Augmenting Everyday Objects with Location Awareness for Home-care: Sandals, Glove, and Table

Hao-hua Chu (朱浩華)
i-space laboratories
Computer Science & Information Engineering Department
資訊工程研究所
Institute of Networking and Multimedia
資訊網路與多媒體研究所
National Taiwan University

Key Point

- What is the ideal and natural way of delivering e-care or i-care to elders at home?
  - Everyday objects not PC-like devices
- Elders' ADLs do not naturally involve PC-like devices
  - But they will involve everyday objects
- Example: good-dietary e-care service
  - Information website?
  - Dining table?

Outline

- Ubiquitous computing (ubicomp) introduction
- Everyday objects augmented with location-awareness
- i-space labs introduction & advertisement
- Q & A

What is ubicomp?

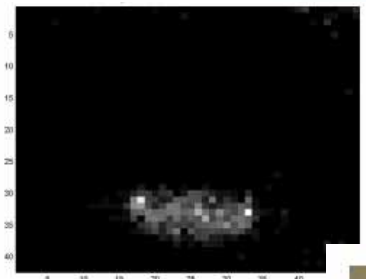
- What does Ubicomp want to do?
  - Beyond PC (Notebook, PDAs, cell phones) world
  - Beyond Internet world
  - = Physical world, into everyday objects
- Invisible, disappearing, calm (Weiser)
  - Hidden into everyday objects
  - Interacting in natural ways through familiar everyday objects
- Elder's home-care is excellent application area for ubicomp.
  - Virtual interaction impractical

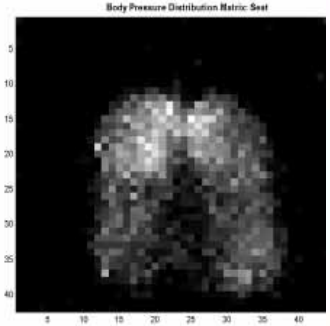
Intelligent Everyday Objects

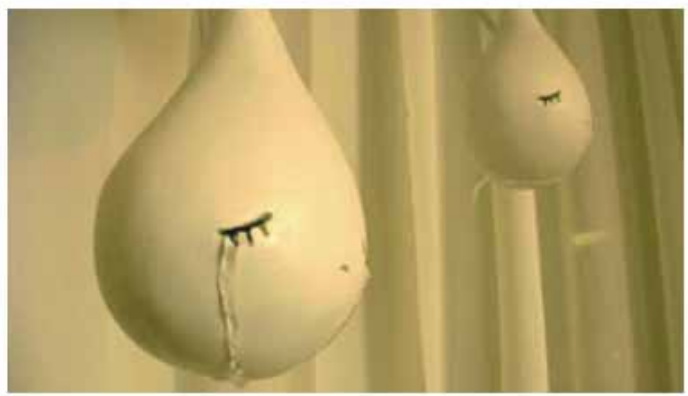
- Embed computing, sensing, and networking capabilities into everyday objects.
- Everyday objects understand you & environment.
  - where are you
  - where are things

Smart Everyday Objects (Examples)

- Posture Chair (MIT)
- Bionic Running Shoes (Adidas)
- Tasting Spoon (MIT)
- Emotional Décor (NYU)







KUs: crying surrogates

Augmenting Everyday Objects

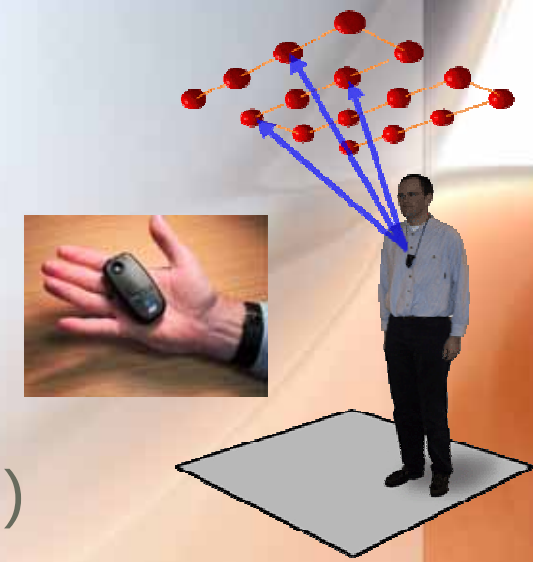
- Work-in-progress projects
- Japanese Geta Sandals
  - Shoes (Slippers) that track where you walk
- Object Locator & Reminder Glove (Prof. Jane Hsu)
  - Never waste your time looking for things
- Diet-aware Dining Table
  - Table that watches what you eat and helps you eat healthy
- Privacy-enhanced camera
  - Protect your privacy in public spaces full of digital cameras (camera phones)

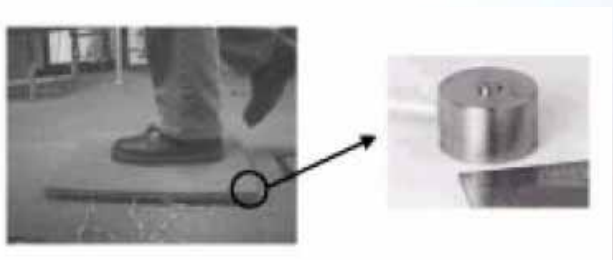
(Japanese) Geta Sandals

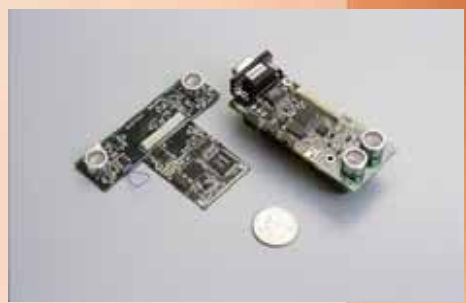
Shoes (Slippers) that track where you walk

Localization Systems

- Determine locations of people or objects
  - GPS (limitation: outdoor-only)
  - Ultrasound (Active Bat, Cricket)
  - WiFi (Radar, ekahau)
  - Vision (EasyLiving)
  - Pressure-sensing smart floor (Gatech)





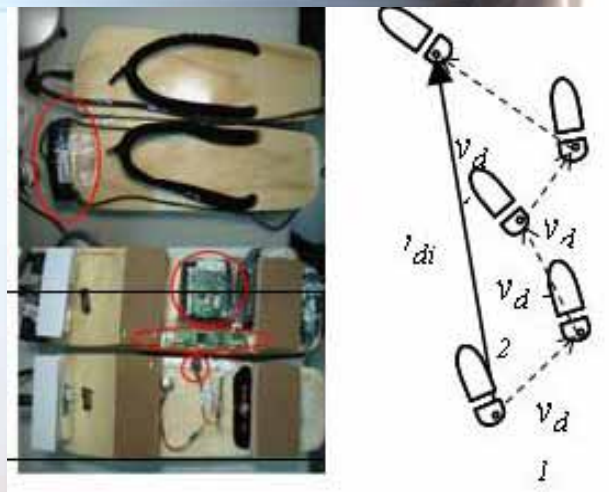


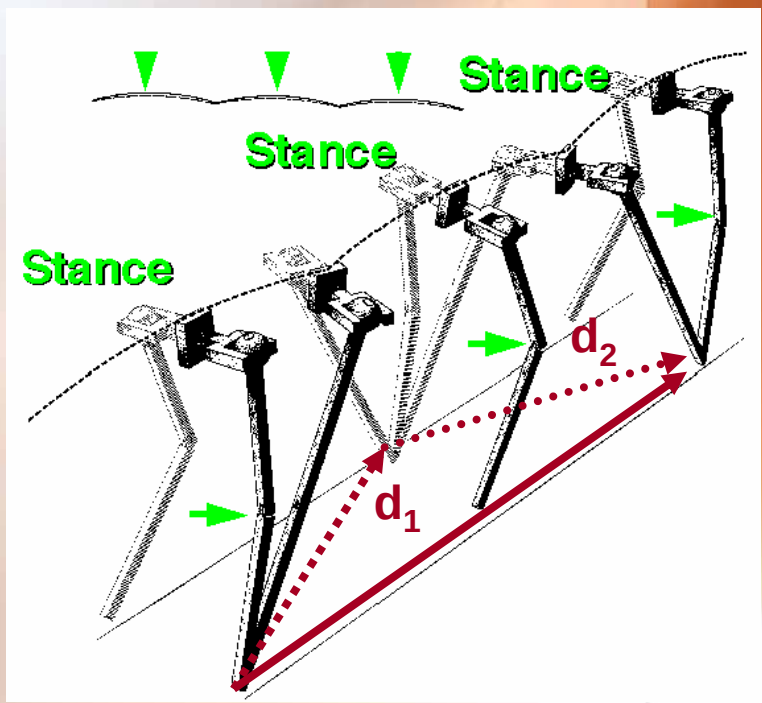
Success in the marketplace?

- Indoor localization systems
- Why not?
  - Certain level of infrastructure support in the environments -> deployment cost, calibration efforts, management cost, etc.
  - Not suitable for everyday environment

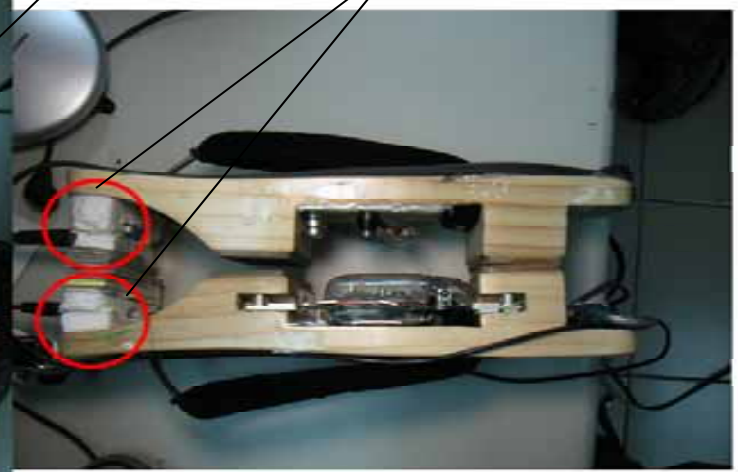
Geta Sandals

- Motivation
  - Track people's locations with minimal infrastructure in the deployed environment
  - Object reminder (Prof. Jane Hsu)
- Hybrid Method
  - Footprint tracking
  - Error accumulation (1~10%)
  - Location-aware RFID tags





Geta Sandals Design



Orientation Sensor

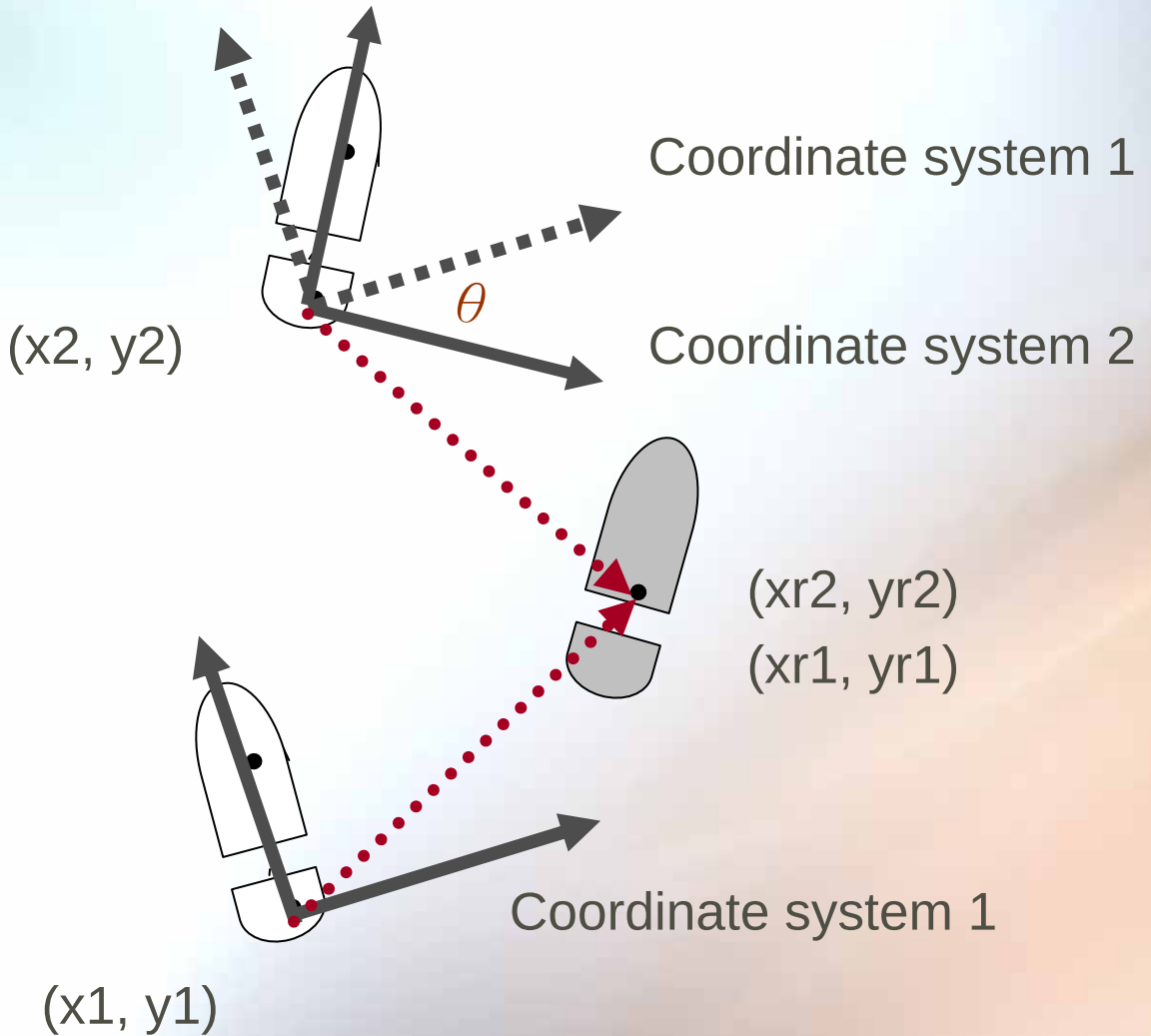
RFID Reader

Pressure Sensor

Ultrasonic receivers
(infrared receivers)

Ultrasonic transmitter
(infrared transmitter)

Translate Coordinate Systems



Play Geta Sandals Video

+

Object Locator & Reminder Glove (Prof. Jane Hsu)

Never waste your time looking for (misplaced) things

Object Locator (Motivation)

- Where did I leave these everyday objects?
  - Glasses, cell phones, wallets, keys, remote controls, …
- Track locations of everyday objects
  - Geta Sandals plus
  - RFID reader Glove plus
  - RFID tags on everyday objects

RFID Reader

iGlove from Intel:
Activity Recognition

Assumption & General Approach

- Assumption:
  - Most of objects are moved by hands
- Picking up phone:
  - Phone presence (RFID tag) detected by the glove reader
- Carrying the phone:
  - Continuous presence (on-hand)
  - Non-presence (pocket-it)
- Dropping the phone:
  - Phone presence (RFID tag) not detected by glove reader
- Location of the object?
  - Foot location when the object's last presence was detected by the glove

Diet-aware Table

Table that watches what you eat and helps you eat healthy

Diet-aware Table (Motivation)

- Health is closely related to eating habit
  - 肥胖和慢性疾病
- 高血壓 冠狀動脈心臟病患:
  - Avoid salty & high-cholesterol food: animal fat, animal intestine, egg yoke, cheese, red meat
  - Recommend fish, milk, mushroom, apples, vegetable oil
- 肝炎病患:
  - 皮, 油炸
- 糖尿病患:
  - Recommend: low sugar, low sodium, low oil

董氏基金會-食品營養組 (http://www.jtf.org.tw/educate/)

Diet-Aware Table (Design)

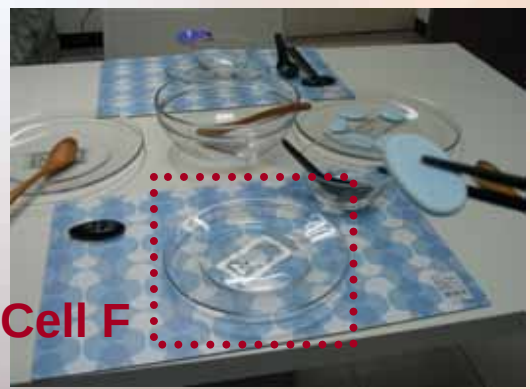
- Sensors underneath table to track food consumption of individuals
  - What food item?
  - How much weight in each food item?
  - Approximate aggregate nutritional intake of a meal
- Tablecloth as display to provide visual dietary recommendations

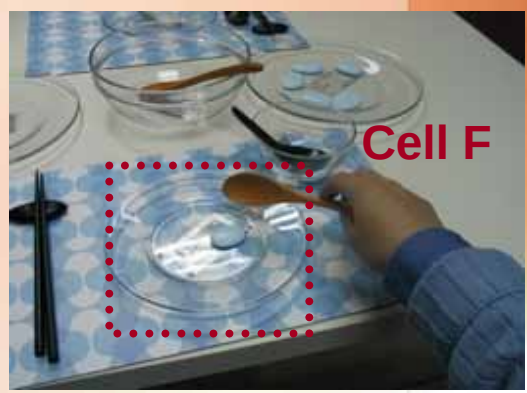
Diet-Aware Table

- RFID tags on food containers
- Two sensor surfaces on table
  - Each surface is made of cells
  - RFID reader surface
    - Detect RFID(s) in each cell
  - Weighting surface (load cells)
    - Measure weight change in each cell
- Track the food path from container(s) → mouth using two sensor surfaces

Tracking Food Path

- A simple case (there are many complex cases)
- Initial condition
  - Cell C [weight = 100 mg, rfid= 123]
- Step 1: translate food from dish to personal plate
  - Cell C [Δ weight = -10 mg, rfid-123]
  - Cell F [Δ weight = +10 mg, rfid=123]
- Step 2: food to mouth
  - Cell F [Δ weight = -10 mg, rfid = 123]
- Consumption [
  rfid=123,
  amount = +10 mg
  ]





Tablecloth (Design)

- Non-graphical UI: visually pleasing and relaxing
  - No warning, no bars, etc.
- History tablecloth (Equator project)
- Illuminating fabric (Luminex)
- Mapping recommended (not) dishes to tablecloth
- One possible mapping:
  - A unique color for each person
  - Healthy dishes glows the assigned color(s) to encourage or discourage consumption

Privacy-enhanced Camera

Protect your privacy in public spaces full of digital cameras (camera phones)

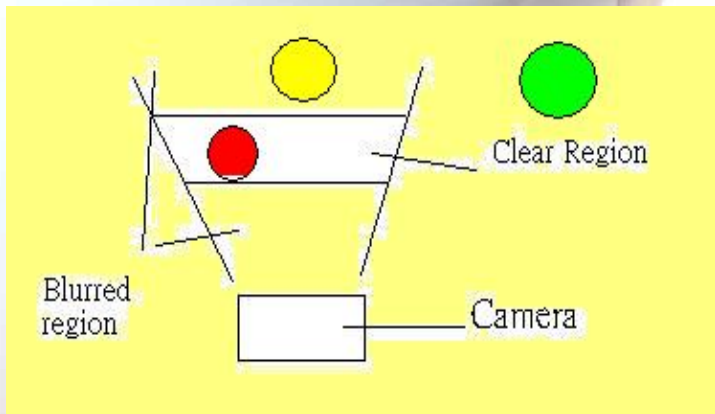
Privacy Camera (Motivation)

- Problems:
  - Too many cameras in public spaces
  - Privacy intrusion for passers-by in the pictures
- Protect privacy of passers-by being unintentionally captured by digital cameras.
  - Help camera users avoid passers-by
  - Help passers-by avoid surrounding cameras


CHAINTECH®
Welcome
IMO-desk
Farm
Motherboard

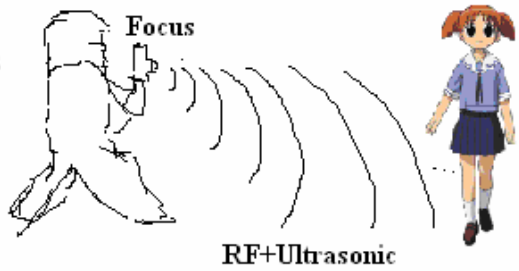
Privacy Camera (General Approach)

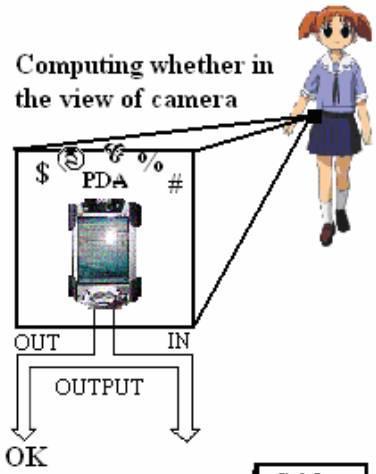
- Who are currently in (or about to come into) camera's recordable region?
  - Viewing angle
  - Camera orientation
  - Passers' locations relative to the camera
  - Camera focal point

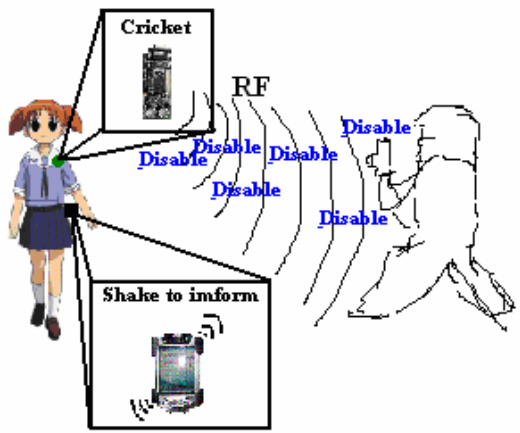


- What happens when passer(s)-by are in the camera view
  - Disable the camera until it receives consents or non-consenting passers walk off the camera view
  - Warn the camera users
  - Warn the passers-by


Cricket mote transmitter
Camera
PDA
RS232 adapter


Focus
RF+Ultrasonic


Computing whether in
the view of camera
$ PDA #
OUT
IN
OUTPUT
OK


Cricket
RF
Disable
Disable
Disable
Disable
Disable
Disable
Disable
Shake to imform

Related Work

- Privacy protecting video surveillance (IBM)
  - Video understanding
  - Masking people
  - Destroy some parts of the pictures
- Pre-processing (prior to actual recording) vs. post-processing

Privacy Camera (Challenges)

- Location privacy
  - Can cameras track locations of nearby people?
  - Better: passers-by track locations of camera(s).
- Location accuracy
  - Minimize annoyance: false positives or false negatives
- Form factor size
  - Can be embedded into cameras and personal devices (on passers-by)
- Other issues:
  - Tracking Distance, Delay time, User interface

i-space laboratories (Vision)

- Empower seemingly senseless space by the right combination of hardware and software, so that we as human can live a quality, yet effortless life.

Vision
Image Processing & Pattern Recognition Lab
影像處理與圖型識別實驗室

Intelligence
Intelligent Agents Lab
智慧型代理人實驗室

Robot
Intelligent Robot Lab
智慧型機器人實驗室

Middleware & Systems
Ubicomp Lab
Ubicomp 實驗室

Architecture
Embedded Computing Lab
嵌入式運算實驗室

Communications
Network & Systems Lab
網路與系統實驗室

Summary

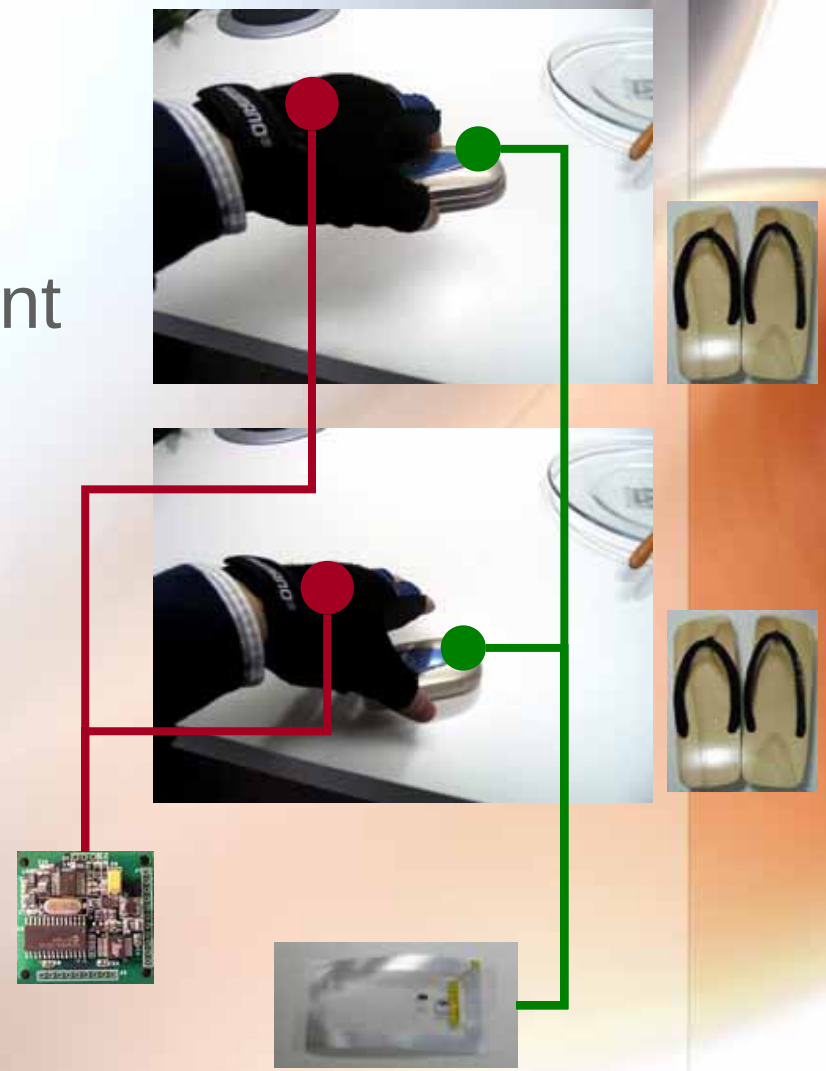
- Ubicomp vision of computing world
  - Physical world of smart everyday objects augmented with computing capabilities
- Location is fundamental in ubicomp & ubihealth
  - Knowing object or people locations are sufficient for intelligent behavior
- Showing early in-progress research activities: welcome any suggestions
- i-space labs homepage: http://mll.csie.ntu.edu.tw/ispace.htm
  - Check out our publications page!

Questions & Answers

Thank You

Tracking Objects (Approach)

- General approach:
  - Identify object (ID) on people's hands [RFID reader & tags]
  - Track people's movement
  - Track location where an object is released from people's hands



Tablecloth (Ambient Display)

- What is ambient display?
  - Visually-pleasing displays of non-critical information
  - Periphery of a user's attention, without distracting or burdening the user
  - Non-graphical user interface
  - Mapping to ambient environment (sound, color, wind, etc.)
- Dangling string (PARC)
- Pinwheels (MIT)
- BusMobile (Berkeley)