Designing for Assistive Technology

COMP 4510
Fall 2019
Prof. Yanco
Hugh Herr, MIT

Brain-robot interfaces, University of Pittsburgh

2008

http://motorlab.neurobio.pitt.edu/multimedia.php
Brain-robot interfaces, University of Pittsburgh

BRAIN-COMPUTER INTERFACE RESEARCH
UPMC Rehabilitation Institute and the University of Pittsburgh School of Medicine

Study participant Jan Scheuermann feeds herself

1) Nov. 28, 2012 - Chocolate bar
2) Nov. 30, 2012 - Chocolate bar
3) Nov. 30, 2012 - Chocolate truffle
4) Nov. 30, 2012 - String cheese
5) Nov. 30, 2012 - Red pepper

December 2012
TRT 05:27
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http://motorlab.neurobio.pitt.edu/multimedia.php
B-Temia Exoskeleton

Images from www.b-temia.com
HRI Design for Assistive Technology

People in the target population might have:

• Limited mobility
• No fine motor control
• Reduced cognitive ability
• Reduced visual field
• Limited communication ability
Designing Assistive Technology

- Inclusion of clinicians in the design and evaluation of assistive robot systems leads to more usable systems
  - Clinicians know their patients well
  - Clinicians and people from the target population should participate in early focus groups, Wizard of Oz studies, and evaluations of the robot systems throughout its development
- Many possible uses of robotics in assistive technology
Designing for Robot Wheelchairs

- User collocated with robot
  - But the wheelchair affects bystanders as well
- Control ranges from shared to (almost) fully autonomous
- Limiting factors in control
  - Fine-motor skills of users
  - Cognitive abilities of users
Supervisory Control of a Robotic Wheelchair

- Wide variety of user abilities
- Users are usually unable to drive a standard powered wheelchair
- Users require different input devices as well as customization of system parameters
Access Methods

- Means for controlling a powered wheelchair or other assistive technology
- Usually selected by a physical therapist to meet the user’s needs and abilities

- Joystick
- Joystick with plate
- Single switch
- Multiple switch arrays
- Sip and puff
- Chin joystick
- Mouth plate
- Eye tracking
Access Method: EagleEyes

• Eye tracking system developed at Boston College
• Measure EOG using electrodes
• Use measurements to control mouse
Access Methods: EagleEyes
Access Method: Single Switch Scanning

- Interface scans through 4 arrows:
  - Forward
  - Right
  - Left
  - Back

- User hits switch when desired command is highlighted
Issues Arising from Interaction Methods

• Can’t pack the interface screen with lots of information
  • System’s user may not be able to read small text or windows
  • System’s user may not be able to move to areas using fine motor control

• When using single switch scanning, all choices have the same level of importance
Designing HRI for Robotic Wheelchairs

- HRI design must account for user abilities as well as convey a sense of safety
- Unexpected movement should be explained or avoided
- Design must account for a wide variety of access methods
Designing HRI for a Wheelchair-Mounted Robot Arm

• MANUS Arm made by Exact Dynamics
Designing HRI for a Wheelchair-Mounted Robot Arm
Provided Arm Controls

- Arm shipped with one of two control methods
  - Joystick and switch
  - Keypad

- Both methods use a single character LCD screen (not shown) for feedback
Control Diagram for Joystick
Redesigned Interface

Providing System Status
Manipulation Assistance Without Object Models

Direct Selection
Open World Assistive Grasping Using Laser Selection

Abraham M. Shultz, James Kuczynski, and Holly Yanco
University of Massachusetts Lowell

Andreas ten Pas, Marcus Gualtieri, and Robert Platt
Northeastern University
Toward Assistive Robotic Pick and Place in Open World Environments

Dian Wang¹, Colin Kohler¹, Andreas ten Pas¹, Alexander Wilkinson², Maozhi Liu¹, Holly Yanco², Robert Platt¹

¹College of Computer and Information Science, Northeastern University, Boston, Massachusetts
²Department of Computer Science, University of Massachusetts Lowell, Lowell, Massachusetts
Telepresence for People with Disabilities
Standard VGo Platform

- 15 cm screen
- 1.2 m tall
- red/green LEDs, microphones
- speakers
- IR distance sensors
- webcam (180 degree tilt)
- bumper
Some commercially available telepresence robots

### Making Your Presence Robotic

A new generation of robots is making it possible to be, in effect, in two places at once. From anywhere with a computer and a Wi-Fi connection, the operator can use the robot to hear, talk, see and be seen and move around a workplace far away. Early adopters include doctors, technology workers and supervisors. The robots range in size, features and price. Here is a sampling.

<table>
<thead>
<tr>
<th></th>
<th>Vgo (made by Vgo Communications)</th>
<th>Tilr (RoboDynamics)</th>
<th>Texai (Willow Garage)</th>
<th>RP-7i (InTouch Health)</th>
<th>QB (Anybots)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height</strong></td>
<td>4'0&quot;</td>
<td>3'8&quot; or 4'2&quot;</td>
<td>5'2&quot;</td>
<td>5'5&quot;</td>
<td>2'6&quot; to 6'0&quot;</td>
</tr>
<tr>
<td><strong>Top Speed</strong></td>
<td>3.75 m.p.h.</td>
<td>2.4 m.p.h.</td>
<td>1.5 m.p.h.</td>
<td>2 m.p.h.</td>
<td>3.5 m.p.h.</td>
</tr>
<tr>
<td><strong>Display Size</strong></td>
<td>7&quot;</td>
<td>8&quot; (touchscreen)</td>
<td>15&quot;</td>
<td>15&quot;</td>
<td>3.5&quot;</td>
</tr>
<tr>
<td><strong>Field of View</strong></td>
<td>60 degrees</td>
<td>55 degrees</td>
<td>140 degrees</td>
<td>360 degrees</td>
<td>130 degrees</td>
</tr>
<tr>
<td><strong>Connection</strong></td>
<td>400 kbps</td>
<td>500 kbps</td>
<td>500 kbps</td>
<td>600 kbps</td>
<td>500 kbps</td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>$4,995</td>
<td>$10,000</td>
<td>Not available</td>
<td>Not available</td>
<td>$15,000</td>
</tr>
</tbody>
</table>

### UNIQUE FEATURES

- **Vgo**: Text-to-speech; camera auto-tilts based on drive speed; remote monitoring headlights and auto-docking to the charger.
- **Tilr**: Web-based controls; can use own video like Skype, Google Vid Chat, MSN, etc.
- **Texai**: Technology agnostic (can pilot on Windows, Mac or Linux), secure connection between pilot and Texai (SSL and VPN tunnel).
- **RP-7i**: FDA-cleared, connects directly to Class II medical devices including electronic stethoscopes, otoscopes and ultrasound.
- **QB**: Untippable, two-wheel drive design; stabilized video; Web-based controls.

Sources: the companies

Margo

- Webcam (180 degree tilt)
- Logitech C910
- Hokuyo UGH bumper
- IR distance sensors
- 6 inch screen
- RGY LEDs, microphones
- Speakers
- RGB LED flowers
- Hokuyo UGH bumper
Margo

The Semi-Autonomous Social Telepresence Robot
Providing a Wide Field of View
Standard VGo Interface
Question

Do HRI design methods used for assistive technology transfer to the design of child-robot interaction?
Gallery at the Discovery Museum, Acton MA
Controlling Artbotics Pieces
Operator Station
Using the Interface
Participants

• 62 groups participated; 115 children total

  • 27 groups in Condition A (operated the robot first, then watched the robot from the peanut gallery)
  • 35 groups in Condition B (watched the robot first, then operated it from the kiosk)

• Youngest participant was 2.5 years old

<table>
<thead>
<tr>
<th>Category</th>
<th>Age Range</th>
<th>Num. children</th>
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</thead>
<tbody>
<tr>
<td>early</td>
<td>0 to 5 years</td>
<td>32</td>
</tr>
<tr>
<td>mid</td>
<td>6 to 10 years</td>
<td>69</td>
</tr>
<tr>
<td>teen</td>
<td>11 to 15 years</td>
<td>12</td>
</tr>
<tr>
<td>not reported</td>
<td>not available</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age category</th>
<th>Num. groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>early only</td>
<td>14</td>
</tr>
<tr>
<td>early-mid mix</td>
<td>9</td>
</tr>
<tr>
<td>mid only</td>
<td>28</td>
</tr>
<tr>
<td>mid-teen mix</td>
<td>5</td>
</tr>
<tr>
<td>teen only</td>
<td>3</td>
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</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th>Task Order</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Task Order</td>
</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Num. exhibits visited</td>
<td>2.30</td>
</tr>
<tr>
<td>Operation time (mins)</td>
<td>3.47</td>
</tr>
<tr>
<td>Access exhibit menu</td>
<td>0.15</td>
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<tr>
<td>Select exhibit button</td>
<td>2.33</td>
</tr>
<tr>
<td>Select hotspot</td>
<td>3</td>
</tr>
<tr>
<td>Select step button</td>
<td>0.44</td>
</tr>
<tr>
<td>Access exhibit information</td>
<td>0.15</td>
</tr>
</tbody>
</table>

![Diagram of task order and exhibit menu interaction](image-url)
Conclusions

• Design principles for assistive technology carry over to designing for children
  – Direct selection
  – Large buttons and key guards
  – Single step processes as much as possible
  – Provide feedback about system state
  – Customization for individual abilities
Providing feedback to bystanders

• Goal: Icons to display on a robot to allow bystanders to quickly identify a robot’s status

• Initial set of messages:
  • OK: Robot is working properly
  • Safe: Robot is safe to be around
  • Dangerous: Robot is unsafe to be around
  • Help: Robot needs assistance
  • Off: Robot is currently turned off
Icon parameters

GREEN  YELLOW  BLUE  RED
Robot conditions
480 participants (first 120 participants in each of the four robot examples) 174 women, 231 men, 1 reported as “other”, and 74 who chose not to report
Assembled icons

• Icons above are top selections for OK from the icon assembly study
• 2 more studies to obtain final group of 5 icons
  • First: Test top candidate icons for a specified interpretation
  • Second: Validate the top icons for their meaning
Bystander feedback
Bystander feedback results

- 15 robot photos
- 6 icon conditions (default/none, ok, safe, help, off, dangerous)
- 2700 participants (first 30 for each of 90 images)
- 1388 female, 1299 male, 7 other, and 6 who did not report
- Ages
  - 18-21: 75
  - 22-34: 1420
  - 35-44: 643
  - 45-54: 304
  - 55-64: 179
  - over 65: 43
- Education
  - HS: 264
  - Trade: 88
  - Some college: 656
  - Assoc: 300
  - BS/BA: 1086
  - Grad: 357
  - No response: 20