastructure
- Satellite Based: GPS
- Satellite Independent: Infrared, Ultrasonic

Sensor Fusion
- Rosum
- RADAR
- RightSPOT
- Active Badge
- Cricket
Categorization

Location Systems

Use Existing Infrastructure

Use Dedicated Infrastructure

Satellite Based

Satellite Independent

Existing Infrastructure

Dedicated Infrastructure

Televison
Bluetooth
Wireless LAN
FM Radio

Satellite Based

GPS
Infrared
Ultrasonic

Sensor Fusion

RADAR
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Cricket
Categorization

Location Systems

- Use Existing Infrastructure
- Use Dedicated Infrastructure

Satellite Based

- Satellite Independent
  - Infrared
  - Ultrasonic
Categorization

Location Systems

Use Existing Infrastructure

Use Dedicated Infrastructure

Satellite Based

Satellite Independent

Infrared

Ultrasonic

GPS

Active Badge

Cricket
Categorization

Location Systems

Use Existing Infrastructure
- Television
- Bluetooth
- Wireless LAN
- FM Radio

Use Dedicated Infrastructure
- Satellite Based
  - GPS
- Satellite Independent
  - Infrared
  - Ultrasonic
  - Active Badge
  - Cricket
Categorization

- Use Existing Infrastructure
  - Television
  - Bluetooth
  - Wireless LAN
  - FM Radio
  - Rosum
  - RADAR
  - RightSPOT
  - GPS

- Use Dedicated Infrastructure
  - Satellite Based
    - Infrared
    - Ultrasonic
    - Cricket
  - Satellite Independent
    - Active Badge
Categorization

Location Systems

Use Existing Infrastructure
- Television
- Bluetooth
- Wireless LAN
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- Sensor Fusion

Use Dedicated Infrastructure
- Satellite Based
  - GPS
  - Infrared
  - Ultrasonic
- Satellite Independent
  - Active Badge
  - Cricket

Sensor Fusion
Categorization

Location Systems

Use Existing Infrastructure

- Television
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- RADAR
- RightSPOT
- Sensor Fusion

Use Dedicated Infrastructure

- Satellite Based
  - GPS
  - Infrared
  - Ultrasound

- Satellite Independent
  - Active Badge
  - Cricket

Existing Work

- Use Existing Infrastructure
- Use Dedicated Infrastructure
- Satellite Based
- Satellite Independent

Current Research

- Sensor Fusion
Categorization

Location Systems

- Use Existing Infrastructure
  - Television
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  - Sensor Fusion

- Use Dedicated Infrastructure
  - Satellite Based
    - GPS
    - Infrared
    - Ultrasonic
  - Satellite Independent
    - Active Badge
    - Cricket

Existing Work

Current Research

Conclusion
**RADAR - Overview**

- Microsoft Research, 2000
  - Wireless LAN access points are used to determine the position of mobile devices
  - Two step approach:
    - Training phase: a database with signal strength values of the operation area have to be created
    - Location phase: uses this database
  - Median distance error 2.5 meters
- a dense grid of measurement points is required
the mobile device measures the signal strength of the access points in communication range

the mobile device compares this sample with the values stored in the database
RADAR - Positioning

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- the mobile device compares this sample with the values stored in the database
Bluetooth - Overview

- invented to replace low-bandwidth cabling e.g. computer peripherals
- communication range up to 10 meters
- proximity approach proposed by
  - a research group at the Lulea University, Schweden
  - a research group at the Chuo University, Japan
Bluetooth - Positioning

- proximity based location determination

(x=10, y=20)
Bluetooth - Positioning

- proximity based location determination

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Bluetooth - Positioning

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(x=10, y=20)
Bluetooth - Positioning

- proximity based location determination

(x=10, y=20)
proposed by PlaceLab and a research group of the University of California, USA

modern mobile devices contain a multiple of communication and sensor interfaces (e.g. Wireless LAN, Bluetooth, GSM, ...
Sensor Fusion - Overview

- proposed by PlaceLab and a research group of the University of California, USA

- modern mobile devices contain a multiple of communication and sensor interfaces (e.g. Wireless LAN, Bluetooth, GSM, ...)

⇒ exploit the correlation between sensed parameters to increase the positioning accuracy and availability
<table>
<thead>
<tr>
<th>Sensor Data:</th>
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<tbody>
<tr>
<td>Wireless LAN</td>
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<td>Bluetooth</td>
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<td>GSM</td>
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Sensor Fusion - Principle of Function

- principle of function

Sensor Data:
- Wireless LAN
- Bluetooth
- GSM
- ...

Position Determination:
- k-nearest Neighbor
- Proximity
- Triangulation
- ...

Introduction

Existing Work

Current Research

- Sensor Fusion - Overview
- Sensor Fusion - Principle of Function
- Sensor Fusion - Challenges
- Generic Location System Architecture

Conclusion
principle of function

Sensor Data:
- Wireless LAN
- Bluetooth
- GSM
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Position Determination:
- k-nearest Neighbor
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Sensor Fusion:
Sensor Fusion - Principle of Function

principle of function

Sensor Data:
- Wireless LAN
- Bluetooth
- GSM
- ...

Position Determination:
- k-nearest Neighbor
- Proximity
- Triangulation
- ...

Sensor Fusion:

Posit
Sensor Fusion - Challenges

- challenges:
  - different sensor types provide different accuracy and precision
  - sensor data is often noisy
  - position estimates from different sensors may conflict with each other
Generic Location System Architecture

- Sensor Fusion - Overview
- Sensor Fusion - Principle of Function
- Sensor Fusion - Challenges

*Generic Location System Architecture*
Conclusion

- Categorization of location systems

- Existing Work
  - GPS
  - RADAR
  - Bluetooth

- Current Research
  - Sensor Fusion
  - Generic Location System