Automatically Generating User Interfaces Adapted To Users’ Motor And Vision Capabilities

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University of Washington
Computer Science & Engineering
Road Map

- Introduction
- Interface generation as optimization
- Modeling motor capabilities
- Adapting to motor capabilities
- Adapting to vision capabilities
- Adapting to motor and vision capabilities together
- Pilot User Study
- Lessons learned
Automatic Interface Generation

- Manually capture design knowledge as rules
- Automatically apply rules to generate new interfaces
Automatic Interface Generation

- Manually capture design knowledge as rules
- Automatically apply rules to generate new interfaces
- **Problems:**
Automatic Interface Generation

• Manually capture design knowledge as rules
• Automatically apply rules to generate new interfaces

Problems:
• New rule sets necessary for every device type, interaction style or even screen size
Automatic Interface Generation

- Manually capture design knowledge as rules
- Automatically apply rules to generate new interfaces

Problems:
- New rule sets necessary for every device type, interaction style or even screen size
- No good way to adapt to individual preferences or needs
Our Approach: User Interface Generation as Optimization

Driven by a “cost function”:

$\text{cost function} = \ldots$

and constraints

[Gajos and Weld, IUI’05]
Find the interface that minimizes $ without violating constraints

[Gajos and Weld, IUI’05]
Single Algorithm -- Many Devices
Single Algorithm -- Many Devices
Robustly Adapting to Different Screen Sizes
Robustly Adapting to Different Screen Sizes
Flatsratesex, für nur 14,99 Euro kannst Du Dir einen monat lang über 200
Private Livecams
anschaun, dazu noch unzählige Bilder und Videos, ohne 0190 ohne versteckte
Kosten.

der absolute Hammer!

http://www.sexania.com

kein bock mehr auf unsere mails? dann einfach hier austragen lassen:
Adapting to Preferences

[Image of a Preferences interface]

\[ \$ (\text{Preferences}) = \text{Preference estimate} \]

[Gajos and Weld, UIST’05]
Adapting to Motor Capabilities

$\$(\text{ ))\%\%$ = Estimated task completion time
Road Map

✓ Introduction
✓ Interface generation as optimization

▶ Modeling motor capabilities
 Adapting to motor capabilities
 Adapting to vision capabilities
 Adapting to motor and vision capabilities together
## Participants

<table>
<thead>
<tr>
<th>Motor-impaired</th>
<th>Device used</th>
<th>Impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse</td>
<td>Muscular Dystrophy</td>
<td>Spinal cord injury</td>
</tr>
<tr>
<td>Trackball</td>
<td></td>
<td>Spinal cord injury</td>
</tr>
<tr>
<td>Head Mouse</td>
<td></td>
<td>Spinal cord injury</td>
</tr>
<tr>
<td>Eye Tracker</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Vocal Joystick</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
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<td>none</td>
<td>none</td>
</tr>
<tr>
<td>Mouse</td>
<td>none</td>
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Unusual device
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<tr>
<td>Vocal Joystick</td>
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<td>none</td>
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<td>Vocal Joystick</td>
<td>none</td>
</tr>
<tr>
<td>Mouse</td>
<td>none</td>
</tr>
<tr>
<td>Track Pad</td>
<td>none</td>
</tr>
</tbody>
</table>

Unusual device
Elicit a Person’s Motor Abilities Model

Pointing

Dragging

List Selection

Select 13
Custom Motor Capability Models

- Supple++
  - Automatically selects the best set of features for a custom regression model for each participant from: ID, 1, log(D), log(W), D, 1/W, W
  - Trains the models
Road Map

✓ Introduction
✓ Interface generation as optimization
✓ Modeling motor capabilities
✓ Adapting to motor capabilities
☐ Adapting to vision capabilities
☐ Adapting to motor and vision capabilities together
☐ Pilot User Study
☐ Lessons learned
UI Building Blocks

• Widgets
UI Building Blocks

- Widgets
- Layout
UI Building Blocks

- Widgets
- Layout
- Structure (divide into windows, pop-ups, tabs)
UI Building Blocks

- Widgets
- Layout
- Structure (divide into windows, pop-ups, tabs)
- Size of interactors
UI Building Blocks

- Widgets
- Layout
- Structure (divide into windows, pop-ups, tabs)
- Size of interactors
Optimization as Search
Optimization as Search
Optimization as Search
Optimization as Search
Optimization as Search

Light Level: \( \mathbb{T} \colon [0,10] \)

Power: \( \mathbb{T} \colon \text{bool} \)

Light: \( \mathbb{T} \colon \{ \ldots \} \)

Light Bank: \( \mathbb{T} \colon \{ \ldots \} \)

A/V: \( \mathbb{T} \colon \{ \ldots \} \)

Projector: \( \mathbb{T} \colon \{ \ldots \} \)

Classroom: \( \mathbb{T} \colon \{ \ldots \} \)

Input: \( \mathbb{T} \colon \text{string, \{data1, data2, video\}} \)

Vent: \( \mathbb{T} \colon \text{int, [0,3]} \)

Light

Level

Power

Screen

Power

Input

Vent

Left

Center

Right
Optimization as Search

Light Level: ![int, [0,10]]

Power: ![bool]

Light: ![bool]

Light Bank: ![bool]

A/V: ![bool]

Projector: ![bool]

Classroom: ![bool]

Input: ![string, {data1, data2, video}]

Vent: ![int, [0,3]]
Optimization as Search

Light Level: \text{!}: \text{<int, [0,10]>}

Power: \text{!}: \text{bool}

Light: \text{!}: \text{\{\ , \}\}}

Light Bank: \text{!}: \text{\{\ , \ , \}\}}

A/V: \text{!}: \text{\{\ , \}\}}

Projector: \text{!}: \text{\{\ , \}\}}

Classroom: \text{!}: \text{\{\ , \}\}}

Input: \text{!}: \text{<string, \{data1, data2, video\}>}

Vent: \text{!}: \text{<int, [0,3]>}

Screen: \text{!}: \text{bool}
Optimization as Search
Optimization as Search
Optimization as Search

Light Level: !: <int, [0, 10]>
Power:!: bool
Light:!: {  ,  }
Light Bank:!: {  ,  ,  }
Light ...
Light ...
A/V:!: {  ,  }
Classroom:!: {  ,  }
Input:!: <string, {data1, data2, video}>
Vent:!: <int, [0, 3]>
Projector:!: {  ,  }
Power:!: bool
Screen:!: bool
Projector:!: bool

Classroom:

Light Bank:

Light:

Light Level: T: <int, [0, 10]>
Power: T: bool

Light ...
Light ...

A/V:

Screen:

Power:

Input:

Vent:

Projector:

Computer 1
Computer 2
Video

Screen

Off
Low
Med
High

Level

Light

Power
Enumerate all the options: ~370 years
Optimization as Search

Enumerate all the options: \(~370\) years

Supple++: \textbf{seconds or minutes}
Results
<table>
<thead>
<tr>
<th>Font</th>
<th>Style</th>
<th>Size</th>
<th>Underline style</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arial</td>
<td>Regular</td>
<td>8</td>
<td>(none)</td>
<td>Strikethrough</td>
</tr>
<tr>
<td>Arial Black</td>
<td>Italic</td>
<td>9</td>
<td>Single solid</td>
<td>Double Strikethrough</td>
</tr>
<tr>
<td>Comic Sans MS</td>
<td>Bold</td>
<td>10</td>
<td>Double solid</td>
<td>Superscript</td>
</tr>
<tr>
<td>Courier New</td>
<td>Bold Italic</td>
<td>11</td>
<td>Dotted</td>
<td>Subscript</td>
</tr>
<tr>
<td>Franklin Gothic Medium</td>
<td></td>
<td>12</td>
<td>Dashed</td>
<td>Shadow</td>
</tr>
<tr>
<td>Italic</td>
<td></td>
<td>13</td>
<td>Wavy</td>
<td>Outline</td>
</tr>
<tr>
<td>Gautami</td>
<td></td>
<td>14</td>
<td></td>
<td>Emboss</td>
</tr>
<tr>
<td>Georgia</td>
<td></td>
<td>15</td>
<td></td>
<td>Engrave</td>
</tr>
<tr>
<td>Helvetica</td>
<td></td>
<td>16</td>
<td></td>
<td>Small Caps</td>
</tr>
<tr>
<td>Latha</td>
<td></td>
<td>17</td>
<td></td>
<td>All Caps</td>
</tr>
<tr>
<td>Lucida Console</td>
<td></td>
<td>18</td>
<td></td>
<td>Hidden</td>
</tr>
<tr>
<td>Lucida Sans Unicode</td>
<td></td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microsoft Sans Serif</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modern MS Sans Serif</td>
<td></td>
<td>21</td>
<td></td>
<td></td>
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<tr>
<td>MS Serif</td>
<td></td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mv Boli</td>
<td></td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palatino Linotype</td>
<td></td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roman</td>
<td></td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Script</td>
<td></td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Fonts</td>
<td></td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Preview**

Times New Roman
Able-bodied

Impaired dexterity

Low strength
Road Map

- Introduction
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- Lessons learned
Popular OS Solution: “Large Fonts”
Popular OS Solution: “Large Fonts”
Account Details

- **Protocol**: pop3
- **Encrypted**: Unchecked

**Server**: imap.web.de
**User**: supple
**Password**: ***********

**Outgoing Server**

- **Authentication**: Checked
- **Encrypted**: Unchecked

**Server**: smtp.web.de
**User**: supple
**Password**: ***********
Our Approach

• User selects desired minimum size for all visual cues

• User interface generation constrained to meet desired visual cue size

• Fast “resize and reflow”
Our Approach

- User selects desired minimum size for all visual cues
- User interface generation constrained to meet desired visual cue size
- Fast “resize and reflow”
Our Approach

Configuration

Accounts
Web.de IMAP
UW IMAP
Web.de POP3
Fastmail

Details
Outgoing Server
Account Details
Incoming Server

Authentication: ☑
Encrypted: 

Server: smtp.web.de
User: supple
Password: **********
Our Approach

Content arranged in tabs
Supple++ Solution
Supple++ Solution
Supple++ Solution
Road Map

- Introduction
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- Lessons learned
for “typical” users
for “typical” users

impaired dexterity

modified cost function
for “typical” users:

- modified constraints

impaired dexterity:

- modified cost function

low vision
for “typical” users

modified constraints

modified cost function

impaired dexterity

low vision

low vision & impaired dexterity

modified cost function
User Study

- 11 participants with motor impairments
- 6 able-bodied participants
User Study
User Study

• In the new study, we found that participants with motor impairments were consistently faster (by 26%) using interfaces generated by Supple++
• made 73% fewer errors
• strongly preferred Supple++ interfaces to manufacturers’ baselines
Summary of Contributions
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• **Supple++** for automatically generating user interfaces adapted to user’s motor and vision capabilities
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- **Supple++** for automatically generating user interfaces adapted to user’s motor and vision capabilities
- No expert necessary
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- **Supple++** for automatically generating user interfaces adapted to user’s motor and vision capabilities
  - No expert necessary
  - Custom regression models for individual motor capabilities
Summary of Contributions

- **Supple++** for automatically generating user interfaces adapted to user’s motor and vision capabilities
  - No expert necessary
  - Custom regression models for individual motor capabilities
  - Novel optimization-based algorithm for efficient ability-based GUI generation
Limitations & Future Work
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- Limitations of modeling
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- Limitations of modeling
- Pointer-only interactions
Limitations & Future Work

- Limitations of modeling
- Pointer-only interactions
- Movement time as proxy for performance
Limitations & Future Work

- Limitations of modeling
- Pointer-only interactions
- Movement time as proxy for performance
- How to address other concerns?
Limitations & Future Work

• Limitations of modeling
• Pointer-only interactions
• Movement time as proxy for performance
• How to address other concerns?
• Design tools
More Information

- **SUPPLE:**
  http://supple.cs.washington.edu/
or Google: supple interfaces

- **Krzysztof Gajos:**
  kgajos@cs.washington.edu

- **Jacob Wobbrock:**
  wobbrock@u.washington.edu

- **Daniel Weld:**
  weld@cs.washington.edu