Designing Interactive Systems I

Mappings, Constraints, Seven Stages Of Action

Prof. Dr. Jan Borchers
Media Computing Group
RWTH Aachen University

Winter Semester ’20/’21

https://hci.rwth-aachen.de/dis
Review

• What are Gestalt Laws for?
  • 8 sample laws?

• How do you compute information content in user interfaces?
  • Analog vs. digital scales?

• What was the key problem of the “Swedish Hair Dryer”?

• How are the conceptual models of designer and user related to each other?
Mappings
Mappings

- Relationships between controls, actions, and intended results
- Connect UI elements to real world
  - Input devices (controls) $\Rightarrow$ (real or virtual) world
  - (Real or virtual) world $\Rightarrow$ output devices (displays)
Natural Mappings

• Good mappings are natural:
  • Spatial analogies
  • Perceptual analogies
  • Biological or cultural analogies

• Advantages:
  • Understood immediately
  • Easier to remember
  • Enable better ease-of-use
Spatial Analogies

• Most prominent example of natural mappings

• How would you arrange the controls for this lifting platform?
Spatial Analogies

- Rule: **Arrange controls in the same way that their real-world counterparts are arranged**
  - Room lamps
  - Car stereo audio fader

- Does not work for **activity**-centered controls
  - Those can be disastrous if not designed carefully
What’s Wrong with This Stove?

- Controls do not use a natural mapping
  - In-line leads to $4! = 4 \times 3 \times 2 \times 1 = 24$ possible arrangements
  - Left/right pairing still leaves 4 possible arrangements
  - Requires labels (which often indicates bad design)

- Better solutions?
Perceptual Analogies

• The UI element (input/control or output/display) is an imitation of the device itself

• “Voodoo Principle”

• Example: Mercedes car seat controls
Biological Analogies

• In-class exercise: Classifying physical measurements

• Rising level = “more”, falling level = “less”
  • Natural for all additive dimensions, e.g., amount (water level), heat (thermometer), volume, line thickness, brightness, weight,…
  • But: not for substitutive dimensions, e.g., color, audio pitch(!), taste, location,…
Biological and Cultural Analogies

• Another natural analogy: Order from top to bottom

• How about from left to right?
Stockholm Ticket Machine
Stockholm Ticket Machine (Redesigned)

1. Välj zoner
Choose zones

1 ZON
2 ZONER
3 ZONER

RABATT
Ungdom / Pensionär

2. Betala
Pay

00 Kr

Kortet går inte att läsa
Sorry your card is not working

3. Ta biljett
Get ticket

Source: http://peterkrantz.com/wud/nylage
Mappings & Conceptual Models

• To remember how mappings work, we develop conceptual models
Result: Some Design Principles

- Discoverability (current states, available states, and actions easy to determine)

- Good conceptual model
  - System image presents operations and results consistently
  - User gets a coherent conceptual model of the system

- Good (i.e., natural) mappings
  - Between actions and results
  - Between controls and their effects
  - Between system state and its visualization

- Good feedback about results
  - Complete and continuous
Constraints
Constraints

- They limit the ways in which an object can be used
- Provide cues for the proper course of action in novel situations

Goals
- Avoid usage errors
- Minimize the information to be remembered

Types
- Physical
- Semantic
- Logical
- Cultural
Physical Constraints

• Rely upon the physical properties (shape, size, etc.) to constrain possible actions
  • Example: The size and shape of a traditional key constrains the action of fitting it into a different lock

• More efficient and useful if constraint is visible ahead of time!
  • Example: Car key should fit both ways, but should then also work both ways
DO NOT TURN THIS LIGHT OFF!
Semantic Constraints

• Rely upon our knowledge of the current situation and of the world to constrain possible actions

  • Example: In a model plane construction kit, there is only one meaningful location for the driver’s figurine—in front the windshield, facing forward

• But: only use constraints that are meaningful for your user population!
Logical Constraints

• Rely upon logical conclusions to constrain possible actions
  • Examples:
    • All parts of a model plane construction kit are to be used (completeness)
    • Performing a task in an obvious order: 1, 2, 3 (sequence)
  • Natural mappings often employ logical constraints
    • Example: Left switch = left lamp is natural/logical
Cultural Constraints

- Rely upon generally accepted cultural standards to constrain possible actions
  - Examples
    - Labels are to be read, so are expected not to be upside down — implies which side is up on a closed package
    - Red = Stop
  - But: Only applies to specific cultural group!
    - Chinese labeling does not give most Westerners an idea where “up” is
    - A root problem of universal design
In-Class Exercise: Constraints

• Think about three examples for objects where constraints help us use them correctly

• Try to find examples for the different types of constraints
  • Physical, semantic, logical, cultural

• Sample areas: kitchen appliances, security devices, vending machines,…
Forcing Functions

- Can help to avoid errors; extreme physical constraints

- But: Think through the burden on normal operation!
  - E.g., seat belts

- Lock-out prevents an action
  - E.g., stairways to basements

- Lock-in prevents prematurely stopping an action
  - E.g., soft power-off switch on computers to avoid data loss

- Interlock enforces correct sequence
  - E.g., microwave turning off when opened, shelves in restroom
The Seven Stages of Action
The Seven Stages of Action

- How do people do things?
- What happens if something goes wrong? How to detect and correct that?
- Two parts to an action
  - Executing the action
  - Evaluating the results
- The Seven Stages of Action models this activity
Execution

- Goal (form the goal)
- Plan (the action)
- Specify (an action sequence)
- Perform (the action sequence)
Goal Formulation

• Goals are often very vague, and problem-oriented
  • “I need more light”

• They need to be translated into goal-oriented plans
  • “Operate the light switch”

• These then need to be specified into concrete action sequences
  • “Turn around, stretch out arm, put finger on switch”
Evaluation

- Perceive (the state of the world)
- Interpret (the perception)
- Compare (the outcome to the goal)
The Seven Stages of Action

Goal

Plan

Specify

Compare

Interpret

Perform

Perceive

Execution

Evaluation

World
More on the Seven Stages

• In reality, steps are hard to distinguish

• Complex tasks include sequences or hierarchies of goals (feedback loop)

• Goals are forgotten, discarded, changed

• Many actions are opportunistic, not planned
  • Meeting leads to talk, deadline-driven work

• Cycle can be event-driven (world) or goal-driven
Gulfs

- The model helps designers detect where things could breakdown
- Gulf of Execution
  - How to operate a device?
- Gulf of Evaluation
  - How to interpret the state of a device?
- The role of the designer is to bridge these gulfs
  - Gulf of Execution: with signifiers, constraints, mappings, and conceptual models
  - Gulf of Evaluation: with feedback and conceptual models
Gulf of Execution

- Even simple actions can seem difficult
- Reason: Cannot see how system works or what to do
  - Example: Peanut bags…
- Connection between plans and execution unclear
- What is the problem? — Mappings, Signifiers, …!
Gulf of Execution

- Gulf of Execution opens up through differences between
  - actions the user plans, and
  - actions the system offers — affordances!
- Ideally, the system lets user execute planned actions directly, without any extra effort
Gulf of Evaluation

• It is often unclear whether an action was successful or what its effect was

• Problem: Missing feedback

• Ideal: System state is easy to perceive and interpret and matches conceptual model that the user has of the system

• Example: Blinking printer LED
  • Still working, or crashed?

• Example: Switches in Myst
  • Part of the fun of the game
**Gulfs**

```
Goal
  \-- Plan
    |     \-- Specify
    |         \-- Perform
  \-- Compare
     |     \-- Interpret
     |         \-- Perceive
\-- World
```
## Seven Stages of Action as a Design Guideline

- The model provides basic checklist of questions to avoid gulfs:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>What do I want to accomplish?</td>
</tr>
<tr>
<td>Plan</td>
<td>What are the alternative action sequences?</td>
</tr>
<tr>
<td>Specify</td>
<td>What action can I do?</td>
</tr>
<tr>
<td>Perform</td>
<td>How do I do it?</td>
</tr>
<tr>
<td>Perceive</td>
<td>What happened?</td>
</tr>
<tr>
<td>Interpret</td>
<td>What does it mean?</td>
</tr>
<tr>
<td>Compare</td>
<td>Is this ok? Have I accomplished my goal?</td>
</tr>
</tbody>
</table>
Summary

• Mappings
  • Spatial, perceptual, biological and cultural analogies

• Constraints
  • Physical, semantic, logical, cultural

• Seven Stages of Action
  • Engineering model
  • Gulfs in execution and evaluation
  • Form goal, plan, specify action sequence, perform, perceive, interpret, and compare