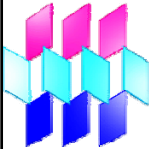**the 1st COE Postdoctoral and Doctoral Researchers Technical Presentation**

Indoor user location system for ubiquitous computing

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Background

- Ubiquitous Computing
  - "Anyone", "Anywhere", "Anytime"

  - Mobile Computing
    - Small devices
    - Wireless networks
  - Pervasive Computing
    - ≒ Invisible Computing
    - Context-aware computing
      - Location systems : position, situation, activity

Location systems(1/2)

- Outdoor
  - GPS (Global Positioning System)
- Indoor
  - Cricket (MIT , Crossbow)
    - radio wave and ultrasound
    - ○ High positioning accuracy
    - × Too many sensors are needed
  - Ekahau (Ekahau)
    - radio intensity from Wi-Fi access points
    - ○ Simple infrastructure
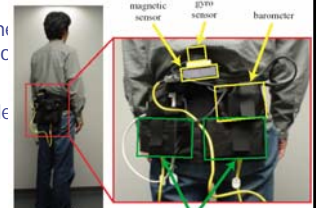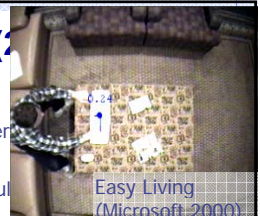   - × Affected by change in environment

Cricket

Location systems(2/2)

- Autonomous positioning system
  (Konishi at al.,Tokyo Univer...
  - ○ No sensor in environment
  - × Large user's system / Accumul...

- Image processing using cam...
  (Easy Living (Microsc...
  - ○ User has no devices
  - × Need some action to ide...

Easy Living
(Microsoft,2000)
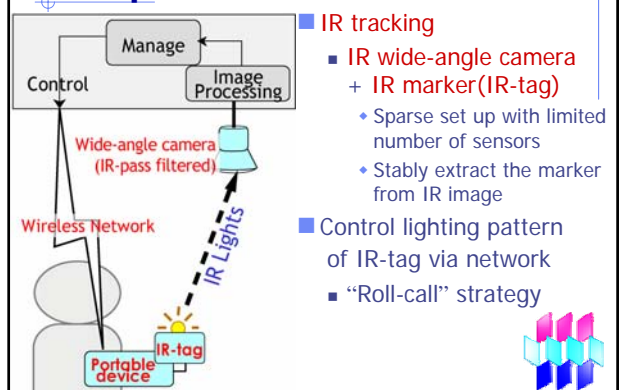
(Konishi at el., 2001)

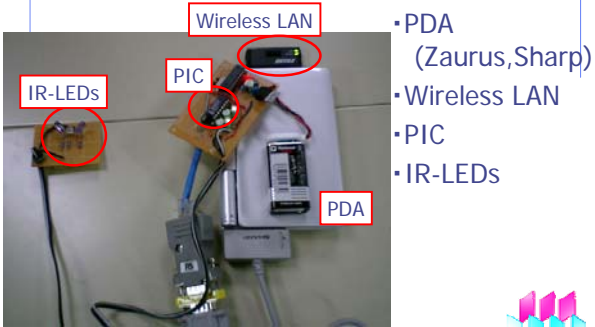---

Objective

User location system for indoors
- ALTAIR
  (Automatic Location Tracking system using Active IR-tag)
  - Automatic tracking and identification
    - Don't disturb daily work
    - Smaller user's equipments
  - High accuracy (~1m)
    ex.) in front of which desk, which part of the room
  - Simple infrastructure
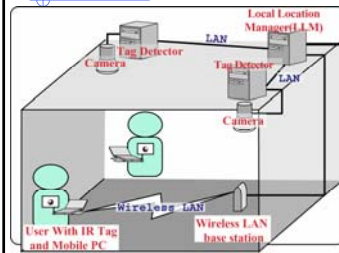   - 2 cameras in an area

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Proposed Method

Manage

Control

Image Processing

Wide-angle camera
(IR-pass filtered)

Wireless Network

IR Lights

Portable device

IR-tag

- IR tracking
  - IR wide-angle camera
    + IR marker(IR-tag)
    - Sparse set up with limited number of sensors
    - Stably extract the marker from IR image
- Control lighting pattern of IR-tag via network
  - "Roll-call" strategy

System (user's system)

- Wireless LAN
- PIC
- IR-LEDs
- PDA

- ·PDA
  (Zaurus, Sharp)
- ·Wireless LAN
- ·PIC
- ·IR-LEDs

System (for an area)
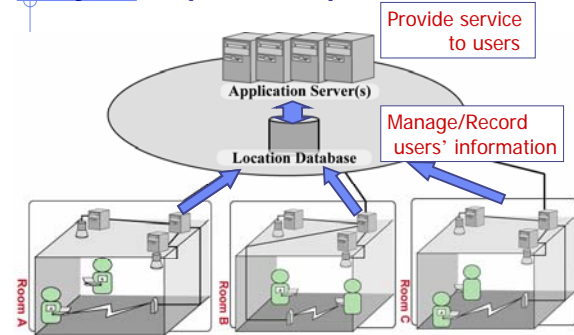

■ IR wide-angle camera
- ■ Tracks lights of all IR-tags
- ■ Calculates IR-tags' positions
- ■ Detects blinking IR-tag

◆ Local Location-Manager(LLM):
- ■ Merges information from cameras
- ■ Sequentially instructs IR-tags of all users to blink
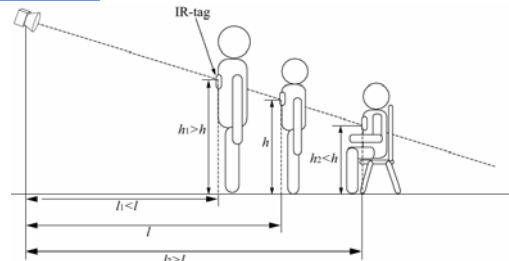- ■ Updates user location and identification

System(servers)

Provide service to users

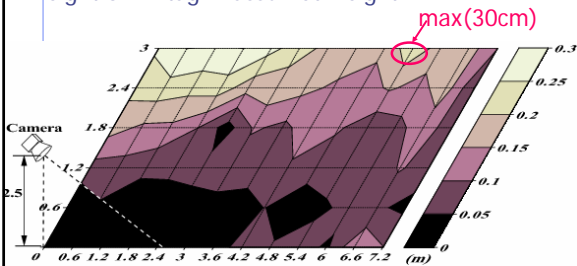Manage/Record users' information

Changes of estimated position

- ■ The system uses only one IR-image for estimating position.
- ■ The estimated position is affected by fixing point of IR-tag, and user's posture.
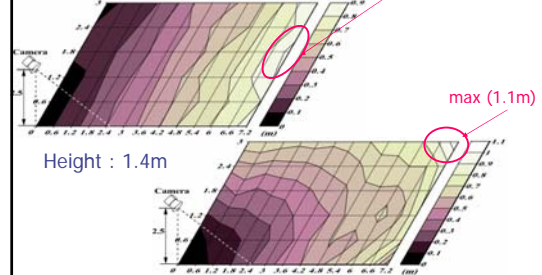
Accuracy (1/2)

Height of IR-tag = assumed height = 1.2m

max(30cm)

- ■ Avarage : 10 cm, Max : 30 cm in 7.2m×6m area

Accuracy (2/2)
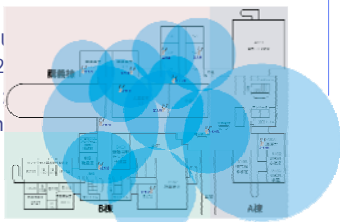
Height : 1.0m

max(90 cm)

max (1.1m)

Height : 1.4m

The system could detect users situation, if the height of IR-tag is changed!

Combination with other systems

- ALTAIR : high accu...
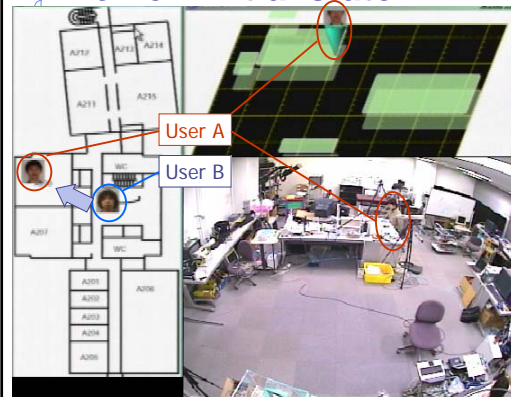 - Each area needs 2...
- Wireless-network ...
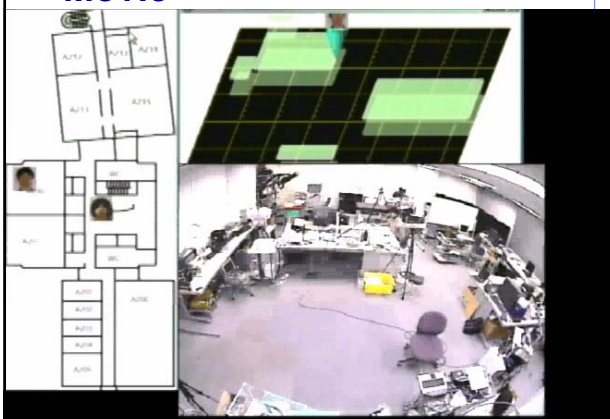 - Which access poin...

- Grant for COE young researcher 2005
  - With Mr. Tobe (inet-lab)
  - At 1st floor in NAIST-IS building
    - Using 12 access points
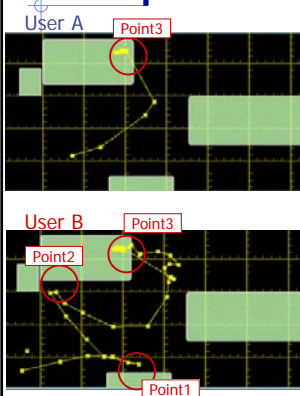   - About 10 – 30 m area for one access point

Movie: Initial state

User A
User B

Movie

Footprints

User A
Point3

User B
Point3
Point2
Point1

- Plots of users' footprints

- These footprints indicate
  - User B moved to Point 3 through Point 1, Point2
  - User A walk out the area
- System could understand situation between user & object (desk, computer …) using circle area of 1m in diameter

Discussion

- The system can …
  - detect user's entering and leaving area automatically
  - start and terminate tracking user automatically

> The system needs no user's prearranged action in all operation of getting users' location

- By monitoring in real-time and plotting user's footprint, system can monitor and record user's activity
  → The system could analyze user's activity

Summary

- User location system for indoors
  - System can get users' location automatically
  - Simple settings
    - 2 sensors (cameras) in one area
    - Wireless network
  - High accuracy (~1m)
  - System can be combined with other location systems.
    - Location system using wireless network
- Future work
  - Downsize the users' system using Zigbee devices