Ubiquitous Computing:
When UbiComp meets VR (U-VR)

Woontack Woo, Ph.D.

KJIST U-VR Lab (http://vr.kjist.ac.kr)
Gwangju 500-712, S. Korea
mailto:wwoo@kjist.ac.kr

Outline

- Introduction
  - My vision: What happen in 10 years?
  - What's UbiComp & WearComp?
  - What's U-VR? Why? & How?
- Applications of U-VR
  - Civilian: Home, Office, Car, etc.
  - What about Military?
- Discussion

Introduction: My Vision

- Future Computing Environment (in 5-10 years)
  - Ubiquitous computing (networking)
  - Convergence, e.g.,
    - Computing vs. Communications
    - Digital vs. Analog
    - Virtual vs. Real
  - Human-centered intelligence
- Main focus of KJIST ***U-VR Lab***
  - Goal: to increase "Quality of Life"
  - **Focus: U-VR for holistic smart environment**

What's UbiComp?

- What's Ubiquitous Computing (UbiComp)?

  "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it"

  - by Mark Weiser "The Computer for the 21st Century," Scientific American, vol.253, no.3, pp.94-104, Sep. 1991

Dr. M. Weiser (52-99)

- Beyond the PC: in the midst of a shift
  - Implicit input & ambient output
- Related areas
  - Ubiquitous (Xerox), pervasive (IBM),
  - Embodied (MSU), Context-aware, situation-aware,
  - Wearable, Smart & tangible space, etc.

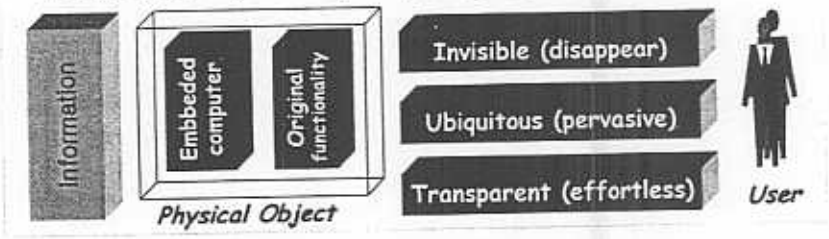
What's UbiComp?

- We define Ubicomp as

"Any computing technology that allows human to do just-in-time interaction with environment through embedded yet invisible interfaces."

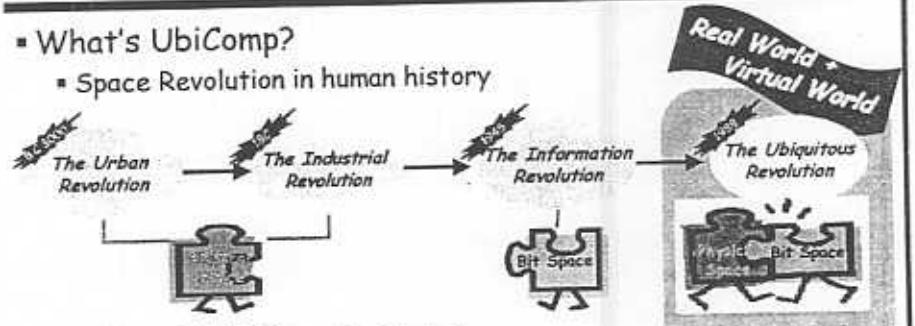
- by Ubicomp group in U-VR Lab @ KJIST

- Anytime, Anywhere, Anything

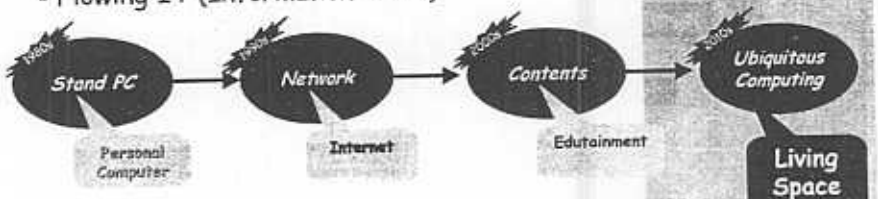


What's UbiComp?

- What's UbiComp?
  - Space Revolution in human history

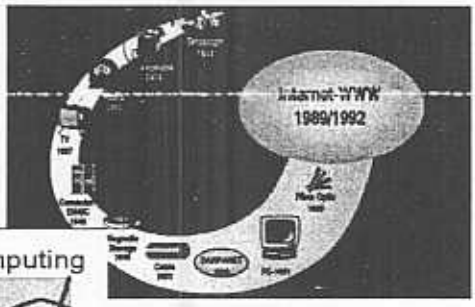


- Flowing IT (Information Tech.)

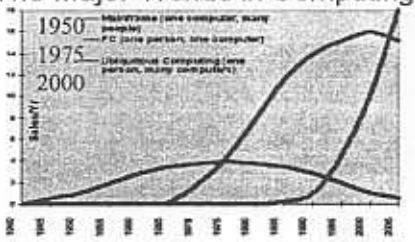


What's UbiComp?

- History and Trend



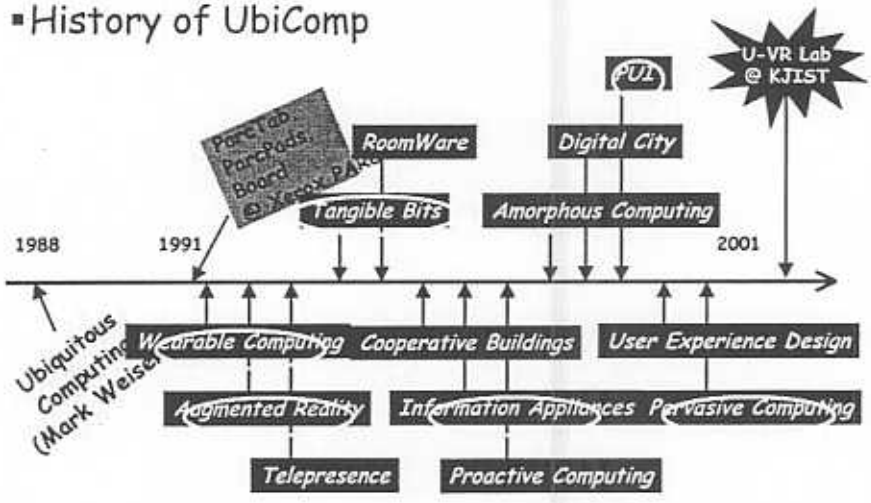
The Major Trends in Computing



the 3rd wave in computing is coming!!!

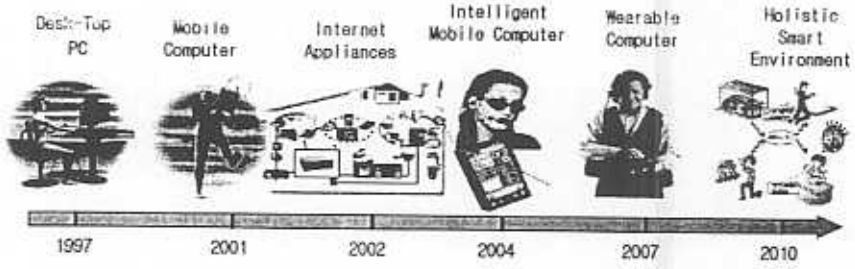
What's UbiComp?

- History of UbiComp



What's UbiComp?

- The Shift to UbiComp: Where are we?



- WIMP-centric
- Generic machines
- Client-server Monolithic apps
- One person, one application, one set of hardware

- Invisible/implicit interaction
- Dedicated appliances
- Universal "glue-like" connectivity
- Infrastructure-centric services
- Multi-person, multi-application, multi-device integration

What's UbiComp?

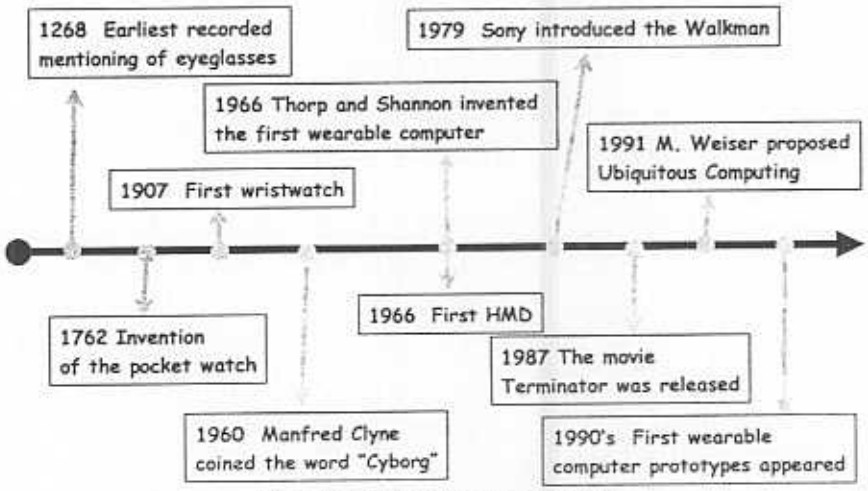
- Ubicomp Components
  - Pervasive/ubiquitous networking
  - Pervasive sensing, monitoring, tracking
    - GPS, GIS, Sensor networks
    - Embedded smart (bio) sensors & id tags
  - Context-aware
    - User/object identification, location, etc.
- What about user?
  - Mobile/wearable devices
  - Wearable computing

What's WearComp?

- What's WearComp?
  - My fuzzy definition
    - Always ON: working, sensing, acting while moving around
    - Always accessible: context-aware & unobtrusive
    - Always part of the user
      - Hand free & multimodal perceptual interfaces
  - Components
    - System: belt or backpack
      - Navigation: Position sensing, navigational display
    - Multi-modal I/O: keyboard, speech, HMD, etc.
    - Processing: context-based sorting & filtering
    - Networking: wireless LAN, IR, RF, etc.
      - Information Gathering: access to pervasive DB

What's WearComp?

- Wearable Computing Synopsis



What's WearComp?

- VR
  - Replace reality
- AR
  - Enhance reality
    - The surrounding env. is real
    - Supplements reality, rather than completely replacing it
  - Virtual and real objects coexist in the same space
    - 3D virtual objects are integrated into a 3D real environment in real time
    - Interactive in real time

Milgram's Reality-Virtuality Continuum

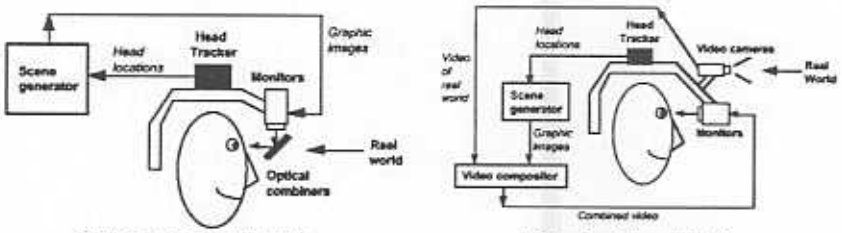
What's WearComp?

- WearComp output display is AR!
  - Seamless integration of real & virtual worlds
  - To enhance reality
    - Remembrance agent
    - Face recognition
    - Physically-based hypertext
    - Navigation aid
    - Augmented memory
- HMD
  - 2D HMD vs. 3D HMD
  - See-through HMD: video vs. optical
    - Head stabilized
    - Body stabilized
    - World stabilized

Increasing registration & tracking requirements

What's WearComp?

- See-through HMD:
  - Optical See-through
    - The AR overlay through a transparent display
  - Video See-through
    - Using video capture from head-worn video cameras as a background for the AR overlay

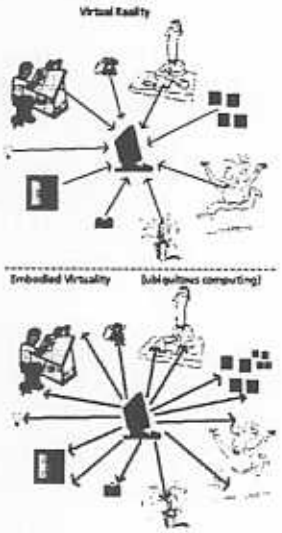


Optical See-through HMD

Video See-through HMD

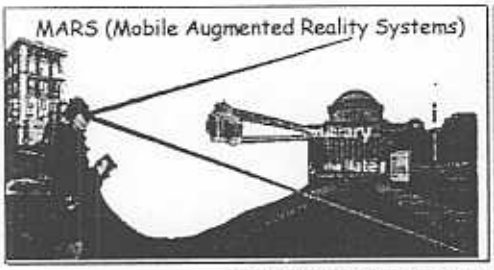
What's U-VR?

- VR vs. UbiComp
  - VR (there):
    - puts people in a computer-generated world
  - UbiComp (here & right now):
    - forces the computer to live out here in the world with people
- What's U-VR?
  - Back to real world !!!
  - U-VR = UbiComp + VR
    - HCI in mixed world (real + virtual)
    - ***Networked wearable AR***
    - Welcome! There are enormous fun challenges in U-VR world !!!



What's U-VR?

- Aimed at
  - Exploring the synergy of 2 promising fields
    - Ubiquitous computing/networking:
    - VR or Augmented reality (AR):
      - 3D displays are used to overlay a synthesized world on top of the real world

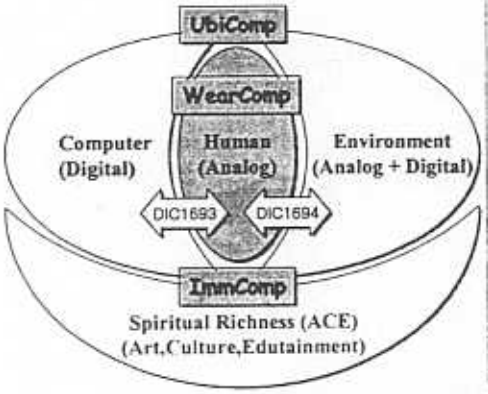


Hardware
- backpack computer
- differential GPS system
- head-worn display interface (w/ orientation tracker)
- spread spectrum radio communication link
- a small stylus-operated computer

Software
- Coterie
- http://www.cs.columbia.edu/graphics/projects/mars

KJIST U-VR Lab

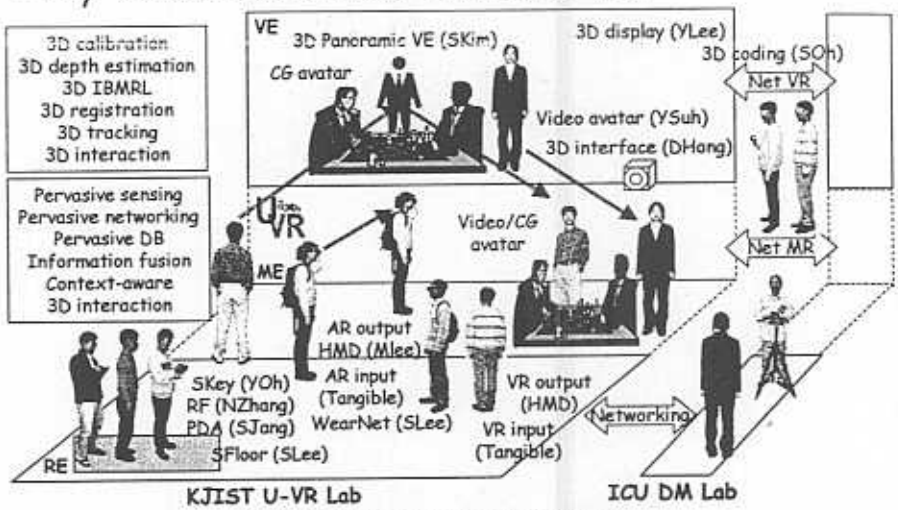
- Main focus of KJIST ***U-VR Lab***
  - Goal: to increase "Quality of Life"
  - **Focus: UPI for holistic smart environment**



- What's Holistic Smart?
  - Material & Spiritual richness
- What's UPI?
  - Ubiquitous computing/communications (Environment)
    - UbiComp: Pervasive sensing, Context-aware
  - Personalized computing/communications (HUMAN)
    - WearComp: AR for 3D HMD, Emotional agents
  - Immersive computing/communications (Interaction)
    - ImmComp: (Networked) I-cubed media systems

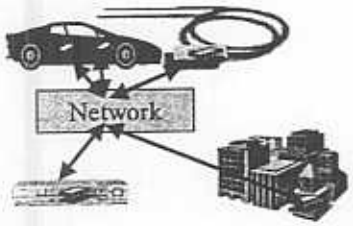
KJIST U-VR Lab

- My Vision: Let's move toward U-VR



UbiComp Challenges

- UbiComp/WearComp Challenges
  - **Sensing & Context-aware**
  - Interoperability
  - Security & Privacy
  - Interface:
    - HCI or Human Environment Interaction
  - Cost & **Killer Applications**



Context-aware

- Why context?.
  - Implicit interaction (vs. explicit)
    - Reduce the communication overhead for users
  - Human-centered smart services
    - Smart relationship btw user and computers
- What's context?
  - 5W-1H: who, what, where, when, how & why
- Difficulty
  - Where < Who < What < When < How << Why

Context-aware

- Context: what we'd like to know
  - Where
    - Are people within an environment?
    - Are people within a community?
    - Are objects within an environment?
    - Is someone looking?
  - Who
    - Who is within an environment?
  - What
    - What is that object in the environment?
    - What are people doing within an environment?

Context-aware

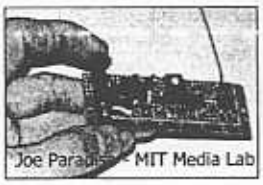
- Context: what we'd like to know
  - When
    - Did some action A occur before, after or during, action B?
    - What will people do next?
  - How
    - In what way did someone perform some action?
    - How are people in the environment feeling?
  - Why
    - What are people saying about their motivations?
    - How is emotional state impacting activity?
    - What are the reasons for people acting as they are?

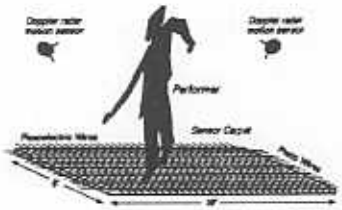
Context-aware

- How to aware context
  - Pervasive sensing: instrument a space with sensors
  - Context analysis
- Pervasive Sensing with Available Sensors
  - Embedded sensors
  - Tag-based people and object tracking
    - Indoor vs. Outdoor
  - Unencumbering object/people tracking
    - Visual sensing : Gesture/activity recognition
    - Acoustic sensing: Speech/sound recognition
  - Affective sensing

Context-aware

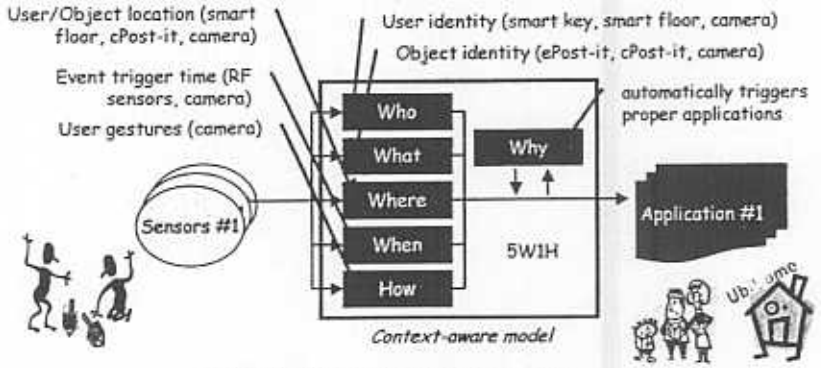
- Embedded sensors
  - Simple switches
  - RFID
  - IR tags
  - RF tags
  - Ultrasound tags
  - Visual tags





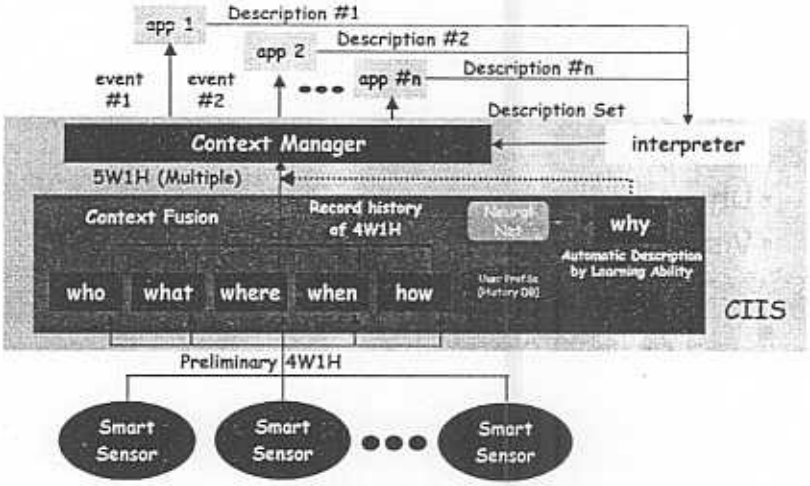
Context-aware

- How to find context?
  - Pervasive sensing:
    - E.g., Smart Floor/Key, ePost-it/cPost-it, etc.
  - Info fusion:
    - data, feature, decision, context fusion



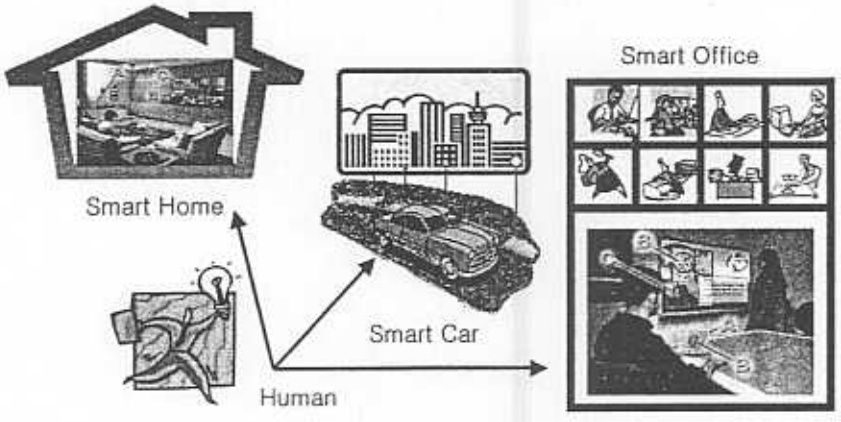
Context-aware

- CIIS: Context Fusion Model



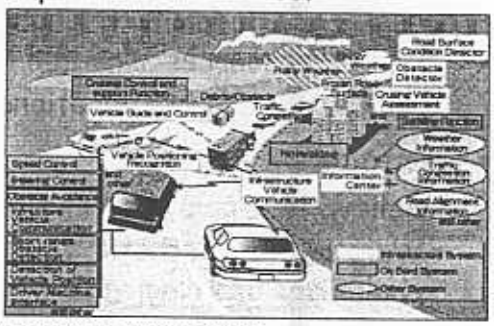
UbiComp Applications

- My Vision:
  - First, we will start with



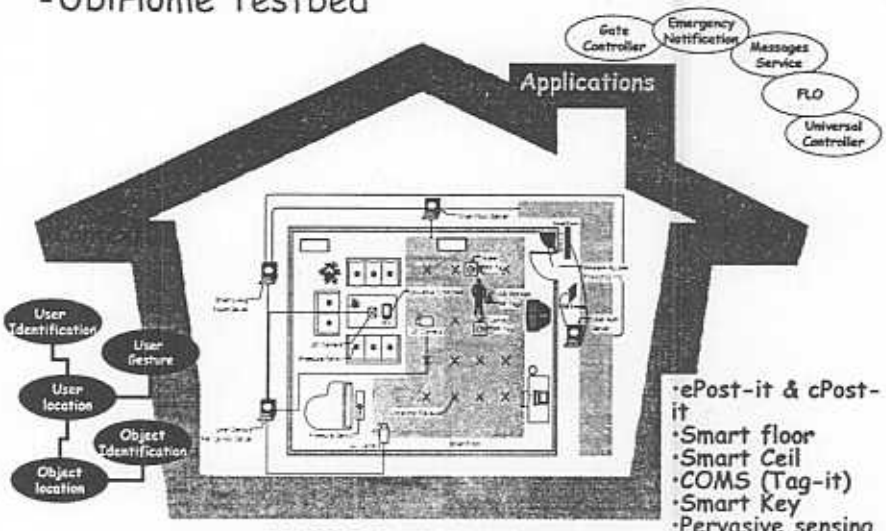
UbiComp Applications

- Why Smart Car?
  - Power/energy, cost, size/weight, UI, tracking, etc.
- Related Projects
  - Daimler Chrysle, GM, etc.
  - Will Consumers Accept Smart Vehicles?



UbiComp

- UbiHome Testbed



- ePost-it & cPost-it
- Smart floor
- Smart Ceil
- COMS (Tag-it)
- Smart Key
- Pervasive sensing (RF)

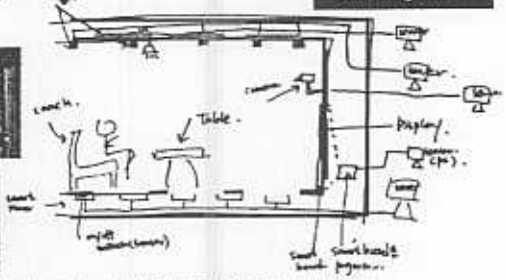
UbiComp Applications

- Why Smart Home?
  - People spend more time in their homes in any other space
  - Home provides a safe and comfortable space where to relax, communicate, learn and be entertained
  - Connect with family/friends, conduct business, manage resources, maintain health, etc.
  - Invest time, money, emotional energy, etc.
- Obstacles: People...
  - Believe that computer make life more complex
  - Wary of the aesthetic, financial and cognitive challenges of bringing new tech into their homes

UbiComp

- Concept: Box-in-the-Box
  - Room-type structure built inside a room
  - Key Mechanisms
    - Universal Device Attachment
    - Modular Wall/Ceiling/Floor Panel
    - Double Wall/Ceiling/Floor
    - Mobile Wall

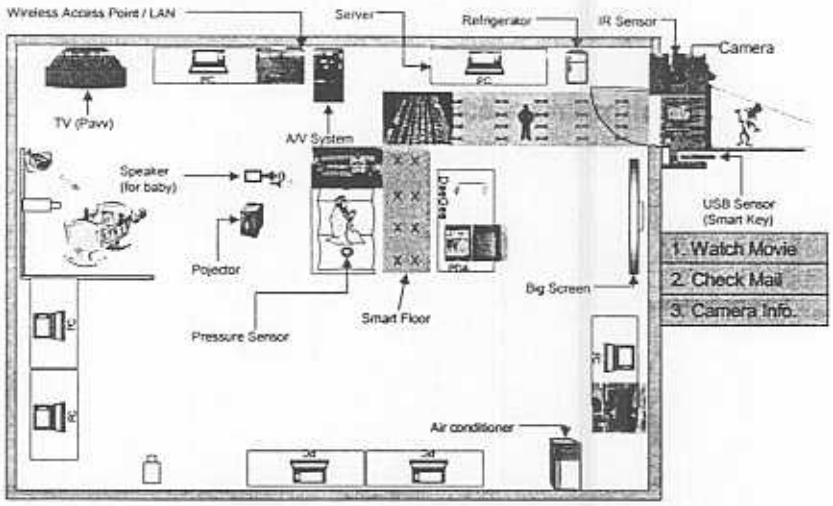
Box-in-the-Box



Figures from Smart Space Lab(SSL) Project, Keio University, JAPAN

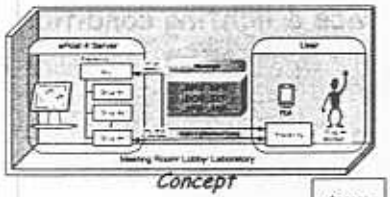
UbiComp Applications

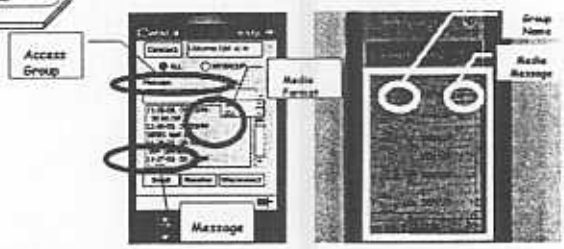
- UbiHome Testbed



UbiComp Applications

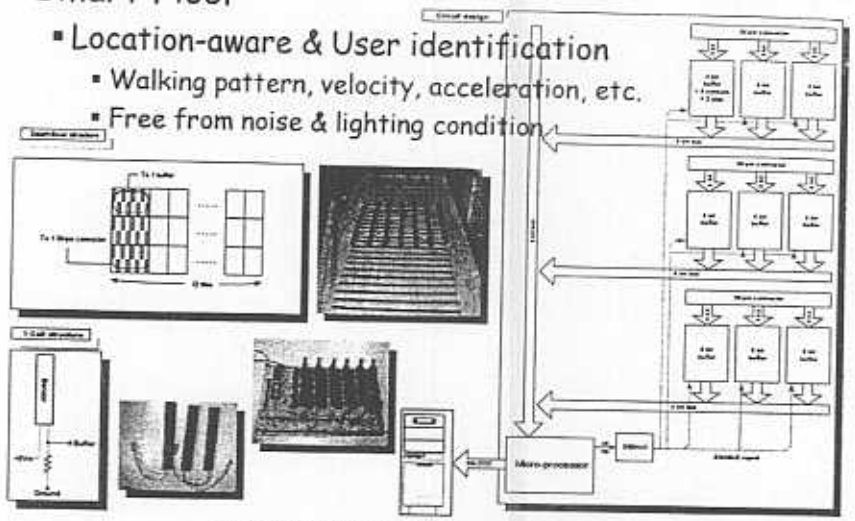
- ePost-it
  - to share media information with unspecified people in shared space





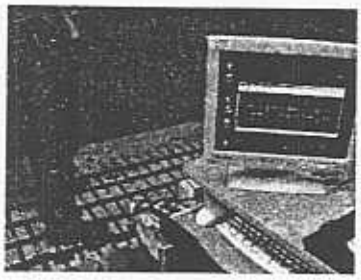
UbiComp Applications

- Smart Floor
  - Location-aware & User identification
    - Walking pattern, velocity, acceleration, etc.
    - Free from noise & lighting condition

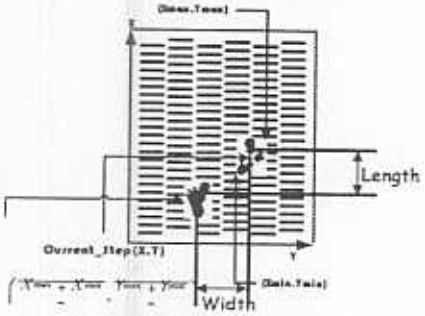


UbiComp Applications

- Smart Floor(2)
  - Location-aware & User identification
  - Two Step Information (Length, Width, Time, etc.)
  - Free from cumbersome device & lighting condition



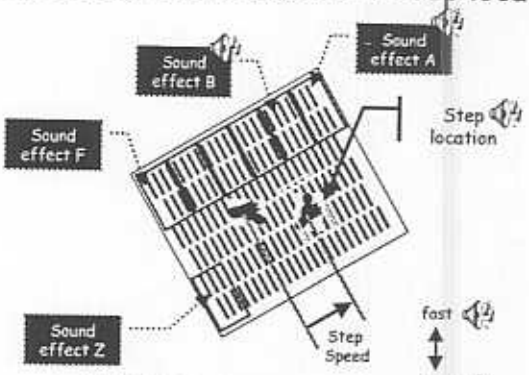
<Smart Floor System>



<Smart Floor Concept>

UbiComp Applications

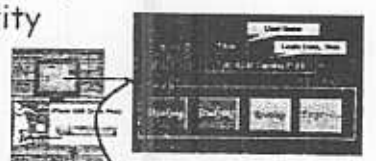
- Dance Floor
  - Application of Smart Floor
  - Play a background music based on step speed
  - Make an effect sound based on step location



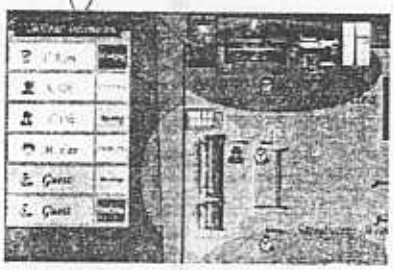
UbiComp Applications

- Smart Key with USB memory stick
  - To recognizes user's identity
  - To carry user's profile

Smart Key System

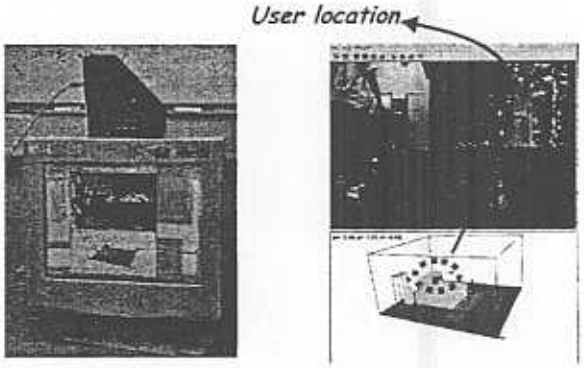


User Identification



UbiComp Applications

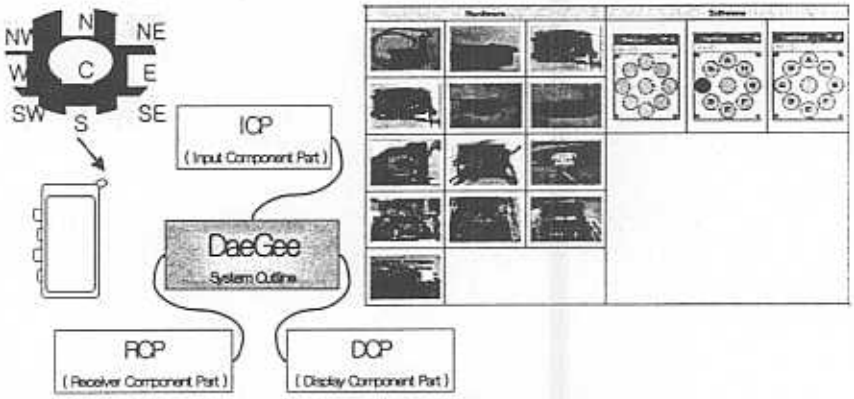
- Smart Camera
  - Track user's location in 3D space



3D Camera

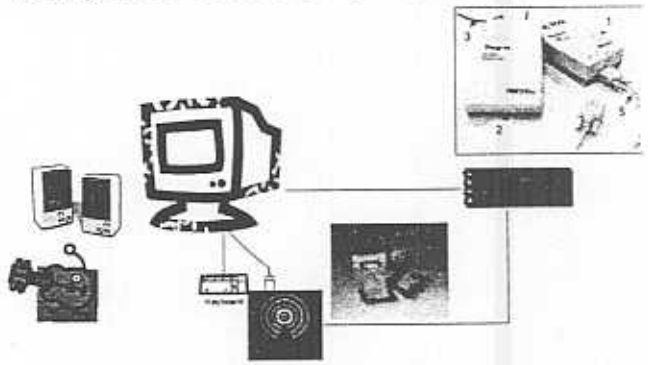
UbiComp Applications

- DaeGee
  - One Hand Multimode Input Device
  - Integrated controller + wearable input device



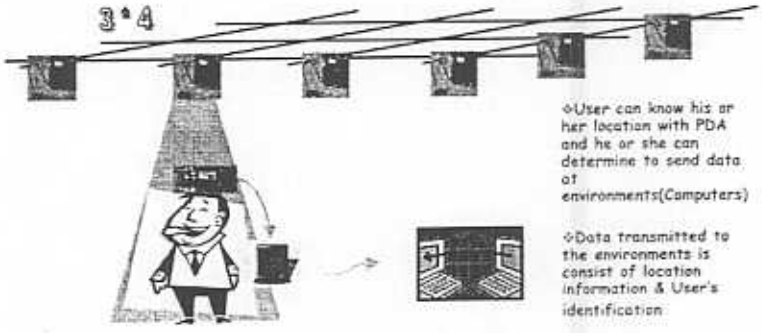
UbiComp Applications

- Tangible Music Player
  - Tangible CD Player can play a music when user just touches RF transponder into RF reader.
  - RF transponder contains information of the music.



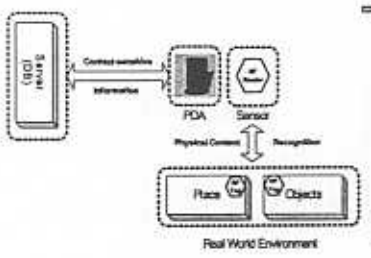
UbiComp Applications

- Smart Ceiling
  - User's Location-aware & identification
  - Object's identification
  - IR sensing -> User/Object Info. from PDA or DB

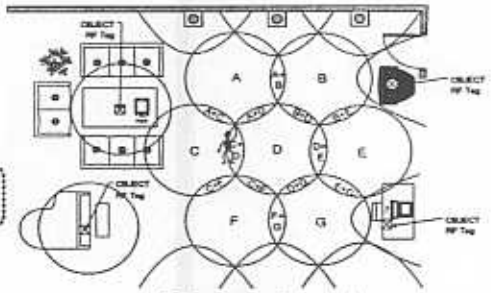


UbiComp Applications

- cPost-it
  - Context-based ePost-it: advanced ePost-it
  - Recognize object with RF sensor
  - Augment the object (real) with information (virtual)



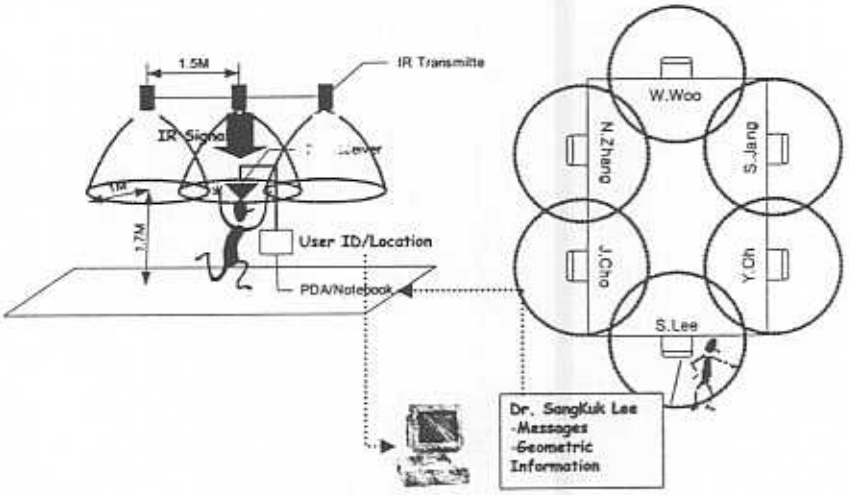
Concept



RF sensor Layout

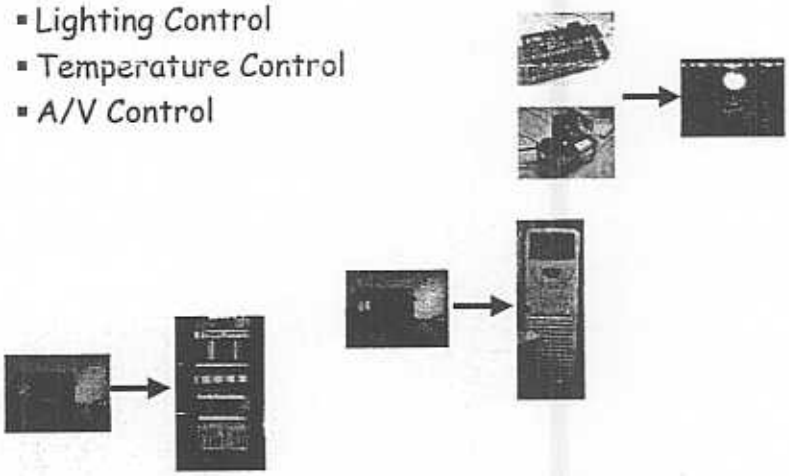
UbiComp Applications

- cPost-it



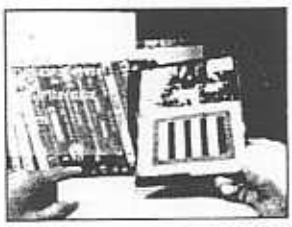
UbiComp Applications

- Controller for Home Appliances
  - Lighting Control
  - Temperature Control
  - A/V Control



U-VR Applications

- U-VR Testbeds
  - WearMIRS: Wearable Multimedia Information Retrieval Simulation System
    - Just-in-time media retrieval w/ video-see-through HMD
  - AR Keyboard: VKB (virtual keyboard)
    - Augment virtual keyboard & track finger position
  - Tele-Education System: Cooking Class



U-VR Applications

- Applications with HMD
  - Manufacturing
  - Medicine
  - Military
  - Architecture
  - Etc.


MAGIC


Context compass


Wearable Conferencing Spaces


Tinmith

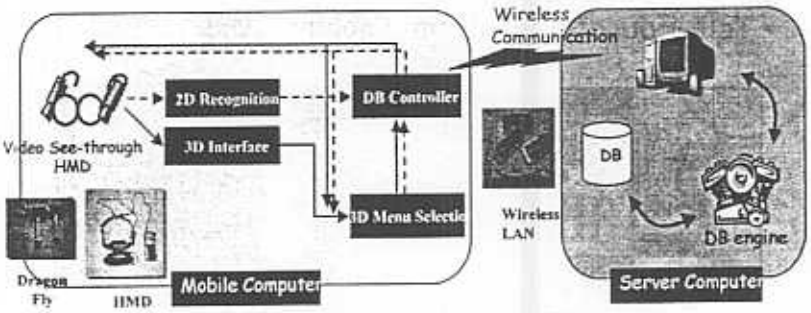

ARQuake


MARS (Columbia U.)


TOWNWEAR

U-VR Applications

- WearMIRS
  - Wearable Media Information Retrieval System
  - Context-awareness using a vision sensor
  - Natural Interface and interaction
  - Multimedia Information Retrieval



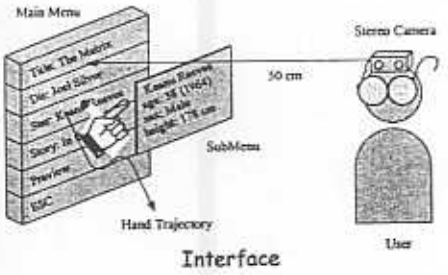
U-VR Applications

- WearMIRS: Interface/Interaction
  - Stereo Camera, Natural Interaction
  - 3D Video See-through HMD
  - Augmented Reality based on 3D Info.

Barcode recognition

Natural interaction

Video clip augmentation (far & near)



Interface

U-VR Applications

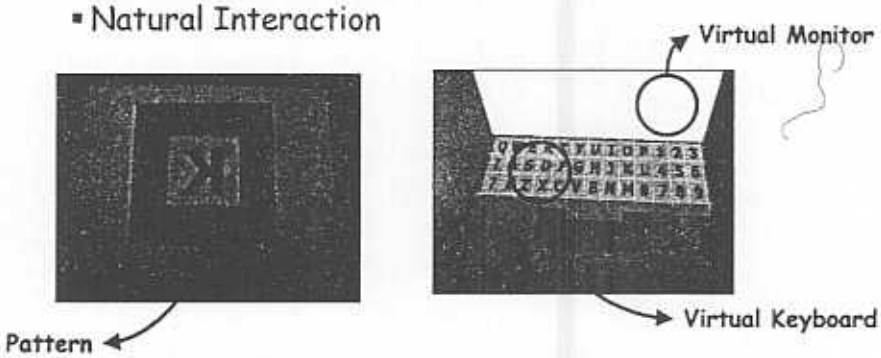
- AR Keyboard
  - Related works
    - SAIT Scurry™
    - VBK (virtual keyboard)
  - Concept
    - 3D Video See-through HMD
    - Physical keyboard is not necessary
    - Both hands are free
  - Procedure
    - Set reference points on a real object
    - Augment virtual keyboard
    - Recognize & track finger position
    - Execute corresponding tasks/sound generation

Scurry™

VBK (http://www.vkb.co.il/)

U-VR Applications

- AR Keyboard: Interface/Interaction
  - USB camera or IEEE 1394 camera
  - Augmented Reality using ARToolKit
  - 3D Video See-through HMD
  - Natural Interaction

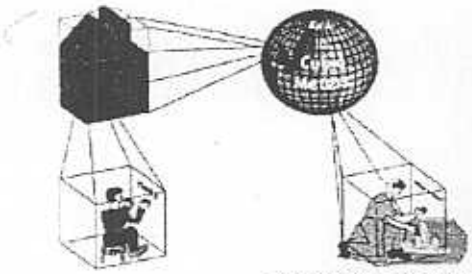


U-VR Applications

- Tele-education system
  - Concepts: for more effective educational env.
    Wearable Computing is needed!!
    - Merge real environment with instructions
    - User can get the lectures anytime and anywhere
  - Example Scenario: Cooking Class

U-VR Applications

- What comes after the WWW?
- WorldBoard (UW):
  - A planetary AR system associating info w/ places
  - Goal: to allow users to
    - post messages on 6 faces of cubic in space
    - experience any info. in any place registered with reality



U-VR Applications

- WorldBoard: 4 primary components
  - Pervasive Computing
    - a continuum from laptop PC to wearable computers to computers embedded in the environment
  - Positioning Proximity Detection Systems
  - Input/Output
    - Mediated and Augmented Reality
  - Channels/Filters/Searching
    - Personalization of Interactions and Data

U-VR Applications

- Location-aware Applications
  - Why?
    - Systems for obtaining information about the surrounding environment are the most popular type of context-aware applications
    - Car navigation systems using GPS
    - Location-based information services with Mobile phone
  - Applications
    - Museum & Exhibition
    - Finding people: family, friends, etc.
    - Tour guide
      - restaurant, etc.

U-VR Applications

What about Military Applications?

U-VR Applications

- WearComp @ GATECH

Wearable computers
The U.S. militarys Land Warrior prototype s
gear and computer hardware.

Radio/CPU
GPS locator device and radio are built into backpack computer, powered by rechargeable battery.

Weapon System
Modified M-16 or M-4 carbine has a daylight video scope that allows the soldier to use the gun as a video camera with helmet display.

Head-Mounted Display
Shows battle plans and soldier positions transmitted over a wireless network. With headset and microphone.

Soldier Control Unit
System interface is strapped to the chest, with buttons also mounted near weapons trigger finger.

Source: Department of Defense AP

UbiComp

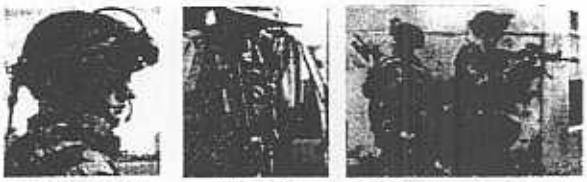
- WearComp @ GATECH
  - Cloth (video)
  - Shoes (quicktime)

U-VR Applications

- Moving to The Battlefield
  - ISR: 감시 정찰
  - C4I: 지휘 통제 (Command, control, comm., computer, info)
  - PGM: 정밀타격
- How to?
  - 지능화: 전투장비, 무기, 군수물자, 군사시설의 지능화
  - 네트웍화: 군사훈련, 국방/전술 공간의 넷트웍화
- Why UbiComp?
  - 전술적 센싱 추적 능력 확대:
    - 사람과 사물의 상태변화 감시와 상태의 실시간 추적
  - 고도화된 전술적 지식의 교환 공유 가능
    - 아군과 적군의 군사사물에 대한 상태변화 정보를 다차원적으로 제공
  - 전술부대의 커뮤니티 파워 증대
    - 군사작전 수행에 필요한 실시간 정보 커뮤니케이션을 구현

U-VR Applications

- Moving to The Battlefield
  - Why do we need ubiComp in a military engagement?
    - We need technology that provides the right information to the right people at the right time in the right form in a distraction interaction
    - The Army Land Warrior Program[6]



(a)T&DCS (b)SCU (c) demonstration

How can the war fighter use all this equipment while focusing his attention on the mission and staying alive?

U-VR Applications

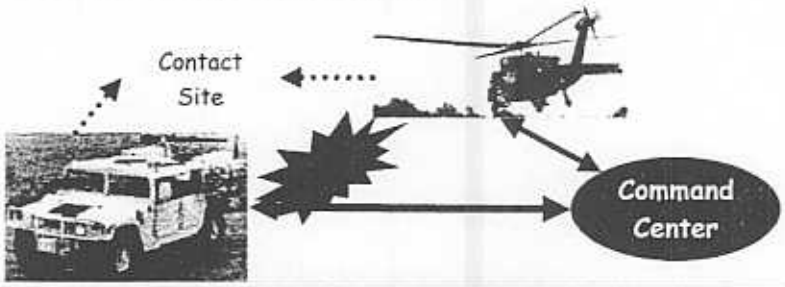
- Moving to The Battlefield
  - Why do we need ubiComp in a military engagement?
    - The Army Land Warrior Program[6]
  - How would ubiComp help the war fighter?
    - How information can flow to the war fighter such that the least possible cognitive load is needed to obtain and utilize that information
    - Portable computers?
      - Smaller, lighter, easier to use
      - interaction through voice and HMD
    - War fighter's situations/need can change rapidly
      - Operate in daylights, darkness, noise, and silence
      - Heat, cold, hunger, fatigue, stress affects the ability to use information devices

U-VR Applications

- Moving to The Battlefield
  - Why do we need ubiComp in a military engagement?
  - How would ubiComp help the war fighter?
    - What information is delivered, the amount of information delivered, and the modality used for delivery
    - The war fighter should not have to continually request information
      - Information that is critical to his situation should be automatically retrieved and delivered
    - Network?
      - Current network models are designed for static environment

U-VR Applications

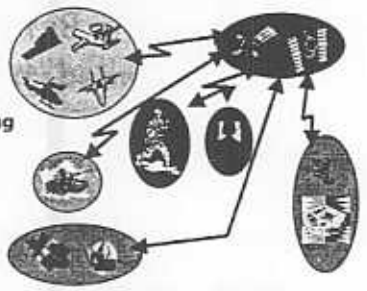
- Moving to The Battlefield
  - Why do we need ubiComp in a military engagement?
  - How would ubiComp help the war fighter?
  - Scenario: Black Hwak Down[7]



The appropriate information is vital to increasing the lethality & survivability of the force

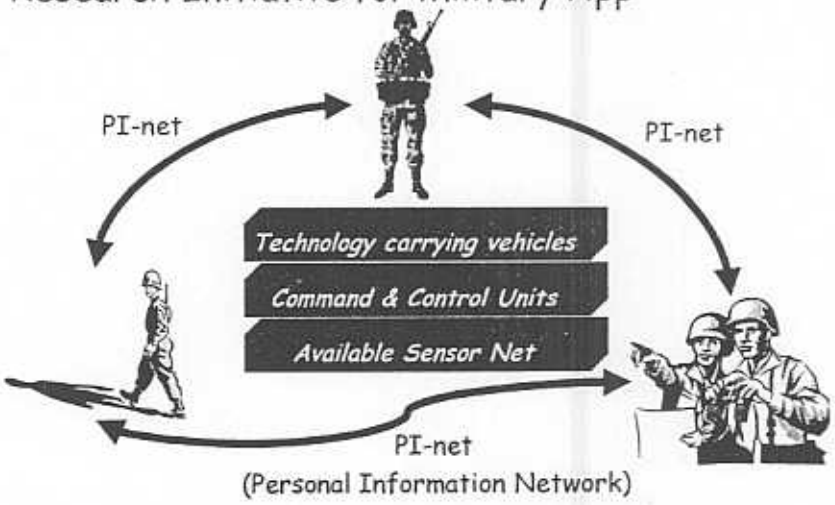
U-VR Applications

- Moving to The Battlefield
  - **Lethality**
    - Accurate weapons using thermal info
    - HMD for detecting, recognizing, and aiming at target
  - **Survivability**
    - Alert system of danger
    - Protect soldiers (bulletproof vest)
    - Cooling/heating system
    - Monitoring soldier's vital signs, wound
  - **Mobility**
    - Modular components (clothes, devices)
    - Light-weight system
    - Land-mine detecting system
  - **Sustainment**
    - Food, water cleaning, power supply system
  - **Command & control**
    - Voice & data communication
    - GPS, digital map



U-VR Applications

- Research Initiative for Military App



U-VR Applications

- Research Initiative for Military App
  - To reduce the barrier to information access
  - To support seamless, nomadic use
    - Methodology for representing/monitoring the environments
      - Allows the task to migrate from one set of resource to another
    - Capability of running on vastly diverse platforms
      - Supports the migration of tasks among highly diverse devices/OS
    - Automating replication, migration, and consistency of data with a virtual information space
      - Provides nomadic data access

U-VR Applications

- Research Initiative for Military App
  - The architecture and architectural components
    - to support a vast array of heterogeneous devices & resource constraints in a dynamic and hostile environment
  - Monitor of the systems
    - To manage the situational information & to support mobility
  - Self-organization
    - Composition of heterogeneous object at the device & network level
  - Resource management
    - Respond to the dynamic environmental changes
  - Connectivity
    - Prioritization algorithm & algorithm for intermittent connectivity
  - Self-configuration
    - The personal body network carried by the warrior
    - The larger network btw the individuals and their mobile spaces

U-VR Applications

- Research Initiative for Military App
  - Proactive HCI
    - The current model of interaction
      - All tasking is done explicitly by the user
    - Ubiquitous/Wearable computing
      - Enable the computer system to make UI, based on sensory input, about the user's information needs and meet those needs without explicit intervention
      - Provide technologies to recognize user intent and to provide the appropriate actions
  - Sensing & context-aware
    - to support fusion, abstraction, and inferencing from a number of sensors along with mission and task information

Summary & Discussion

- Summary:
  - U-VR: When UbiComp meets VR
    - My vision: What happen in 10 years?
    - What's UbiComp & WearComp?
    - What's U-VR? Why? & How?
  - U-VR Applications

Thank You!

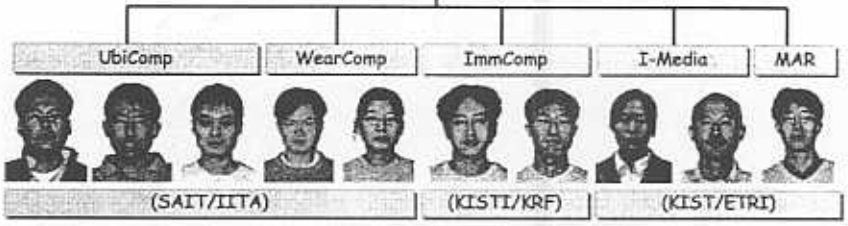
Summary & Discussion

- Discussions & More information
  - Woontack Woo,
    - KJIST U-VR Lab, Gwangju 500-712, S. Korea
    - mailto:wwoo@kjist.ac.kr
    - T. (062) 970-2226
    - F. (062) 970-2204
  - Web: http://vr.kjist.ac.kr

Thank You!

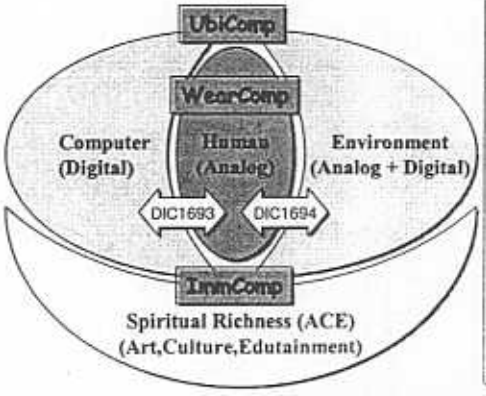
KJIST U-VR Lab

- KJIST U-VR Lab (Since Feb. 2001)
  - Members :
    - 1 faculty member
    - 3 Ph.D candidates
    - 7 M.S. candidates



KJIST U-VR Lab

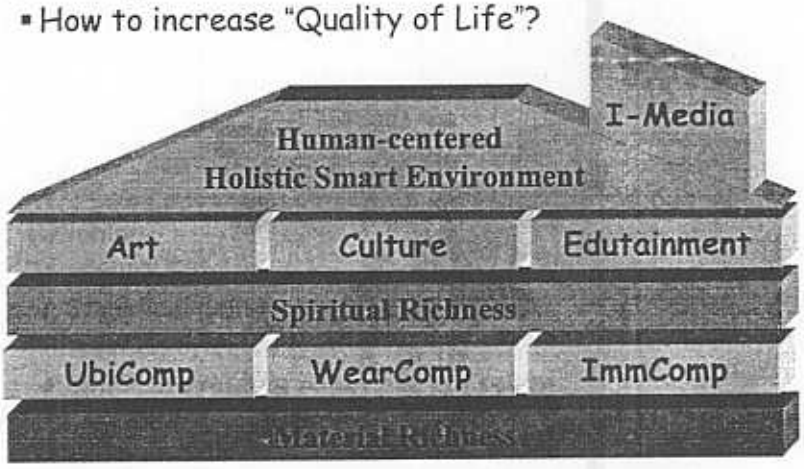
- Main focus of KJIST ***U-VR Lab***
  - Goal: to increase "Quality of Life"
  - **Focus: UPI for holistic smart environment**



- What's Holistic Smart?
  - Material & Spiritual richness
- What's UPI?
  - Ubiquitous computing/communications (Environment)
    - UbiComp: Pervasive sensing, Context-aware
  - Personalized computing/communications (HUMAN)
    - WearComp: AR for 3D HMD, Emotional agents
  - Immersive computing/communications (Interaction)
    - ImmComp: (Networked) I-cubed media systems

KJIST U-VR Lab

- Strategy
  - How to increase "Quality of Life"?



Reference

[1] Jean Scholtz,"ubiquitous computing in the military environment", http://www.darpa.mil/ito/research/uc/SPIE-f.pdf
[2] http://research.microsoft.com/easyliving/
[3] http://www.research.ibm.com/thinkresearch/pervasive.shtml
[4] http://cooltown.hp.com/cooltownhome/index.asp
[5] http://tangible.media.mit.edu/
[6]http://www.army.mil/soldiers/dec2000/pdfs/awe.pdf
[7] http://www.apple.com/trailers/columbia/black_hawk_down/
[8] http://www.cs.cmu.edu/~aura
[9] http://endeavour.cs.berkeley.edu
[10] http://www.cc.gatech.edu/projects/infosphere/
[11] http://lazowska.cs.washington.edu/presentations/portolano.ppt