Implicit Interaction – smart living in a smart world

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and User Interface Engineering

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Definition
User Interface Engineering

User Interface Engineering is a structured approach for designing and implementing useful and usable interactive systems.

By following the user interface engineering process the interactive qualities of a system are ensured.
User Interface Engineering

• create user interfaces in a structured way
• ensure system properties by design
  – utility
  – efficiency
  – usability
  – pleasurably
  – durability
  – openness
• research challenges
  – develop models to allow prediction and validation
  – systematic exploration of modalities and interaction techniques
  – toolkits and development support
  – designing specific interfaces that allow user creativity

Pervasive Computing

Enabling Intelligent Environments

• Processing
  cheap, fast, small, energy efficient
• Storage
  big and fast
• Networking
  global, local, ad-hoc, low-power
• Displays
  projection, flexible materials, power consumption
• Sensors
  types, speed, accuracy, price
• Actuators
  many, computer controlled

“The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.”
(Mark Weiser)
User Needs & Technology Drive

• Looks at user needs on a more general level (e.g. Maslow’s hierarchy of needs)
• Successful designs have addressed
  – Survival
  – Safety
  – Food
  – Love
  – Communication
  – Recognition / admiration
  – …

• Allow technology to drive actual applications

technology creates opportunities and user needs…

…but if we do not understand the user products are likely to fail!
Unpredictable* Users?  
Smart Users?  
Creative Users?  

*if you have a nail, everything at hand looks like a hammer…

What is interaction with Ubiquitous Computing?

Communication appliance with hand written text input?
How many computer* did you use today?

*what is a computer anyway…
How many computer* did you use today?

How many of these systems are adaptive?
How many of these systems are context-aware?
How many of these systems are networked?
How many of these systems are embedded?

*what is a computer anyway…
How do we interact with computers beyond the desktop?
Future User Interfaces

**novel user interface paradigms**

- Tangible and physical user interface
- Context-aware user interfaces and Implicit interaction
- Speech and gesture
- Physiological and emotional interaction
- Eye gaze interaction
- Interfaces ecologies

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**Design Space for Interactive Systems**

**Implicit and explicit multimodal interaction**

<table>
<thead>
<tr>
<th>modality</th>
<th>mode of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>command line</td>
<td>explicit</td>
</tr>
<tr>
<td>GUI &amp; direct manipulation</td>
<td>implicit</td>
</tr>
<tr>
<td>gestures and speech</td>
<td>implicit</td>
</tr>
<tr>
<td>tangible and physical UIs</td>
<td>implicit</td>
</tr>
<tr>
<td>physiological and emotional</td>
<td>implicit</td>
</tr>
<tr>
<td>eye gaze</td>
<td>implicit</td>
</tr>
</tbody>
</table>
Implicit Interaction
Tracking of User Activities on a Webpage

- **Approach**
  - Proxy server
  - Adding java script to web pages
  - Reporting interaction back while user is on a web page

- **Data collected**
  - Detailed data
  - Time stamped
  - Visualization on top of the application
Eye Gaze Interaction

An new modality for explicit and implicit interaction

Implicit and explicit input
Eye gaze as additional input

• Using an eye tracker as additional input channel
  – For explicit and implicit interaction
• Currently mainly used
  – Psychology, e.g.
    • Where do people look? Gaze path, How long do they look at an item?
  – Usability testing, e.g.
    • Where do user look first?
  – Users with severe disabilities, e.g.
    • Eye movement as only input

• Systems are still expensive
• Hardware and processing required is already today very affordable
• Expectation for future devices (if it is shown they are useful)
  – Hardware included in the screen similar to speakers today
  – Integration of eye tracking into everyday devices
Video Based Eye Gaze Tracking

- The picture shows the camera with an infrared LED mounted below the tablet PC.
- The white pupil in the camera image comes from reflection of infrared light (red eyes from flash light).
- The infrared light also causes a reflection glint, which does not move as the eye is perfectly round.

The position of the gaze on the screen can be calculated by the distance from the glint to the pupil center.

Calibration with calibration points
Implicit use of eye-gaze

You look where you click!

Touch Sensitive Mouse
Implicit Gaze Interaction

- Capacitive sensor to detect hand/finger on the mouse
- Additional input parameter
- Center mouse on the position where the user looks
Explicit use of eye-gaze

You decide where you look!

Implementing a Gaze Gestures Algorithm

- Translation of a path into a string
- Similar to mouse gesture, extended with timeout and timeout character
Design of the User Study

• 2 tasks to see how well users can perform gestures

• Different screen backgrounds

• Further task to find out how often gestures occur during normal work

Some Results of the User Study

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Helping Lines</th>
<th>Text Background</th>
<th>Blank Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLRRLR</td>
<td>3113 (±627)</td>
<td>3089 (±728)</td>
<td>3288 (±810)</td>
</tr>
<tr>
<td>3U1U</td>
<td>2222 (±356)</td>
<td>2311 (±443)</td>
<td>2429 (±307)</td>
</tr>
<tr>
<td>RD7DR7</td>
<td>3163 (±490)</td>
<td>3563 (±651)</td>
<td>3569 (±520)</td>
</tr>
</tbody>
</table>

Time in milliseconds of the gestures

• The time of a gestures is largely independent from the background
• The time depends on the number of strokes in the gesture
Some Results of the User Study

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Gesture</th>
<th>Gesture</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDLU</td>
<td>0 DRUL</td>
<td>2 RLRLRL</td>
</tr>
<tr>
<td>DLUR</td>
<td>2 RULD</td>
<td>3 3U1U</td>
</tr>
<tr>
<td>LURD</td>
<td>1 ULDR</td>
<td>0 RD7DR7</td>
</tr>
<tr>
<td>URDL</td>
<td>1 LDRU</td>
<td>1</td>
</tr>
</tbody>
</table>

- Most gestures do not or very seldom occur during normal work
- Specific gestures (RLRLRL) do occur frequently as they are a typical reading gesture

Experiments with Standard Applications and Media Devices

- Eye gesture remote control
- Gaze gestures with 4 strokes need about 2 seconds
- Slower than dwell time or pressing a key
- However
  - no need for calibration
  - no Midas touch problem
Further application of eye-gaze

- Imagine a TV that tracks eye-gaze
  - “…people who watch like you also watched…”
  - No ad-skipping anymore :-(
  - …

Interaction in smart environments
Augmented Tools
Exploration of a design space

- Implicit interaction and activity recognition
- Force sensing built-in to a knife
- Load cells in the cutting board

Study Setup (1)
Study Setup (2)

[Image of study setup with labeled components: camera, microphone, knife holder, sensor knife, cutting board]

Results (2)

<table>
<thead>
<tr>
<th>classified as</th>
<th>apple</th>
<th>carrot</th>
<th>kohlrabi</th>
<th>banana</th>
<th>leek</th>
<th>pepper</th>
</tr>
</thead>
<tbody>
<tr>
<td>apple</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>2</td>
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<tr>
<td>carrot</td>
<td>0</td>
<td>102</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
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<tr>
<td>kohlrabi</td>
<td>3</td>
<td>0</td>
<td>183</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>banana</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>167</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>leek</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>179</td>
<td>4</td>
</tr>
<tr>
<td>pepper</td>
<td>2</td>
<td>17</td>
<td>29</td>
<td>1</td>
<td>9</td>
<td>89</td>
</tr>
</tbody>
</table>

**TABLE II**
Confusion matrix of the best classification result using the knife data.
Implicit Data Generation
Beyond the Desktop

• Think about
  – Your car navigation system
  – Your mobile phone
  – Your radio and TV
  – Your gas/electricity/water supply meter

  – …
  – Your cloths and shoes
  – Your waste bin
  – Your sewage leaving the house
  – …

• A great wealth of information?
  – Understanding human behavior
  – Anticipating needs
  – Providing just in time services
  – New services and products

• Or just pure horror?

Conclusion and Discussion

• New technologies create new user interface options

• Several research challenges
  – Exploring the design space
  – Creating models
  – Building toolkits and development tools

• Beyond the desktop calls for new approaches
  – Undo does not work well in the real world
  – Multi-tasking with real-world tasks
Further Reading


• Visit our websites at:
  - http://www.pervasive.wiwi.uni-due.de/
  - http://www.hcilab.org
  - http://albrecht-schmidt.blogspot.com/