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

Andreas Bulling, Daniel Roggen, Gerhard Troster
Wearable EOG goggles: Seamless sensing and context-awareness in everyday environments

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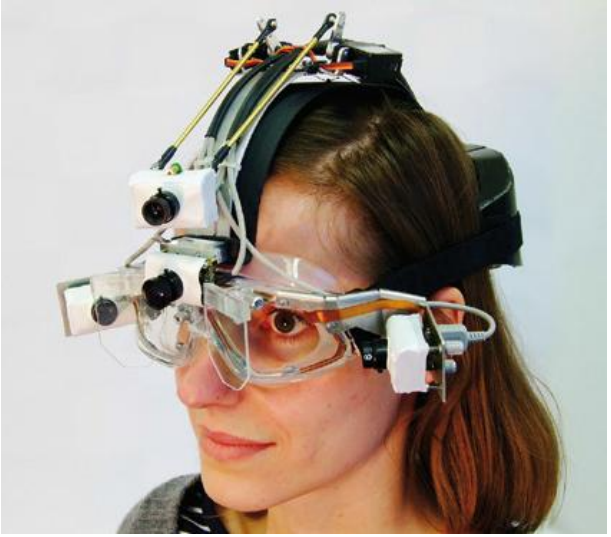
Eye tracking: Different Methods

Video based



Eye see cam [2]

Eye attached reflector

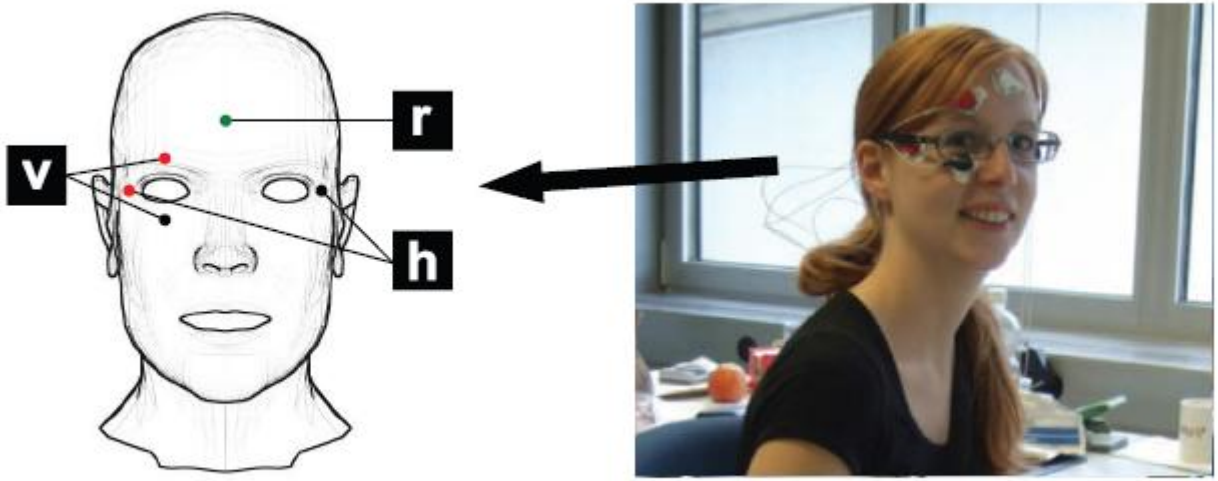
Contact Lens [3]

Electrooculography

Bulling, 2011

Electrooculography

- Eye as electrical dipole
  - Varies with light
- Electrodes can determine eye movements
- Only rough directions



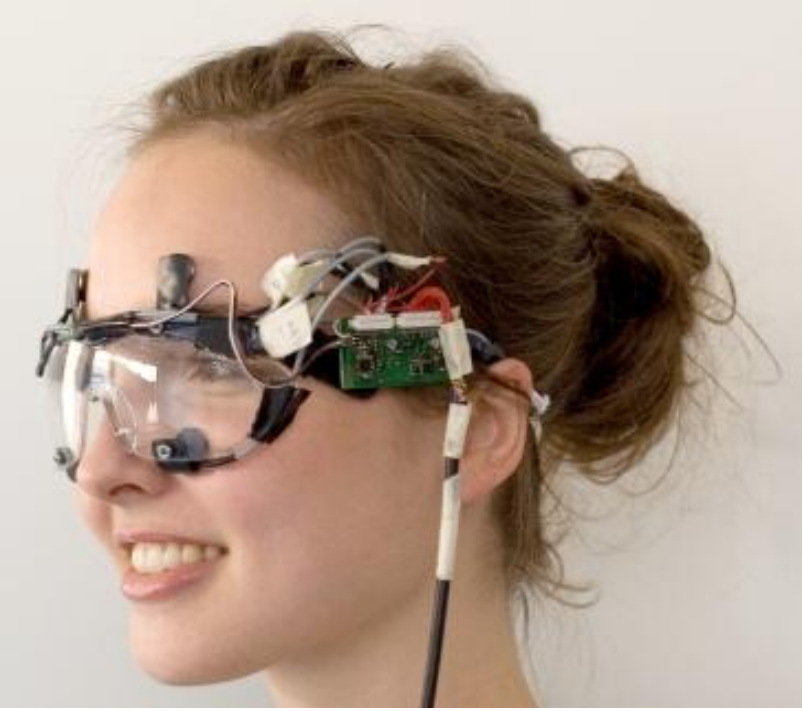
Aside: How Eyes Work

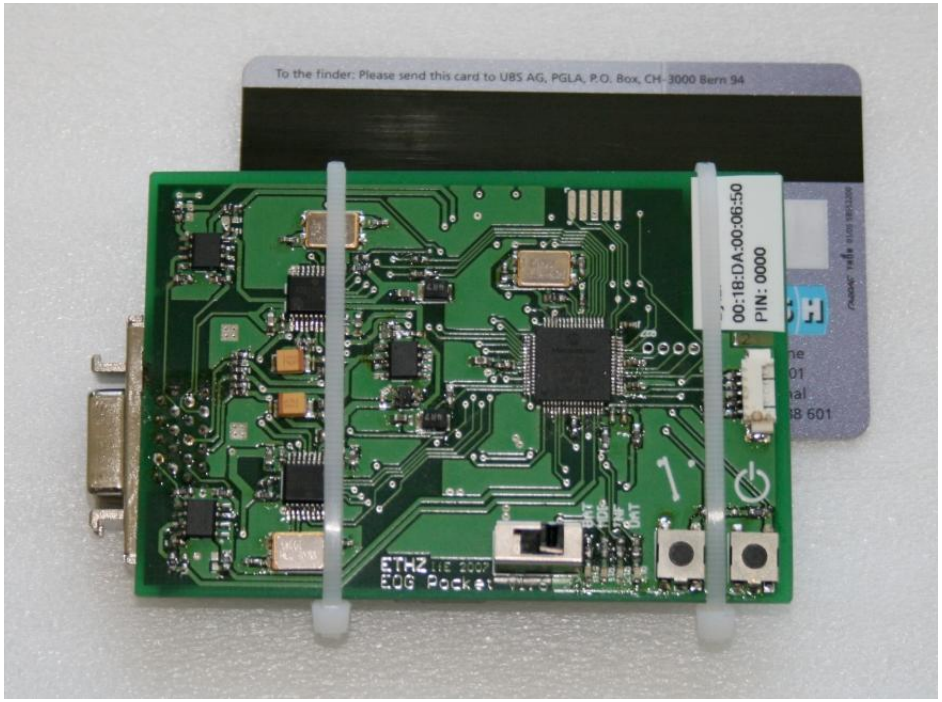
- Periods of gaze fixed on target (Fixations)
- Very fast twitch between fixation points (Saccades)
- “Random” twitches for scanning
- Blinks

Eye movement when scanning a face [2]

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

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Preprocessing

- Calibration
- Drift Compensation

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Event detection

- Blinks
- Fixations
- Saccades

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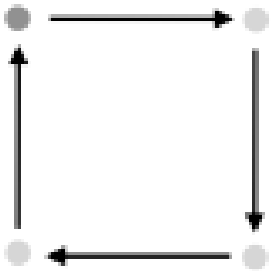
Classification

- Activity
- Gesture

Experiment: Eye gestures



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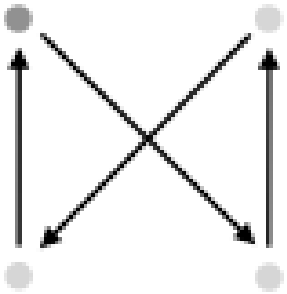

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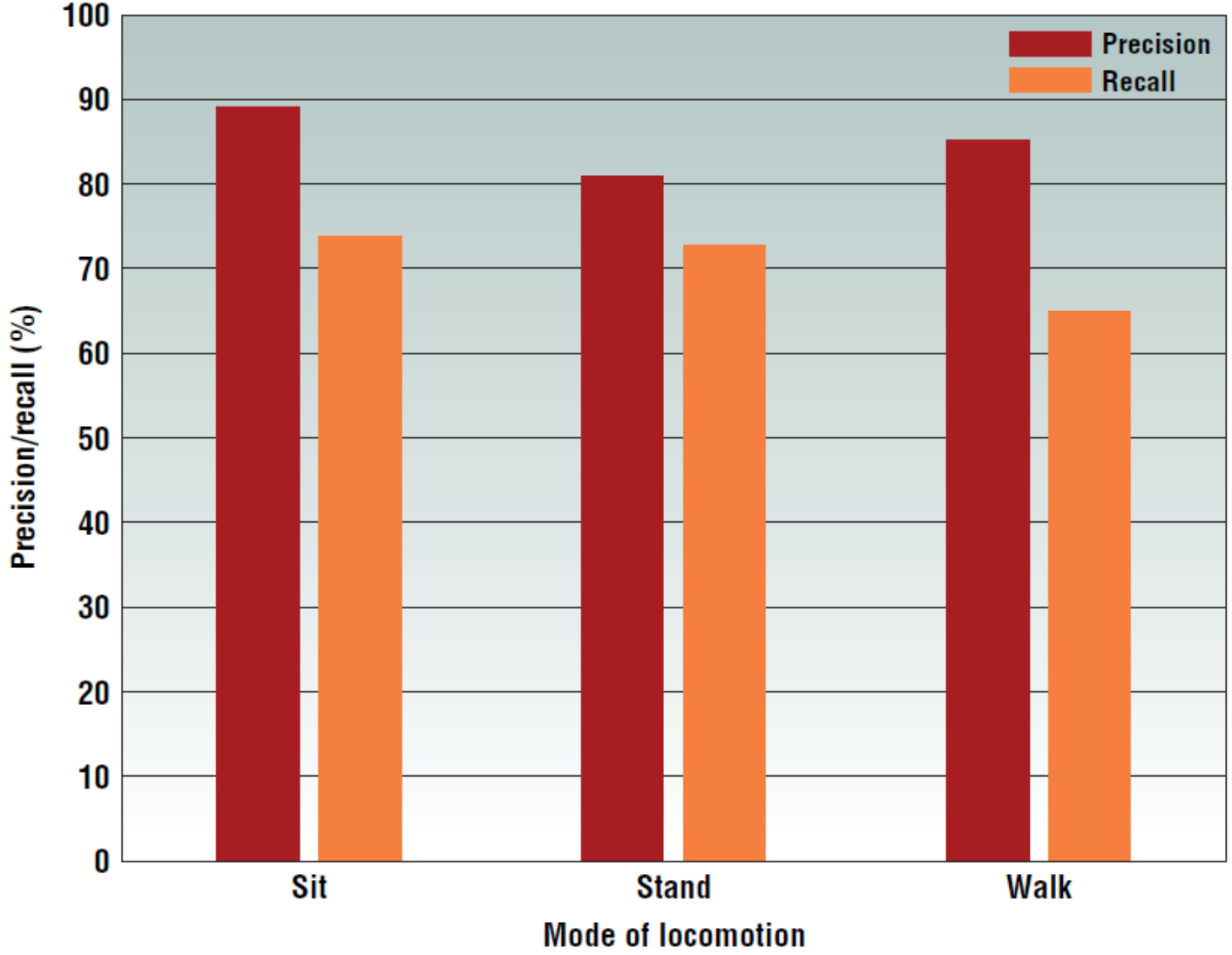
- Event detection generates String
- Match String to defined Gestures

Experiment: Recognize Reading Activity

Experiment: Recognize Reading Activity



Other Recognizable Activities

- Recognize
  - Web browsing
  - Watching video
  - Driving
  - Remembered face ⇔ New face

Wearable EOG Goggles: Conclusions

+ Many activities detectable

+ Good Precision

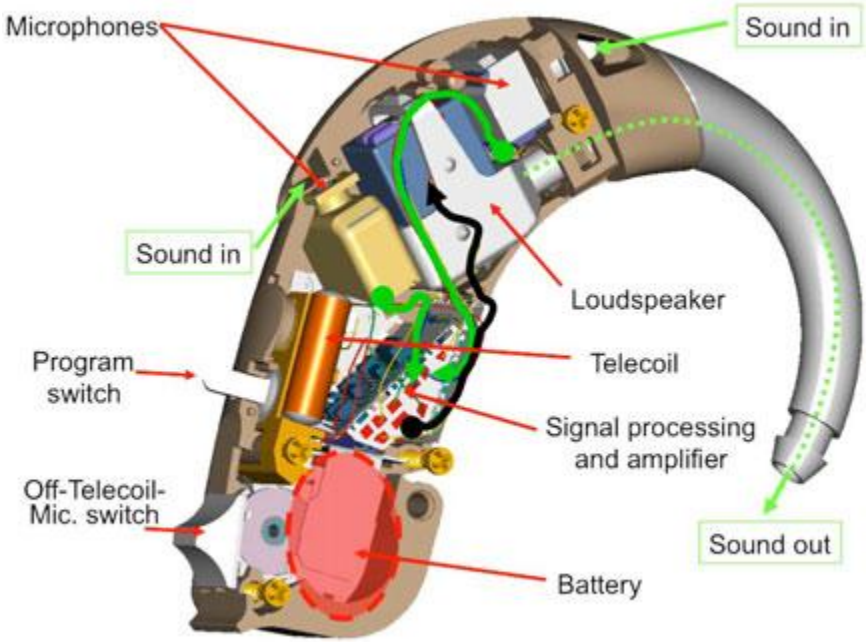
+ Cognitive process visible

- 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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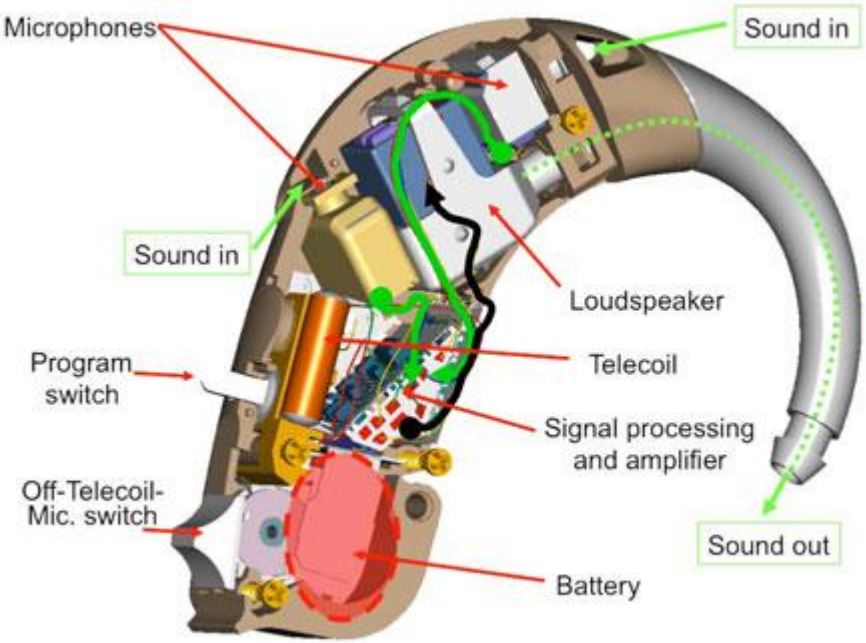
How Hearing Aids Work: Hardware

- Many microphones
- Audio filters
- Several Profiles



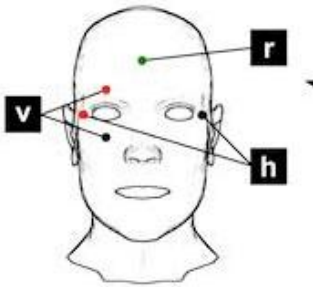
How Hearing Aids Work: Hearing Profiles

- 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 he hearing aid

Improving Hearing Aids: Data Analysis

Data Collection + Feature Extraction

Body movement	Eye movement	Sound

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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

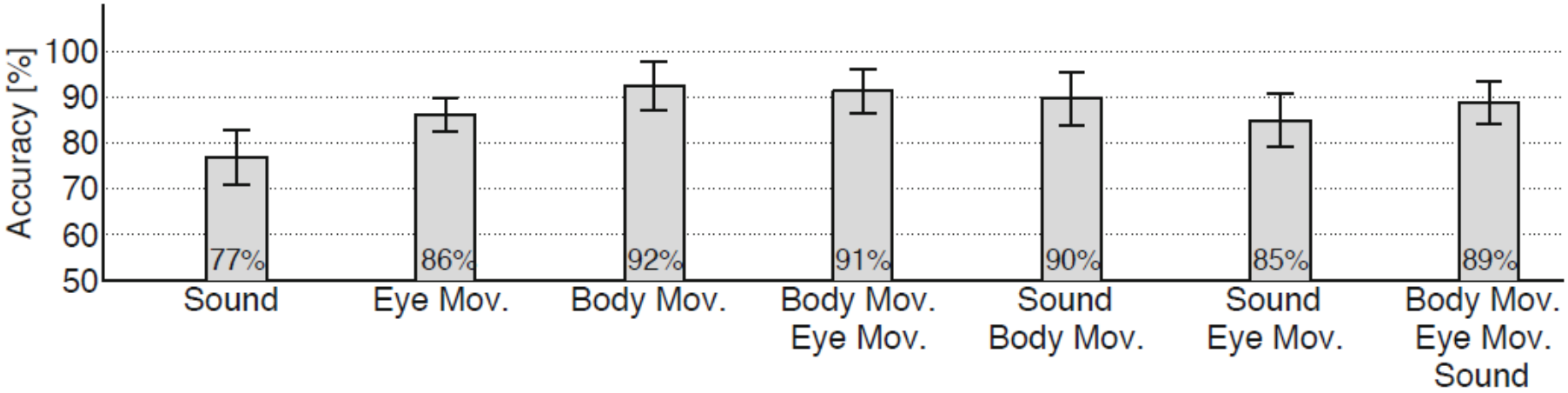
Conversation in office




Improving Hearing Aids: Experiment

Trying to concentrate

Improving Hearing Aids: Experiment Results



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 [4]

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

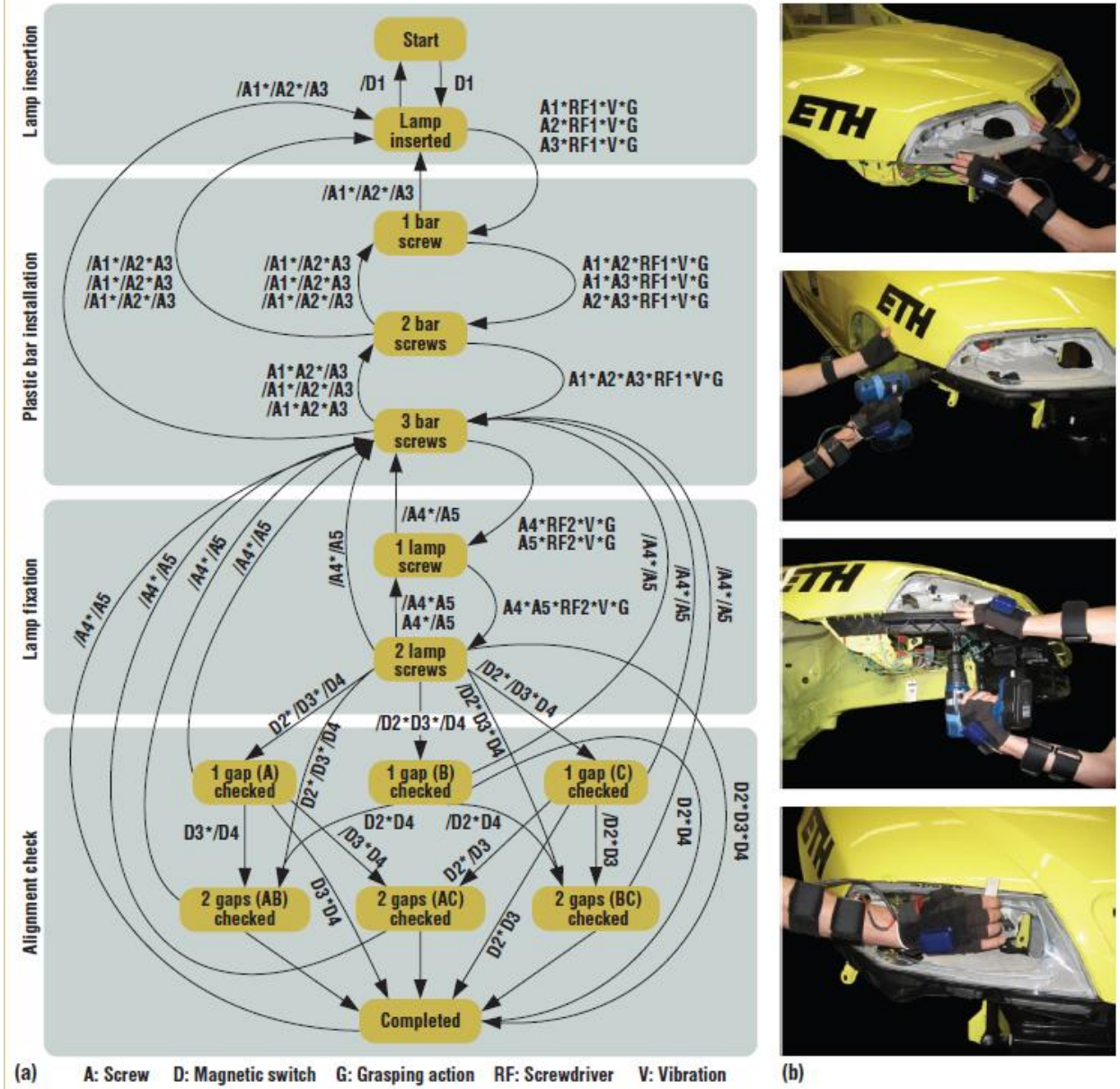
- Training for assembly line: “Learning island”
- Tracking on the job: Quality control

Scenario1: Learning Island

- Theory sessions
- Specially prepped car
- Supervisor judges performance

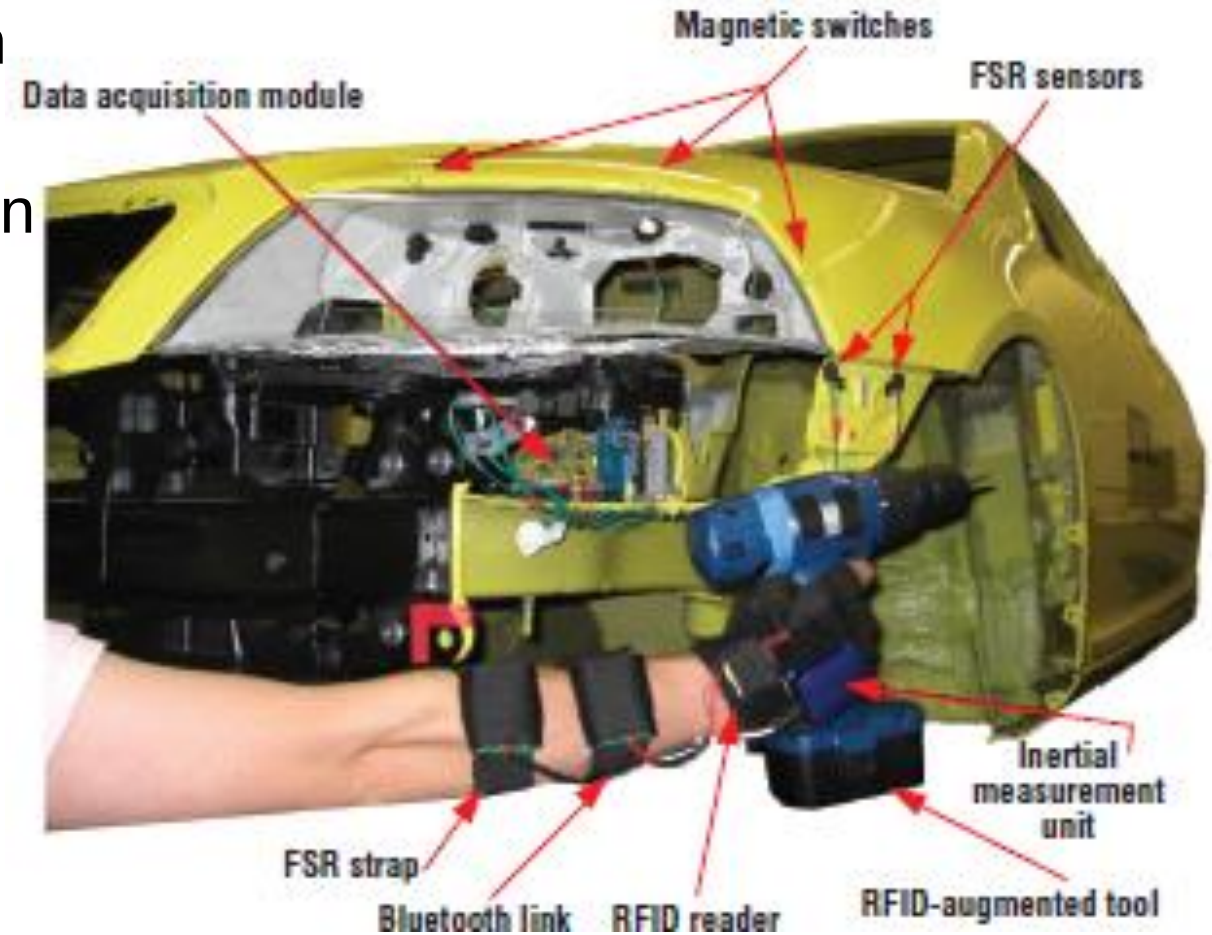
Scenario1: Learning Island

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


Lamp insertion
Plastic bar installation
Lamp fixation
Alignment check
Start
Lamp inserted
1 bar screw
2 bar screws
3 bar screws
1 lamp screw
2 lamp screws
1 gap (A) checked
1 gap (B) checked
1 gap (C) checked
2 gaps (AB) checked
2 gaps (AC) checked
2 gaps (BC) checked
Completed
/D1
D1
/A1*/A2*/A3
A1*RF1*V*G
A2*RF1*V*G
A3*RF1*V*G
A1*A2*RF1*V*G
A1*A3*RF1*V*G
A2*A3*RF1*V*G
A1*A2*/A3
/A1*/A2*/A3
/A1*A2*A3
A1*A2*A3*RF1*V*G
/A4*/A5
A4*RF2*V*G
A5*RF2*V*G
/A4*A5
A4*/A5
A4*A5*RF2*V*G
D2*/D3*/D4
/D2*D3*/D4
/D2*/D3*D4
D3*/D4
D2*D4
/D2*D4
/D3*D4
D2*/D3
/D2*D3
D2*D3*D4
(a)
A: Screw
D: Magnetic switch
G: Grasping action
RF: Screwdriver
V: Vibration
(b)

Learning Island: Sensors

- Bending strips in bracelet
- Accelerometer on glove
- RFID reader in glove
- Switches on car

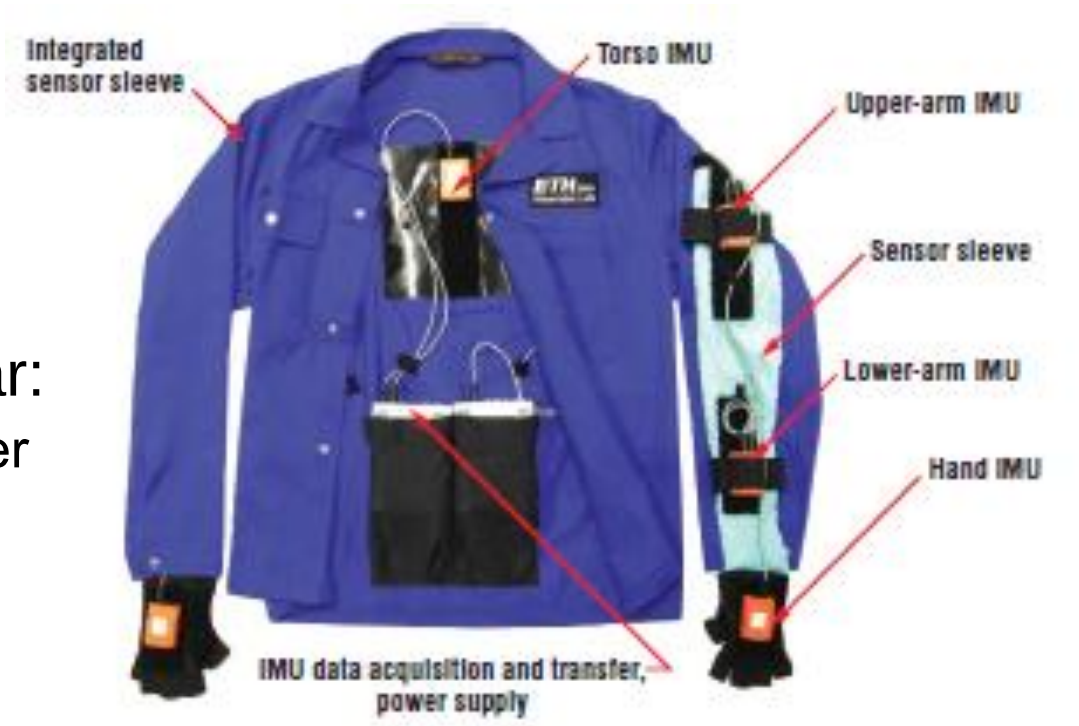


Scenario2: Quality Control

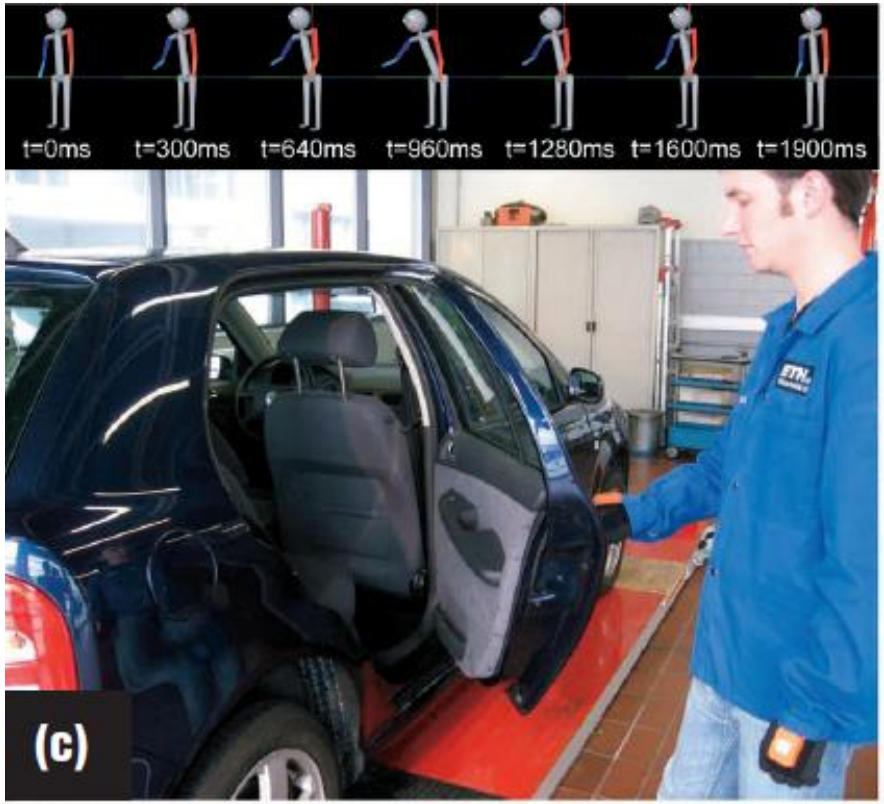
- Checklist on finished car
  - Doors, hood, trunk etc
- Write up faults
  - Improvement: direct data entry

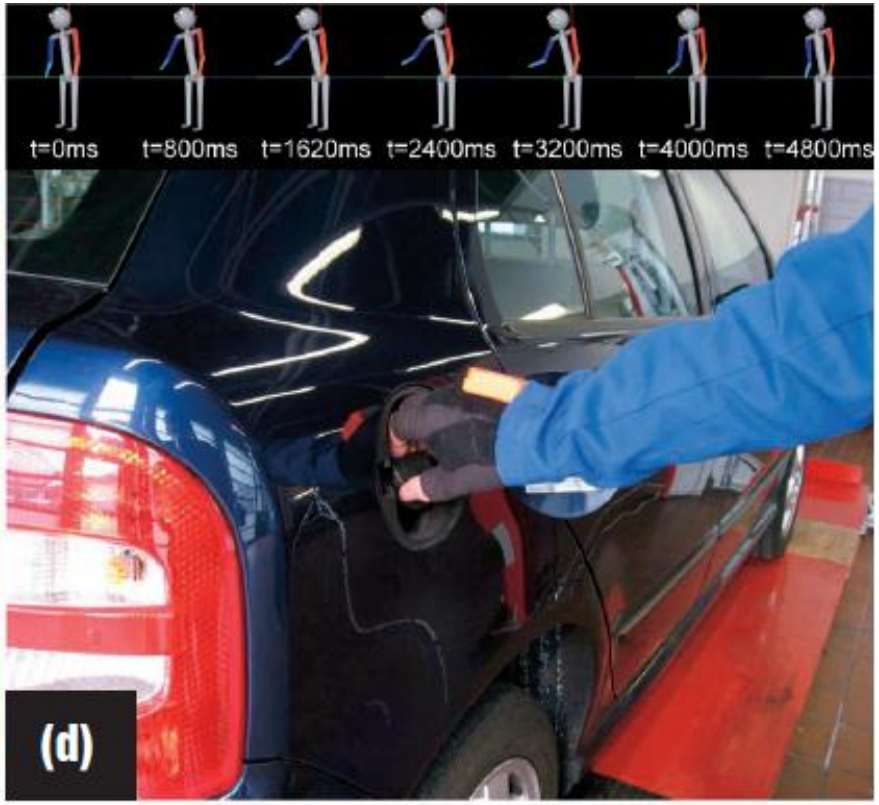
Quality Control: Sensors used

- Bending strips in sleeves
- Accelerometers on Gloves
- Position relative to car:
  Tags on worker's shoulder



Quality Control: In Action





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?

	Eye Tracking with Electrodes	Improving Hearing Aids	Activity Tracking in Car Manufacturing
Helpful?	potentially	++	+
Unobtrusive?	-	potentially	+
Reliable?	+	+	+

Discussion

Sources

[1] EyeSee Cam www.eyeseecam.com

[2] Image with saccades: http://en.wikipedia.org/wiki/File:Szakkad.jpg

[3] Image contact lens: http://en.wikipedia.org/wiki/File:Contact_Lens_Ayala.jpg

[4] Image Hyundai plant: http://commons.wikimedia.org/wiki/File:Hyundai_car_assembly_line.jpg

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

Paper2, Hearing aids: Tessendorf, Bulling et al, 2011 https://www.andreas-bulling.de/fileadmin/docs/tessendorf11_pervasive.pdf

Paper3, Activity tracking: Stiefmeier et al, 2008 http://dl.acm.org/citation.cfm?id=1399121

Additional papers:

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

Bulling, Troster: What's in the Eyes for Context-Awareness? (2011)