Human Pacman: A Mobile Entertainment System with Ubiquitous Computing and Tangible Interaction over a Wide Outdoor Area

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Outline

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3. System Design and Game Play
4. Human-Computer Interface Issues
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Background

- Derived from work on ubiquitous computing
- Pirates! Played on PDA's with proximity sending technology
  - Little immersive experience and no Augmented Reality (AR) or Virtual Reality (VR)
- Previous work in AR include AR2 Hockey, AquaGuantlet
  - Small space with limited movement and interaction
- ARQuake is an AR-extension of Quake with wearable computers with GPS and can be played indoor/outdoor
  - Single player with little social interaction
- Transitioning between Reality-Virtuality continuum
  - The Magic Book
  - Touch-Space

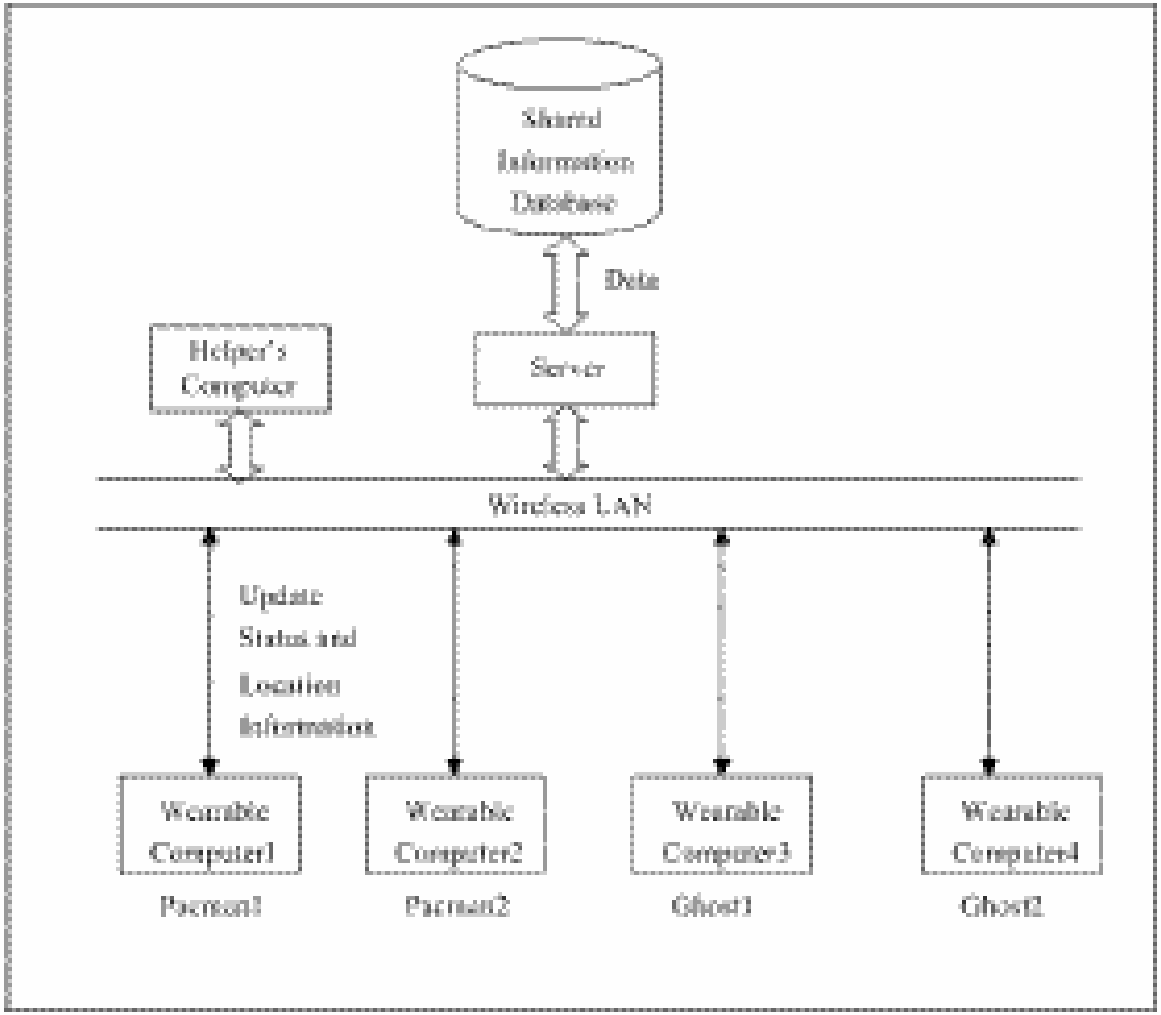
Novel Features of Human Pacman

- Physical Gaming
- Social Gaming
- Mobile Gaming
- Ubiquitous Computing
- Tangible Interaction
- Outdoor Wide-Area Gaming Arena
- Seamless Transition between real and virtual worlds

System Design and Game Play

- Centralized architecture
- Four main entities
  - Central server
  - Wearable computers
  - Laptops
  - Bluetooth embedded objects
- Underlying program built on client-server

System Architecture

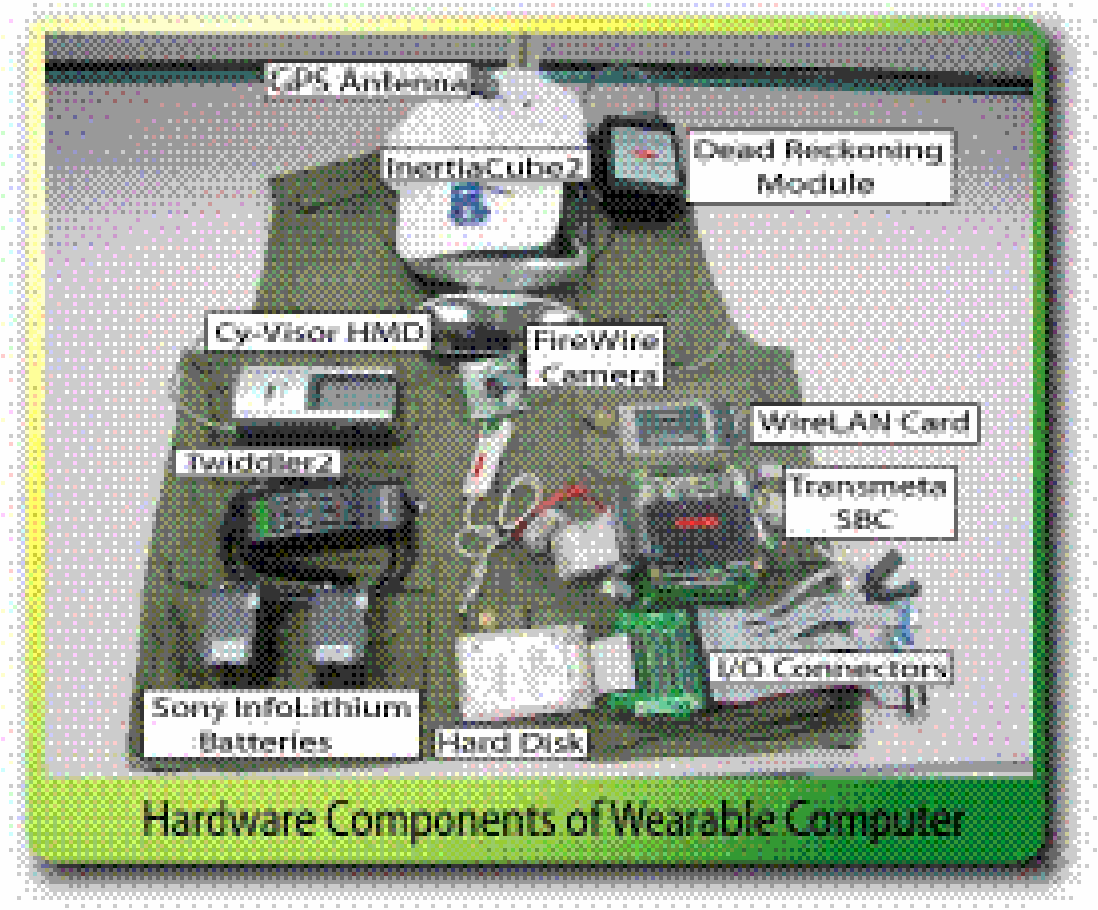


System Architecture Details

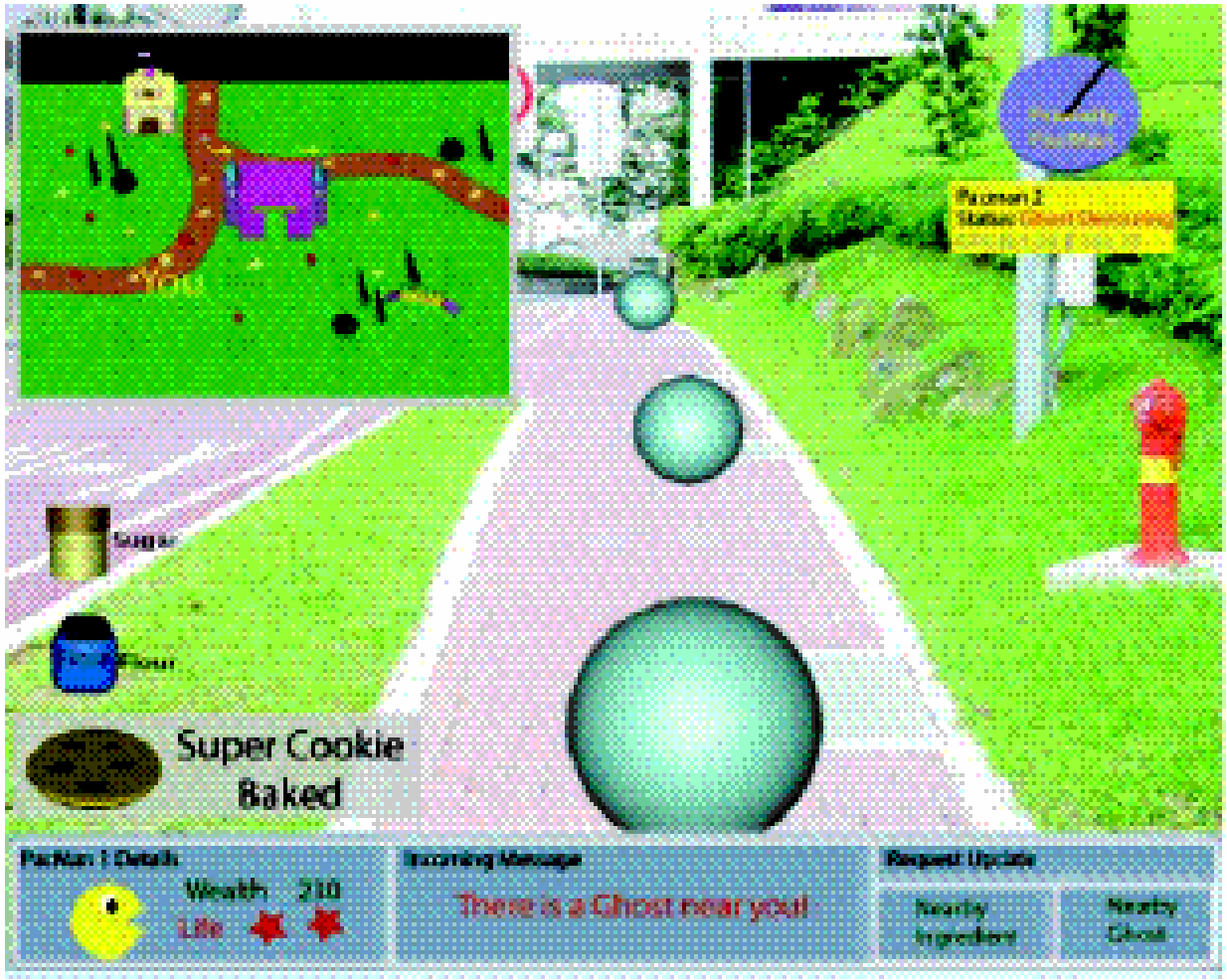
- Underlying program built on client-server architecture
- Clients are wearable computers & laptops
- Server is a desktop computer communicating via wireless LAN
- Players' physical location and status is updated on a regular basis to server
- Server maintains current player information and facilitates communication between players and Bluetooth-enabled objects

Wearable Computer

- Motherboard and Crusoe processor
- Handheld keyboard & mouse
- Head-mounted display with firewire camera
- Inertia sensor
- GPS and dead-reckoning device
- Bluetooth device



First-person View



Main Concepts

- Team Collaboration: Each Pacman/Ghost is in coalition with one Helper
- Ultimate Game Objectives: Similar to traditional Pacman: collect all virtual plain cookies while avoiding ghosts
- The Nature of Pac-World: dualistic fantasy world with both Augmented Reality (AR) and Virtual Reality (VR)
  - Pacman and ghosts can switch between two modes, while helpers can only view in VR mode
  - Real-time link between physical world and virtual world

Views of picking up sugar jar

Pacman, Ghost and Helper

- Pacman moves about physically in AR mode, collecting (virtual) cookies, finding and collect (physical) ingredients
- Ghosts track down and devour Pacman by tapping shoulder capacitive sensor pad
- Physical touch interaction exemplifies tangible physical interaction between humans
- Helper is a new character who acts as advisor for Pacman or Ghost

Player and Helper

- Informs player of positions of enemy units and special ingredients
- Relays other important information
- Promotes collaboration and interaction between humans

Actual Game Play

- Starting the game – Pacmen and Ghosts start from different physical locations
- Collection of plain cookies – Physical player walks through cookie and corresponding AR and VR cookies disappears
- Devouring Enemy Players – Physically touch enemy's capacity sensor pads
- Ending the game – When either team meets their goal or time limit of ten minutes

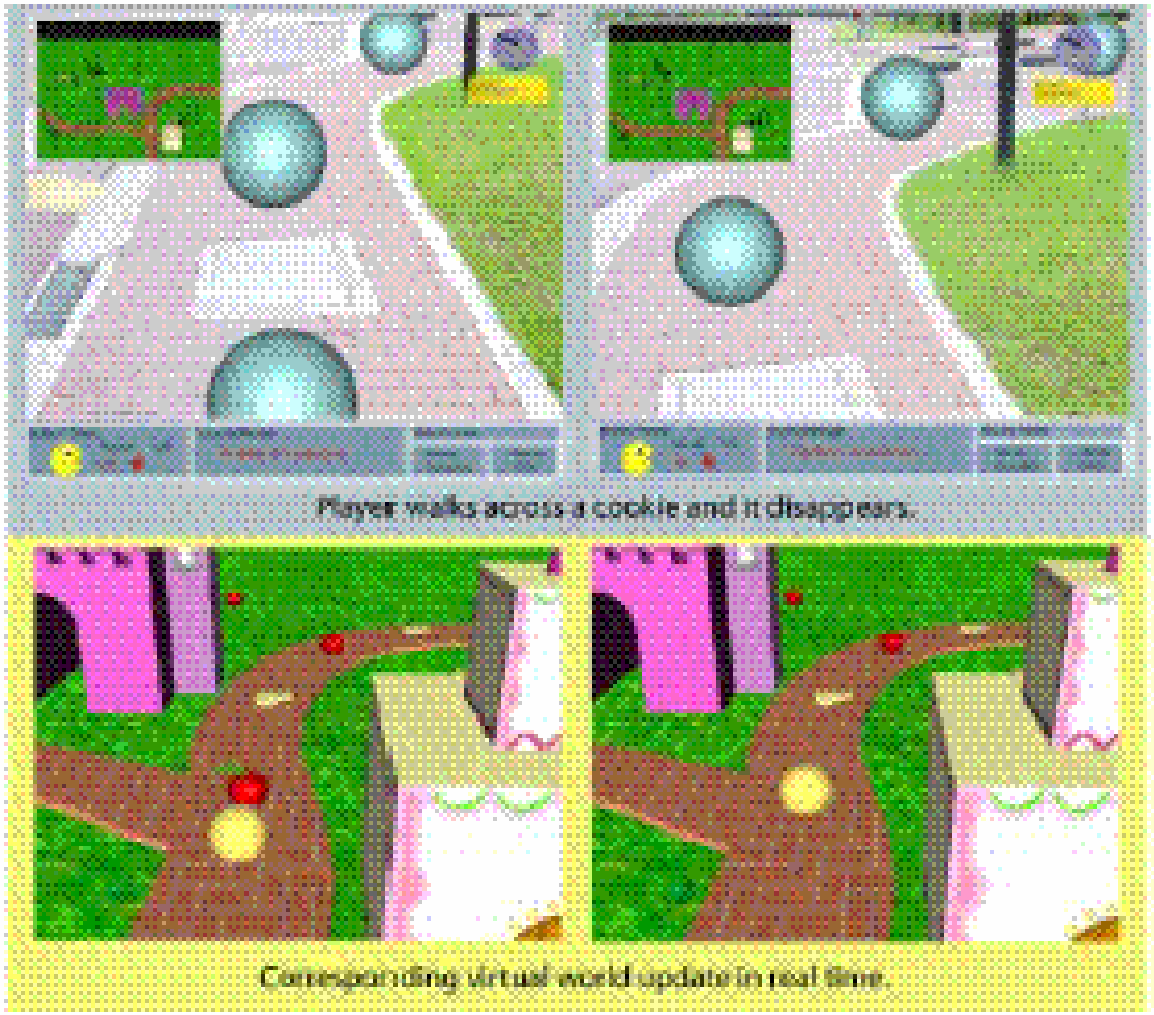
Ingredients

- Ingredients include flour, butter, sugar and "special" ingredients such as chocolate chip and almond to make "special" cookies (butter and super)
  - Butter cookie → 1 minute immunity from ghosts
  - Super cookie → 30 seconds lag then 3 minutes of ghost-devouring power
- When Pacman is within 10 metres of object, they are notified and can begin to hunt for it
- Pacman picks up object, which sends message to players wearable computer, which sends corresponding message to server

Collaboration between players

- Pacman/Ghost and Helper Collaboration
  - Helpers have complete view of Pac-world including positions of all players and ingredients
  - Helpers collaborate among themselves to achieve team goals
- Pacman and Pacman Collaboration
  - Exchange ingredients between Pacmen
  - Not allowed to transfer special cookies

Corresponding AR and VR Views



Problems in Implementation

1. Disconnection in communication often interrupts flow of the game

2. Bandwidth limitations constrains type of multimedia transmissions

3. Unstable outdoor conditions results in high-error rate in the network

Solutions:

- Carefully select area for game play
- Embedded components can process and store local data

Implementation Considerations

- Maintaining power to wearable computers
  - All mobile computing devices require power
  - Not a big problem since game duration is very short
- Disadvantages of using the head-mounted display
  - Hassle of wearing headgear
  - Low-resolution
  - Eye-fatigue
  - Dim-lighting conditions
  - Also not major issue since game duration is short

Tangible Interface

- GUI's still dominant paradigm for interactions with computers
- Computer-Augmented Environments started visions of merging electronic systems into the physical world; followed up by various projects including "Brick", "Tangible Bits" and "mediaBlocks".
- In Human Pacman, the Tangible Interface is explored by using Bluetooth devices and capacitive sensors
- Bluetooth devices support automatic device discovery → detection of close physical proximity
- Capacitive sensors detect physical touch actions

Context Awareness in Outdoor Environments

- Pioneered at Olivetti Research and Xerox PARC
  - Active Bade System and PARCTab
  - Expensive and confined to indoor area
- Emergence of cheap GPS and networked sensors has resulted in similar projects
  - Most use primitive 2D maps and text-based informational displays
  - Smart Sight (tourist assistant) included audio/visual navigational aid around campus, but relied on laptops
- Human Pacman captures Context Awareness in 3 ways:
  - Location awareness GPS and DRM
  - Perspective awareness from Inertia device
  - Information context from omniscient helper player

Addressing Human-Computer Communication Challenges

- **Address:** How do I address one (or more) of many possible devices?
  - Bluetooth devices have unique address
- **Attention:** How do I know the system is ready and attending to my actions?
  - graphical feedback in HMD is highly effective for displaying messages/status
- **Action:** How do I effect a meaningful action, control its extent and possibly specify a target or targets for my action?
  - induced by touch or by clicking on-screen icons

Addressing Human-Computer Communication Challenges (2)

- **Alignment:** How do I know the system is doing (has done) the right thing?
  - real-time graphical feedback
- **Accident:** How do I avoid mistakes?
  - most actions are very “obvious” – i.e. have to physically pick up an ingredient

Conclusion

- Physical and mobile gaming is gaining popularity over traditional PC or TV-based gaming
- Mixed-reality games that allowed transition between reality and AR or VR
- Tangible interfaces and physical interactions between human players
- Social gaming and collaboration is appealing
- Can be extended to educational applications, i.e. “learn by experience” simulations

Discussion

- Social/cultural issues?
  - Now that “physical touch” is part of the game, to what limits can we use this?
  - i.e. can physical domination be used to win games?
- Issues with outdoor environment
  - Unpredictability
  - Danger
- What other physical other interfaces could be used to increase the user experience?
  - i.e.. Force-feedback haptics