Wearable Computers and Augmented Reality

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Outline

- Wearable computers
  - Overview
  - Research issues
- Augmented reality
  - Components
  - Applications
  - Research issues

Wearable Computers

- Battery-powered PC on belt
- Head-mounted display
- Speech input
- Wireless communication

Application Premises

Tool Model
- Application specific
- Worn only while doing a certain job
- Hands-free requirement

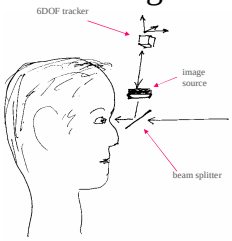
Clothing Model
- Worn all day; used all day
- Wide variety of applications
- User sometimes unaware of application

Research Emphases

Tool Model
- User interface design
  - Speech input
  - Eye tracking
- Development issue: creating/transforming application data

Clothing Model
- Packaging; incorporating into clothing
- Battery life
- AI, agent technology
- Activity inferencing
- Image processing
- Design of keyboard or keyboard substitute

Augmented Reality



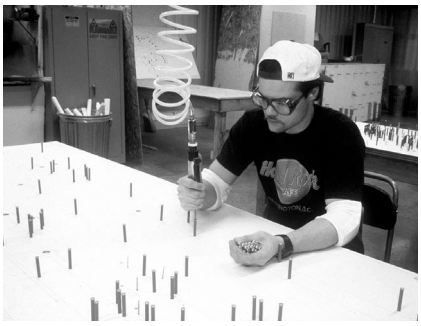
- Wearable computer
- See-through head-mounted display
- 6DOF head position/orientation tracker

Superimposes and *stabilizes* computer-generated information upon specific coordinates of the real surroundings.

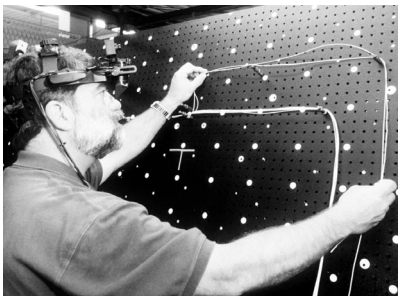
An example: aircraft wire bundle assembly at Boeing

Formboard storage

Formboard rework



The AR "generic" formboard

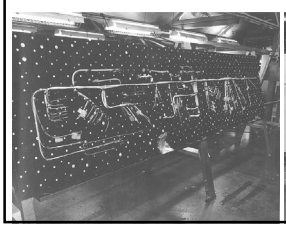


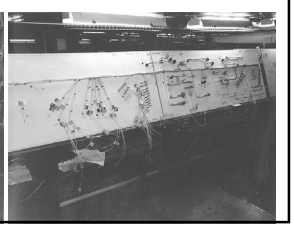
experiment in the Boeing Everett factory, summer 1997

- six-week experiment
- wire shop & mockup shop workers
- AR vs. traditional bundle forming
- TriSen optical tracker & see-through HMD
- Via II wearable computer (in vest)

Summary of Results

It worked. We could assemble bundles on the AR formboard, move them over to the traditional formboard, and they would pass QA inspection.

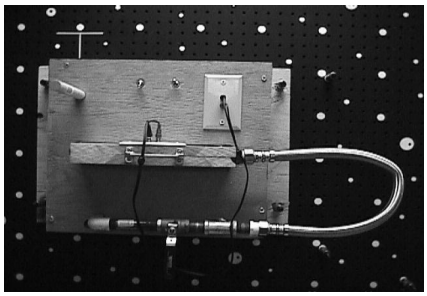


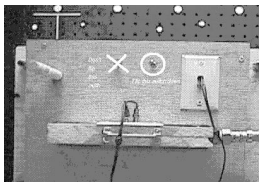


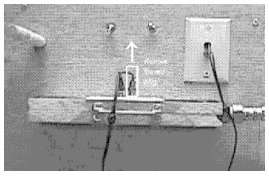
Results…

- Productivity was no higher. Clearly fault of the user interface.
- Wide disparity of user acceptance levels. Women hated the HMD.
- Intriguing anecdotal evidence of training benefits

AR-for-Maintenance Lab Demo





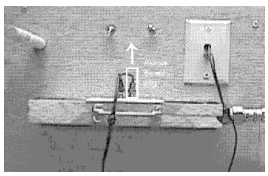


Applying Augmented Reality to Maintenance

- Potential to guide minimally-trained mechanic through a complex maintenance procedure
- The ultimate in "just-in-time" training -- occurs during the maintenance procedure, on the real item being maintained
- Good fit for the military -- complex equipment, maintainers expensive to train, hard to keep – also for Space Station: on-orbit training for astronauts
- Requires portable, easily-deployed & registered tracker system, comfortable see-through head-mounted display

Also notice:

- The "minimalist" nature of the annotations.



AR research issues

- Tracker design
  - At 50 Hz., track head xyz position to 1 mm., roll-pitch-yaw orientation to .1 degree
  - 2+ m. range (near term)
  - Robust
  - Portable
  - Easy to set up/calibrate
  - cheap

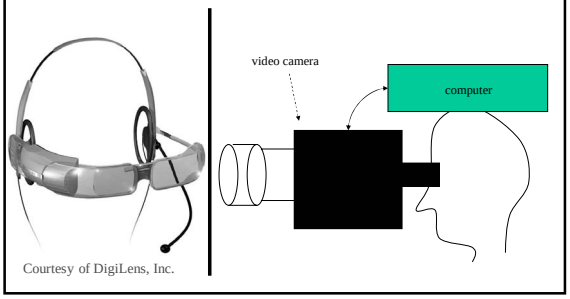
Trackers – what's available now

- Magnetometers – AC and DC
- Acoustic-inertial hybrid
- Optical-inertial hybrid
- Videometric
- "ultimate" tracker: track against real environment; no fiducial marking

AR research issues (2)

- Authoring system
  - Use real object and AR
  - Use CAD model of object and VR
- User interface
  - What to show the user
  - How user should give input to system
- AR display design

AR display design: optical see-through vs. video see-through



Courtesy of DigiLens, Inc.

AR display design: advantages of optical see-through and video see-through

Optical

- Higher-resolution (now)
- Lightweight
- Higher frame rate (now)

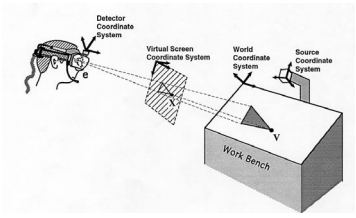
Video

- Work in image domain
  - Pixel resolution
  - Partial occlusion
- Eliminate "image rivalry"

AR research issues (3)

- Registration: establish fixed relationship between tracker coordinate system and real-world coordinate system, and between tracker coordinate system, display, and user's eye
- Calibration: use objects in known world coordinates to adjust for systematic tracking or display errors
- (these terms often blurred together in AR research, and referred to as "calibration")

Registration: the basic idea



$$V_V = (T_{VD} \bullet T_{DS} \bullet T_{SW}) \bullet V_W$$

which pixel on display to illuminate — detector to virtual screen of display — dynamic – this is what tracker gives you — world coordinates to tracker source coordinates – fixed at setup time — point in real world coordinates

Also needed: e_V : coordinates of eye in virtual screen coordinates

Summary

- Inherently multi-disciplinary research
  - CS – interface design
  - Physics – tracker design
  - Physiology; optics – HMD design
- And you get to wear funny hats!