Design and Distribution of Physical and Mobile Interfaces for Multi-Tag Interaction

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Diploma Thesis
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Outline

- Motivation
- Topic of the Thesis
- Related Work
- Preliminary Classification of Multi-Tag Interaction
- 1st User Study: Navigation and Selection
- 2nd User Study: Actions and Objects
- 3rd User Study: GUI Widgets
- Summary
Physical Mobile Interaction

- Interaction between mobile devices and smart objects [Rukzio et al., 2007]

- Goals
  - More intuitive, simpler and direct interaction
  - Overcoming the adversities of mobile devices

- Single-Tag Interaction
  - Interaction with single tag ➔ often first interaction step
  - No real physical interface & interaction
  - Suggested classification [Herting et al., 2008]: Presentation of Information, Physical Hyperlinks, Tagging, Broadcasting, Tag Emulation, 2-Way-Interaction

- Multi-Tag Interaction
  - Interaction with more than one tag or object
  - Stronger focus on physical interface & interaction
  - No suggested classification

Sources: www.touchandtravel.de, www.visa-asia.com
• Investigation of interface and interaction design distributed between physical objects and mobile devices
• Classification of Multi-Tag Interactions and Applications
• Comparison and evaluation of different designs for Single-Tag Interaction and Multi-Tag Interaction
  • Categories of Multi-Tag Interaction
  • Specific example applications
  • Different designs for Single-Tag Interaction and Multi-Tag Interaction
• Best practices for design of multi-tag applications and interfaces
Related Work

- Enabling Technologies
  - Numeric Identifiers, Bluetooth, Infrared, Visual Markers, Laser Pointer, RFID, Near Field Communication (NFC)

- Basic Physical Mobile Interaction Techniques
  - Touching, Pointing, Scanning, User Mediated Object Interaction [Rukzio et al., 2007], Hovering [Välkkynen, 1997]

- Advanced Physical Mobile Interaction Techniques (Multi-Tag Interaction)
  - Collect & Drop [Broll et al, 2008]
    - Action Items and Data Items
  - Touch & Interact [Hardy et al., 2008]
    - Interaction with public display (cf. touch screens)

Source: [Rukzio et. Al , 2007]
Preliminary Classification of Multi-Tag Interaction

- **Navigation**
  - Interaction-specific
  - Navigation within an application accomplished through physical interaction
  - Different tags offer different entry points to an application

- **Selection**
  - Interaction-specific
  - Selection of options/items accomplished through physical interaction

- **Combination of Information**
  - Application-specific
  - Combination of same/different types of information (e.g. actions and objects)

- **Mapping**
  - Application-specific
  - Mapping of specific application-features to specific tags
The First User Study (1)

- **Tested categories**
  - Selection
  - Navigation

- **Use case**
  - Ordering in a restaurant with the help of an NFC enhanced menu

- **User study design**
  - 16 participants
  - Independent variables: design, task complexity, interface complexity
  - Dependent variables: execution time, errors, attention shifts
The First User Study (2)

- **Results**
  - The more tags the faster the execution time
  - Problems: usage of radio buttons; handling of NFC
  - Freedom during execution (order of execution, time of correction etc.)
  - no permanent switching between mobile device and poster

→ Multi-Tag Interaction #3
The Second User Study

- **Tested category**
  - Combination of Information

- **Use case**
  - Interacting with a City Guide Poster to get information, plan a route or send an e-mail

- **Workflow**

```
Start ← Welcome ← Sight-list ← Sight → Information → Route → Add Sights → Generated Route
1
2

Action
Poster Handy
STI MTI #1
MTI #2 MTI #3 MTI #4

Object
Handy Poster
```
2nd Study: Single-Tag Interaction

- Tag-Enhanced Poster & Mobile Application

MunichCityGuide

Nokia

Deutsches Museum
- Welcome to the MunichCityGuide
- just press "OK" and select the sight you want to see:

- Route:
  - Deutsches Museum
  - Hotspots
  - Hartop
  - Sendlinger Tor
  - March
  - Viktualienmarkt

- Information:
  - Send email

- Options:
  - Text
  - Email

- Selected sights:
  - Deutsches Museum

- Additional sights:
  - Deutsches Museum

- Your route:

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2nd Study: Multi-Tag Interaction #1

- Tag-Enhanced Poster & Mobile Application
2nd Study: Multi-Tag Interaction #2

- Tag-Enhanced Poster & Mobile Application
2nd Study: Multi-Tag Interaction #3

- Tag-Enhanced Poster & Mobile Application
2nd Study: Multi-Tag Interaction #4

- Tag-Enhanced Poster & Mobile Application
2nd Study: Independent Variables

- **Design**
  - Single-Tag Interaction
  - Multi-Tag Interaction #1 (Sights as Tags)
  - Multi-Tag Interaction #2 (Actions as Tags)
  - Multi-Tag Interaction #3 (Sights and Actions as Tags)
  - Multi-Tag Interaction #4 (Actions for each Sight as Tags)

- **Task**
  - Information (Combination of object and action)
  - Route (Combination of several objects and an action)
  - Send eMail (Combination of object, action and additional information)
2nd Study: User Study Design

- **Implementation**
  - Java ME, Nokia 6131 NFC SDK, J4ME

- **User Study Design**
  - 15 Participants (Latin Square Design)
  - Demographic Questionnaire, Modified IBM “Computer System Usability Questionnaire”, Comparing Questionnaire
  - Video Analysis
  - Dependent Variables: Attention Shifts, Errors and Execution Time
  - Beforehand analysis with the Keystroke-Level-Model
  - Evaluation with SPSS
• **Attention Shifts**
  
  • Between mobile device and poster
  
  • Equal number of Attention Shifts due to forced execution order (except errors)
  
  • Differing number of Attention shifts by series of tags (trust of haptic feedback)
  
  • Multi-Tag Interaction #3 highest number of attention shifts
• **Errors**
  
  • Hardly any errors
    • Explanation and practice beforehand
  
  • Problems:
    • Handling of radio buttons
    • Forgotten confirmation
    • E-mail: Information unnecessarily added
    • Confusion when to touch route-tag
• **Execution Time**
  • Time from “Start” to “Submit”
  • From slowest task to fastest: Route, Send eMail, Information
  • Slowest Prototype: Multi-Tag Interaction #2
  • Fastest Prototype: Multi-Tag Interaction #4
  • Comparison with Keystroke-Level Model
    • Adjustment of attention shifts
    • Problems with “sequences of tags” (mental acts (1.35s), pointing faster, KLM based on old Nokia phone)
    • More tags ➔ bigger difference
2nd Study: Qualitative Evaluation

- **(Nearly) equally liked: Multi-Tag Interaction #3 (5 users) and Multi-Tag Interaction #4 (6 users)**
  - Reasons: Fewer keypad input; less forced attention shifts

- **Least liked: Multi-Tag Interaction #2**
  - Reasons: Unintuitive work-flow (actions on poster, sights on mobile interface)

- **Suggestions for improvements**
  - Correction of already given input (e.g. sights during selecting a route)
  - Reduce confirmation on mobile interface
The Third User Study

- **Tested categories**
  - Navigation and Selection

- **Use case**
  - Searching for a book in a library

- **Workflow**

```
<table>
<thead>
<tr>
<th>Navigation</th>
<th>Poster</th>
</tr>
</thead>
<tbody>
<tr>
<td>STI</td>
<td>MTI #1</td>
</tr>
<tr>
<td>---</td>
<td>MTI #2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handy</td>
</tr>
<tr>
<td>Poster</td>
</tr>
</tbody>
</table>

Start → Welcome → Search Parameter → Text Field → Mediatype → Library → Submit → Search Results
```
3rd Study: Single-Tag Interaction

• Tag-Enhanced Poster & Mobile Application
3rd Study: Multi-Tag Interaction #1

- Tag-Enhanced Poster & Mobile Application

Library Search
- Start
- Search parameter
- Textfield
- Mediatype
- Library
- Submit
3rd Study: Multi-Tag Interaction #2

• Tag-Enhanced Poster & Mobile Application

Library Search

- Start
- Author
- Title
- Keyword
- Textfield
- Book
- Journal
- Magazine
- CD/DVD
- UniBib
- Stud.-Bib
- Stabi
- Submit
3rd Study: Independent Variables

- **Design**
  - Single-Tag Interaction
  - Multi-Tag Interaction #1
  - Multi-Tag Interaction #2

- **Task Complexity**
  - Low Complexity (no changes)
  - High Complexity (changes in the end)
3rd Study: User Study Design

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  - Java ME, Nokia 6131 NFC SDK

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  - 15 Participants (Latin Square Design)
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  - Video Analysis
  - Dependent Variables: Attention Shifts, Errors and Execution Time
  - Beforehand analysis with the Keystroke-Level-Model
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• **Attention Shifts**
  - Between mobile device and poster
  - Equal number of attention shifts due to forced execution order (except errors (e.g. MTI #1))
  - Differing number of attention shifts by series of tags (trust of haptic feedback)
• **Errors**
  - Hardly any errors
    - Explanation and practice beforehand
  - Problems:
    - Dropdown
    - Multi-Tag Interaction #1: Confirmation
    - Multi-Tag Interaction #2: Handling of “radio buttons” and “checkboxes” on poster
• **Execution Time**
  - Time from “Start” to “Submit”
  - Slowest prototype: Multi-Tag Interaction #1
  - Comparison with Keystroke-Level Model
    - Adjustment of attention Shifts
    - Problems with “sequences of tags” (mental acts (1.35s), pointing faster, KLM based on old Nokia phone)
  - More tags ➔ bigger difference
3rd Study: Qualitative Evaluation

• (Nearly) equally liked: Single-Tag Interaction (7 users) and Multi-Tag Interaction #2 (8 users)
  • Reasons for STI: similar to known online form
  • Reasons for MTI #2: less keypad usage; good overview

• Least liked: Multi-Tag Interaction #1
  • Reasons: many forced attention shifts; confirmation after each selection

• Suggestions for improvements
  • Clear distinction between radio buttons and checkboxes (e.g. colors)
Conclusion

• **Summarized results**
  - NFC usage only for navigation rather annoying than benefit
  - Using NFC for greater number of items for selection is fine for users
  - Minimization of attention shifts
  - Freedom during interaction important
  - Crucial interaction steps (e.g. submit) as buttons on mobile interface preferred
  - Differences in the processing of tags (e.g. radio buttons vs. checkboxes) has to be clearly distinguished

• **Suggestions for further research**
  - Fourth category “Mapping”
  - Provision and placement of help
Questions?
Thank You!

Library Search

Object

MunichCityGuide

Handy

Poster

Book

Journal

Magazine

CD/DVD

UniBib

Stud.-Bib

Stabi

Submit

Start

Author

Title

Keyword

Textfield

STI

MTI #1

MTI #2

MTI #3

MTI #4