Assistive Wearable Technology

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Assistive Wearable Technology: Principles

Measure
Sensors

Deduce Activity/Environment
Walking? Dancing? Reading? Driving?

Application
Help React Record
# Assistive Wearable Technology

## Portability
- Lightweight
- Low-Power
- Unobtrusive

## Sensors
- Cameras
- Microphones
- Electrodes
- Accelerometers
- Gyros
- Bending Strips

## Applications
- Traffic
- Office
- Home
- Industry
- Enhance Gestures
- Disabilities
- Sports
- Medicine
- Military
Assistive Wearable Technology: Papers

- Wearable EOG Goggles
- Improving Hearing Aids
- Activity Tracking in Car Manufacturing
Wearable EOG goggles:

Seamless sensing and context-awareness in everyday environments

Andreas Bulling, Daniel Roggen, Gerhard Troster

Wearable EOG goggles: Seamless sensing and context-awareness in everyday environments
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Eye tracking: Different Methods

Video based

Eye attached reflector

Electrooculography

Eye see cam

Contact Lens

Bulling, 2011
Electrooculography

- Eye as electrical dipole
  - Varies with light
- Electrodes can determine eye movements
- Only rough directions
Aside: How Eyes Work

- Periods of gaze fixed on target (Fixations)
- Very fast twitch between fixation points (Saccades)
- “Random” twitches for scanning
- Blinks

Eye movement when scanning a face²
Wearable EOG goggles: Hardware

- **Sensors:**
  - 4 Dry electrodes
  - 1 Light sensor
  - 1 Acceleration sensor

- **Data Processing:**
  - Signal amplifier in goggles
  - Data processing unit on body
Eye Tracking: Data Analysis

Data Acquisition
- 4 Electrodes per eye
- Accelerometer
- Light Sensor

Preprocessing
- Calibration
- Drift Compensation

Event detection
- Blinks
- Fixations
- Saccades

Classification
- Activity
- Gesture
Experiment: Eye gestures

• Event detection generates String
• Match String to defined Gestures
Experiment: Recognize Reading Activity
Experiment: Recognize Reading Activity

<table>
<thead>
<tr>
<th>Mode of locomotion</th>
<th>Precision (%)</th>
<th>Recall (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sit</td>
<td>90</td>
<td>70</td>
</tr>
<tr>
<td>Stand</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>Walk</td>
<td>90</td>
<td>60</td>
</tr>
</tbody>
</table>

Legend:
- precision
- recall
Other Recognizable Activities

- Recognize
  - Web browsing
  - Watching video
  - Driving
  - Remembered face ⇔ New face
Wearable EOG Goggles: Conclusions

+ Many activities detectable
+ Good Precision
+ Cognitive process visible
- Glasses, cables, belt
- Size limit to electrodes
- No “Killer app”
Improving Hearing Aids with Wearable Sensors

Bernd Tessendorf, Andreas Bulling, Daniel Roggen, Thomas Stiefmeier, Manuela Feilner, Peter Derleth, and Gerhard Troster
Recognition of Hearing Needs from Body and Eye Movements to Improve Hearing Instruments
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How Hearing Aids Work: Hardware

- Many microphones
- Audio filters
- Several Profiles
How Hearing Aids Work: Hearing Profiles

- Speech
- Speech in noise
- Noise
- Music
Selecting Hearing Profiles

- Users prefer automatic switching if reliable
- Decision based on sound only
  → Ambiguity
Improving Hearing Aids: Additional Sensors

- 9 Accel+Gyro units
- EOG on one eye
- Microphone of the hearing aid
Improving Hearing Aids: Data Analysis

Data Collection + Feature Extraction

| Body movement | Eye movement | Sound |

SVM classifier (person indep.)

Determine situation

Select settings

Directional on? | Filters?

Apply settings

DSP in hearing aid
Improving Hearing Aids: Experiment

- Artificial situation in lab
- Overlay standard office noise
- Alternate scenarios
  - Work → Noise
  - Work while others talk → Noise
  - Talk to someone → Speech in noise
Improving Hearing Aids: Experiment

Working in office
Improving Hearing Aids: Experiment

Conversation in office
Improving Hearing Aids: Experiment

Trying to concentrate
Improving Hearing Aids: Experiment Results

Accuracy [%]

- Sound: 77%
- Eye Mov.: 86%
- Body Mov.: 92%
- Body Mov. Eye Mov.: 91%
- Sound Body Mov.: 90%
- Sound Eye Mov.: 85%
- Body Mov. Sound: 89%
Improving Hearing Aids: Conclusions

+ Solves a real problem
+ Good Precision

- Bulky Sensors
+ Potential for improvements

- No Hearing impaired test subjects
Activity Tracking in Car Manufacturing

Hyundai assembly line

Thomas Stiefmeier, Daniel Roggen, Georg Ogris, Paul Lukowicz, Gerhard Troster
Wearable Activity Tracking in Car Manufacturing
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Activity Tracking in Car Manufacturing

- Training for assembly line: “Learning island”
- Tracking on the job: Quality control
Scenario 1: Learning Island

- Theory sessions
- Specially prepped car
- Supervisor judges performance
Scenario 1: Learning Island

- Automatically judge performance
- Context-sensitive help replaces theory session
- Specific task: exchange front lamp
Learning Island: Sensors

- Bending strips in bracelet
- Accelerometer on glove
- RFID reader in glove
- Switches on car
Scenario 2: Quality Control

- Checklist on finished car
  - Doors, hood, trunk etc

- Write up faults
  - Improvement: direct data entry
Quality Control: Sensors used

- Bending strips in sleeves
- Accelerometers on Gloves
- Position relative to car: Tags on worker’s shoulder
Quality Control: In Action

(c) (d)
Activity Tracking In Car Manufacturing: Conclusions

+ Useful for training
- Vague on usefulness in checking
- Switches on Car needed
- Task model not fault tolerant
+ Sensors not disruptive
+ Thorough acceptance study
## Is the vision fulfilled?

<table>
<thead>
<tr>
<th>Eye Tracking with Electrodes</th>
<th>Improving Hearing Aids</th>
<th>Activity Tracking in Car Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helpful?</td>
<td>potentially</td>
<td>++</td>
</tr>
<tr>
<td>Unobtrusive?</td>
<td>-</td>
<td>potentially</td>
</tr>
<tr>
<td>Reliable?</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Discussion
Sources

1) EyeSee Cam www.eyeseecam.com
3) Image contact lens: http://en.wikipedia.org/wiki/File:Contact_Lens_Ayala.jpg

Paper1, EOG goggles: Bulling et al, 2009 http://dl.acm.org/citation.cfm?id=1520468

Additional papers:
Bulling et al.: Eye Movement Analysis for Activity Recognition Using Electrooculography (2011)