IPM 10/11 – T1.4
Mental Models

Licenciatura em Ciência de Computadores

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U.PORTO FC

Summary

- Mental models vs. Conceptual design
- Human goal-oriented action
- Structural and functional models

Recall: Design Concepts

design concept is highest level and open to interpretation;
It is a *starting point*

- Affordance
  - visible constraints
- Mapping
- Feedback
  - Causality (true and false kinds)
  - Understandable action
- Visibility
- Conceptual models

Other factors:

- Transfer effects
- Cultural associations
- Individual differences

"Psychology of everyday things",
Don Norman, 1988

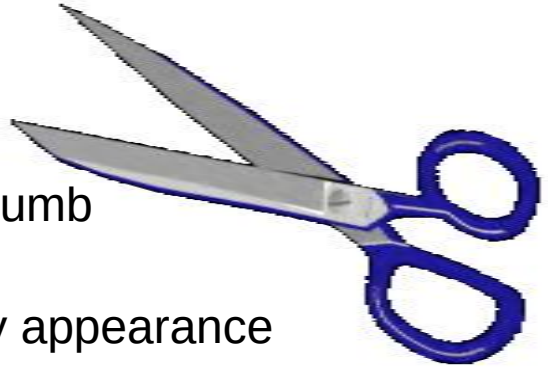
Will it work? Why seven?
How does the drive train work?
Which wheels steer? …

Our conceptual model of a bike isn't as good as we think it is …
… but it's good enough to recognize this as a bike!

Conceptual models: learning goals

- People have "**mental models**" of how things work
- We **build** our conceptual models from **many things**, inc:
  - affordances
  - causality
  - constraints
  - mapping
  - positive transfer
  - population stereotypes/cultural standards
  - instructions
  - interactions (inc. w/ other people)
  - familiarity with similar devices (positive transfer)
- Models **may be wrong**, esp. if attributes are misleading
- Models allow us to **mentally simulate** device operation
- The designer has control over the **system image**

An object that **helps** you form a conceptual model: **Scissors**

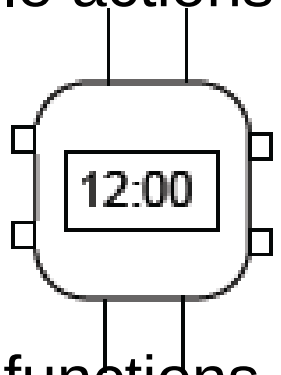


- Affordances:
  - Holes for something to be inserted
- Constraints:
  - Big hole for several fingers, small hole for thumb
- Mapping:
  - Holes-for-fingers suggested / constrained by appearance
- Positive transfer and cultural idioms:
  - Learnt when young; constant mechanism
- Conceptual model:
  - Physical object implies how the operating parts work

The object implies a **reasonable conceptual model.**
- Some things you don't understand you do anyway: why big blade down?
- Model's not perfect: what about "glide" style of cutting?

An object that **hinders** conceptual model formation: **Digital watch**

- Affordances:
  - Four buttons to push, but not clear what they will do
- Constraints and mapping unknown:
  - No visible relation between buttons, possible actions and end result
- Transfer of training:
  - Little relation to analog watches
- Cultural idiom:
  - Somewhat standardized core controls and functions
- But still highly variable conceptual model:
  - Must be taught



Mental models

"In interacting with the environment, with others, and with the artifacts of technology, **people form internal, mental models of themselves and of the things with which they are interacting.**

These models provide **predictive** and **explanatory** power for understanding the interaction.“

– Norman (in Gentner & Stevens, 1983)

Mental models vs. Conceptual Design

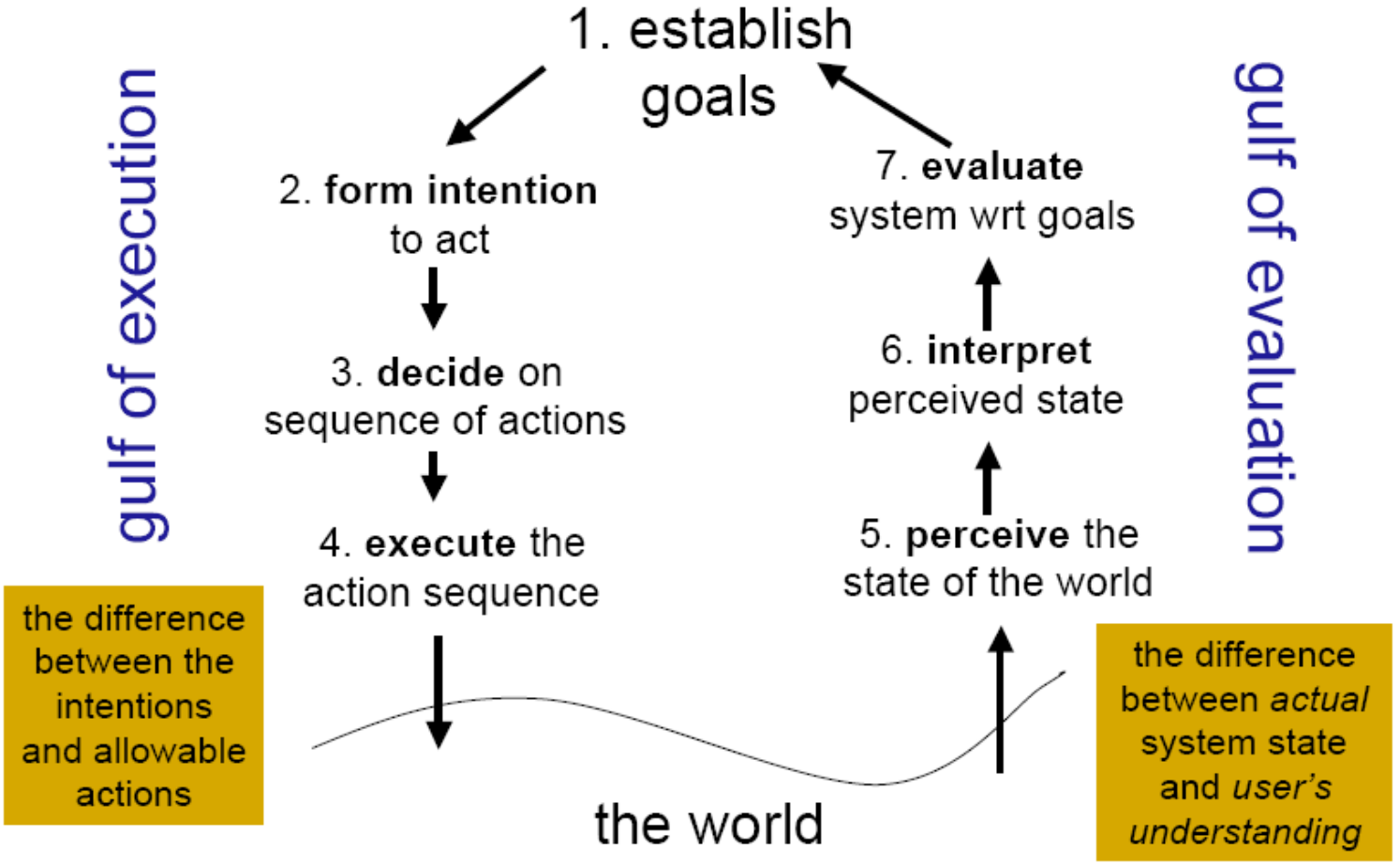
Mental models: *something the **user has (forms)***

- Users "**see**" the system through mental models
- Users **rely** on mental models during usage
- There are various **forms** of mental models
- Mental models can **support** users' interaction

Conceptual design: *something the **designer does***

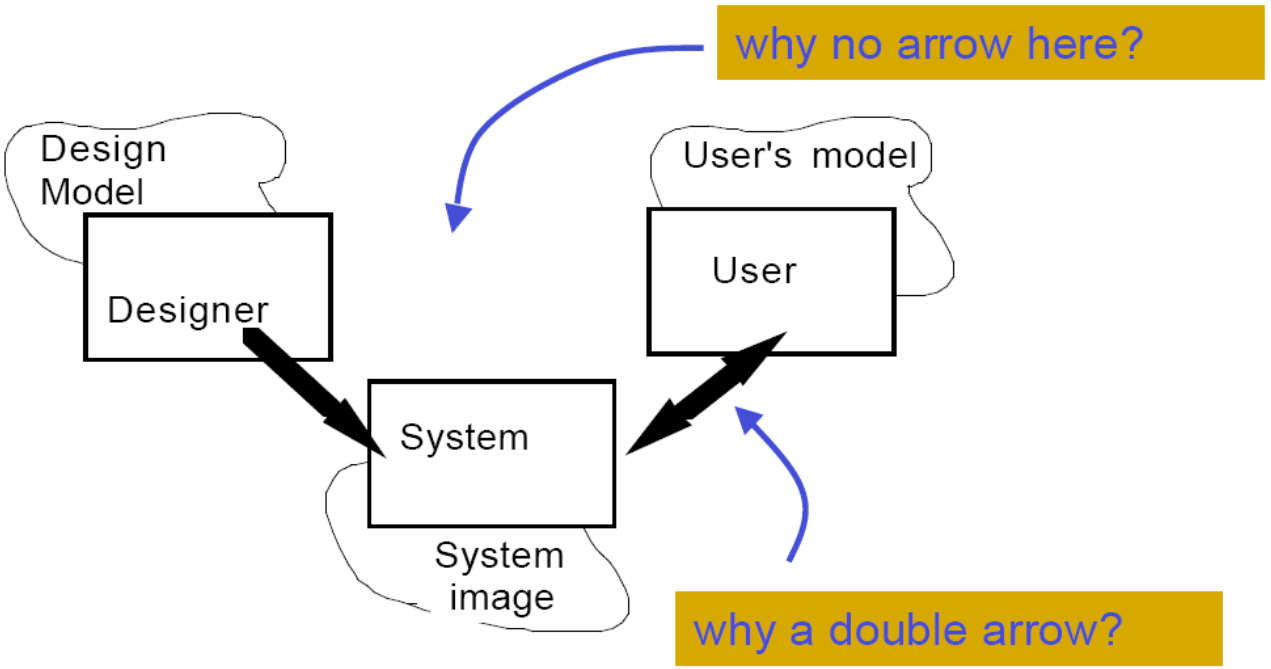
- **Defining** the *intended* mental model
  - Hiding the technology of the system
- **Designing** a suitable system image
  - Applying appropriate design guidelines
- **Analysis** using "walkthroughs"

Norman's seven-stage model
a description of human goal-oriented action



Conceptual Design

- Designing systems so users can understand them
- Assisting the user to build useful mental models



Various models

- **Design model** is the designer's conceptual model
- **System model** is a model of the way the system works
- **System image** results from the physical structure of what has been built (including documentation, instructions, labels) – it is what the user "sees"
- **User's model** is the "**mental model"** developed by the user through interaction with the system
  - User tries to match the mental model to the system model

Conceptual mismatch

- **Misconceptions** happen when user's model differs from the system model
  - Document sizes measured in bytes, not pages or words
    - Sun and SGI Unix use different measures for files
  - Dates may be in non-standard formats
    - Whose birthday is 09-06-46 (what country are we in)?
  - Userids (and files) may be constrained by system design
    - userid hmitchel@cs.ubc.ca
  - Error message may use system-specific codes
    - Error 404 in HTTP

Unix *mv* example

- The mv command in Unix “moves” files:
  - Simple mental model: it renames a file
- System model: more complicated
  - Two filenames are provided:
    - file is moved & changed
    - if the second filename already exists, it is deleted
  - Directories renamed only if second does not exist
    - mv will not delete a directory!
    - If second directory exists, first becomes a subdirectory
  - One or more filenames can be moved to a directory
    - Second filename must be an existing directory
    - All files are moved but retain their names

Some characteristics of mental models

- Incomplete
- Constantly evolving
- Not accurate representation
  - (contain errors and uncertainty measures)
- Provide a simple representation of a complex phenomena
- Can be represented by a set of if-then-else rules

Acquiring mental models

- **During system usage**:
  - The user's own activity leads to a mental model
  - Explanatory theory, developed by the user
  - Often used to predict future behavior of the system
- **Observing others** using the system:
  - Casual observation of others working
  - Asking someone else to "do this for me"
  - Formal training sessions
- **Reading** about a system
  - Documentation, help screens, "for Dummies" books

This is done **by the user** (not the designer)

Runnable models: ‘perturb’ system to figure out how it works

- These are **dynamic models**
  - Includes a notion of **causality**
  - “doing this will result in this”
- Used for **explanation**
  - To understand why the system responded as it did
  - Part of Norman’s model of behavior (interpretation)
- Used for **prediction**
  - To select an appropriate action
  - Also part of Norman’s model (intention)

Runnable models: **'doing *x* will result in *y*'**

1. **Establish the goal** to be achieved
2. **Form the intention** for action to achieve goal
3. **Specify the action** sequence corresponding to the intention

What would be a good **x**?

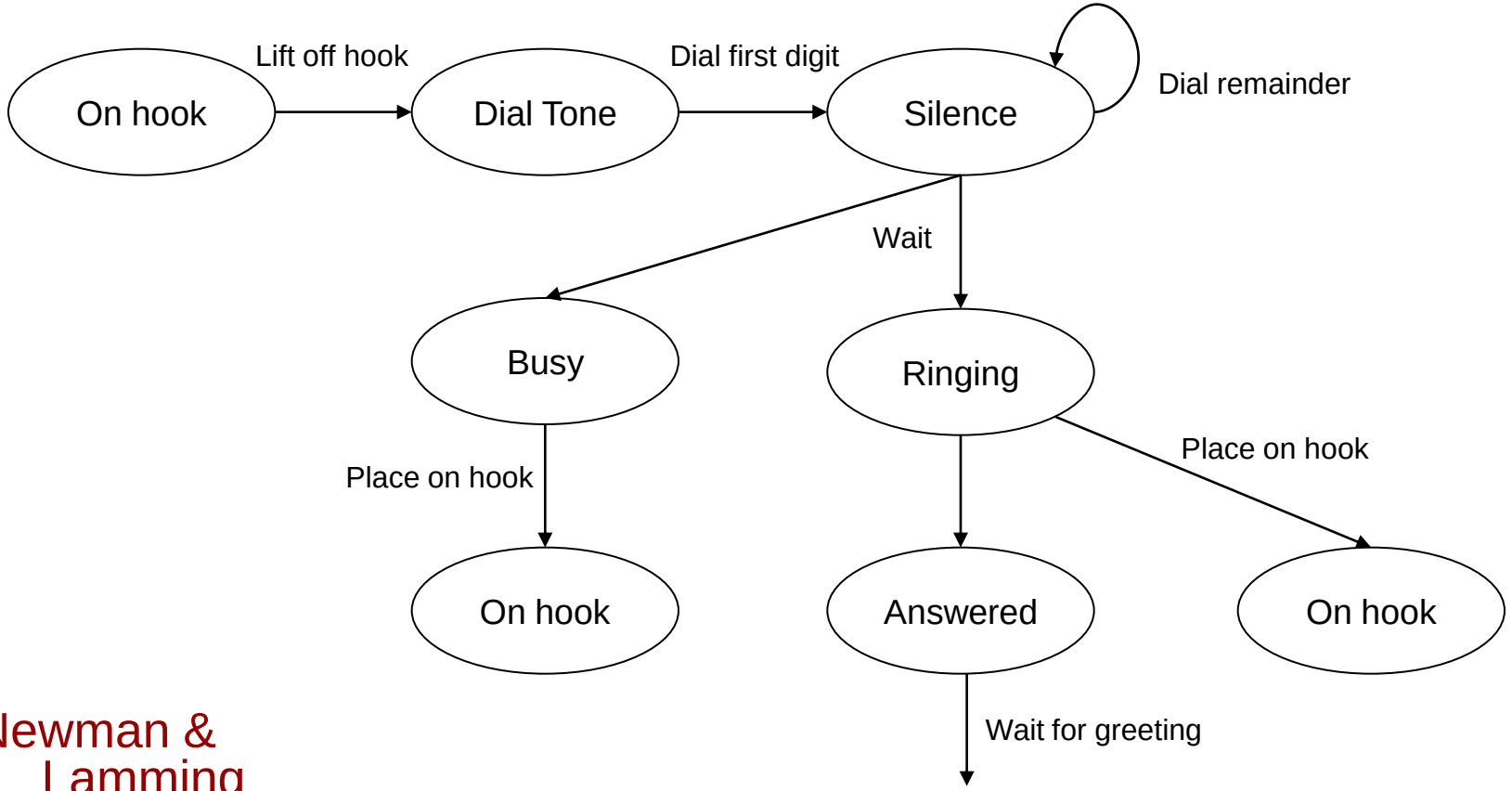
4. **Execute** the action sequence

5. **Perceive** the system state resulting from the action sequence
6. **Interpret** the perceived system state
7. **Evaluate** the system state with respect to the goal and the intentions

Did **y** happen?

What does it mean?

Mental model of a telephone call



Newman & Lamming

Fig 13.5

Common forms of mental models: Many categorizations. Very high-level.

- **Structural:** presents an image of *what* the system *is*
  - Descriptive (not prescriptive)
  - User may need additional knowledge to actually use it
  - Often more powerful / flexible, and often harder to use (esp. if don't have the necessary additional knowledge
  - ***Road map:*** *it may show a particular* type *of information, but it isn't customized to your particular use of that info.*
- **Functional:** action-based; describes *how* it is used
  - Prescriptive; specific; often step-by-step
  - Does not assume global or system knowledge
  - Easier to use, but not very helpful for problem-solving or dealing with the unexpected
  - ***Google directions:*** *great when everything's there; need more when there's a roadblock.*

Structural models

Presents an image of ***what* the system *is***

- Most maps and schematics
  - Provide a specific view of the system; “use as needed”
  - ***Different views:*** *street, bus, bike maps of same region are customized to drivers, bus riders and bikers. All are structural models.*
- Object-action models
  - Users think in terms of concrete or abstract objects
  - The system supports action on the objects
  - ***Unix:*** *files are objects, commands like mv acts on them*
- Analogies/metaphors
  - A new system (closely) resembles an old system
  - (usually) intent is to help *transfer* existing system knowledge
  - *desktop metaphor; spreadsheet.*

Functional models

Presents an image of ***how* the system is *used***

- Many kinds of user manuals
  - step-by-step “how-tos”.
- State transition model
  - Changes in state need to be “visible”; step through them.
  - ***Telephone example**, earlier slide; **online shopping cart***
- Functional “mapping” models
  - Different from a “system map”!
  - Users learn a sequence of actions to accomplish tasks
  - The mappings need to be rote-learned; often arbitrary
  - *Hand-held **calculator** maps “math” to key presses;*
  - ***keyboard shortcuts***

How users use mental models e.g. State transition model

- Our view of using a telephone is as a series of **state changes**
  - e.g. represented as in telephone example (earlier)
- MM predicts how long we wait at various points
  - Unexpected delays or unfamiliar responses not understood
- We try to fit what we hear into our model:
  - international calls may encounter different delays
  - international calls may have extra steps
  - international calls may result in different signals
  - a separate device exerts control in fax calls

A very common mental model: object-action models

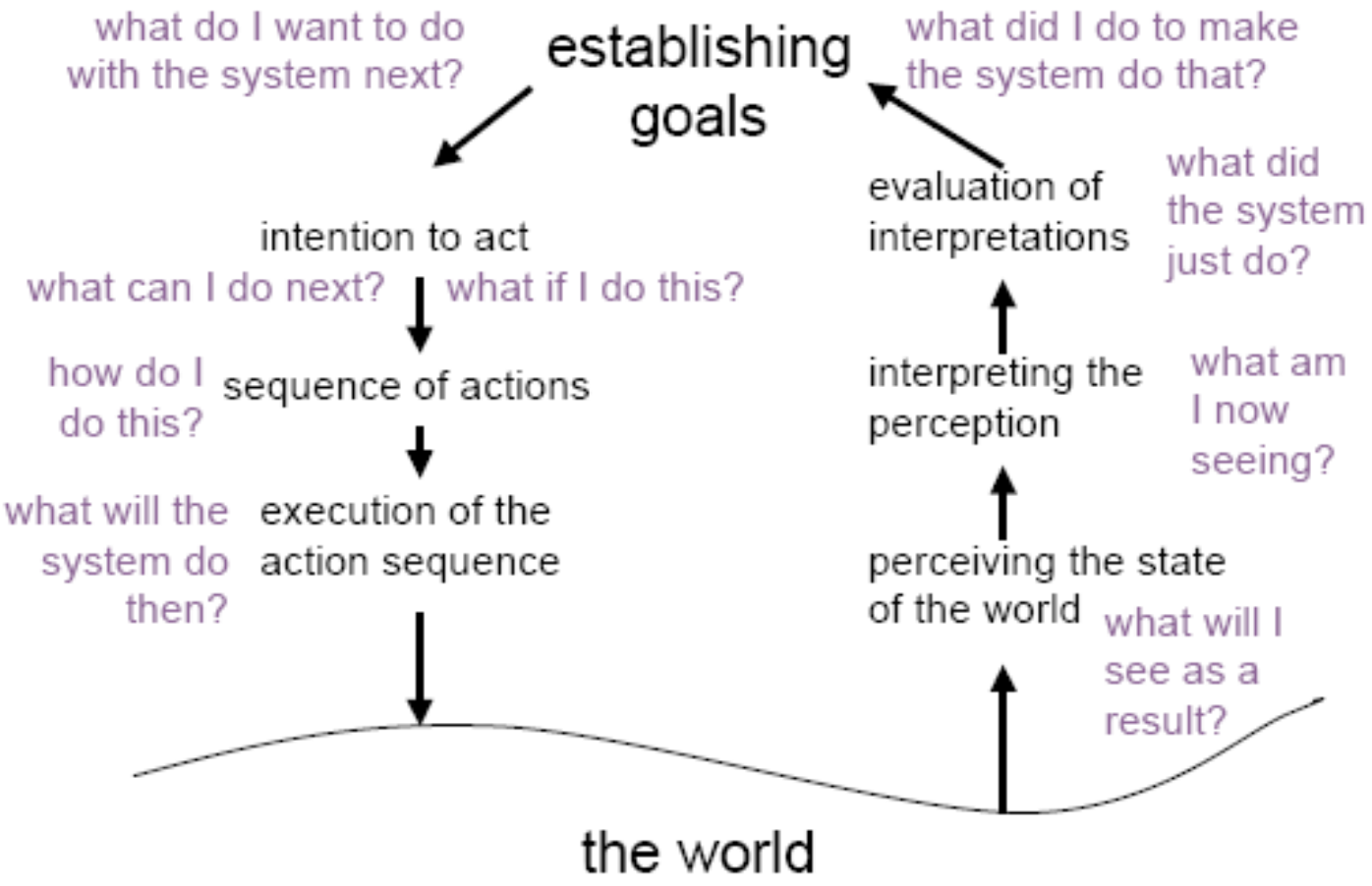
- Users think in terms of either concrete or abstract objects
- The system supports action on the objects

- Examples (for each: what is object, what is action?):
  - Unix mv command
  - Spreadsheet *(based on a physical ledger; compare with use of a calculator)*
  - *"Photoshop" an image file*

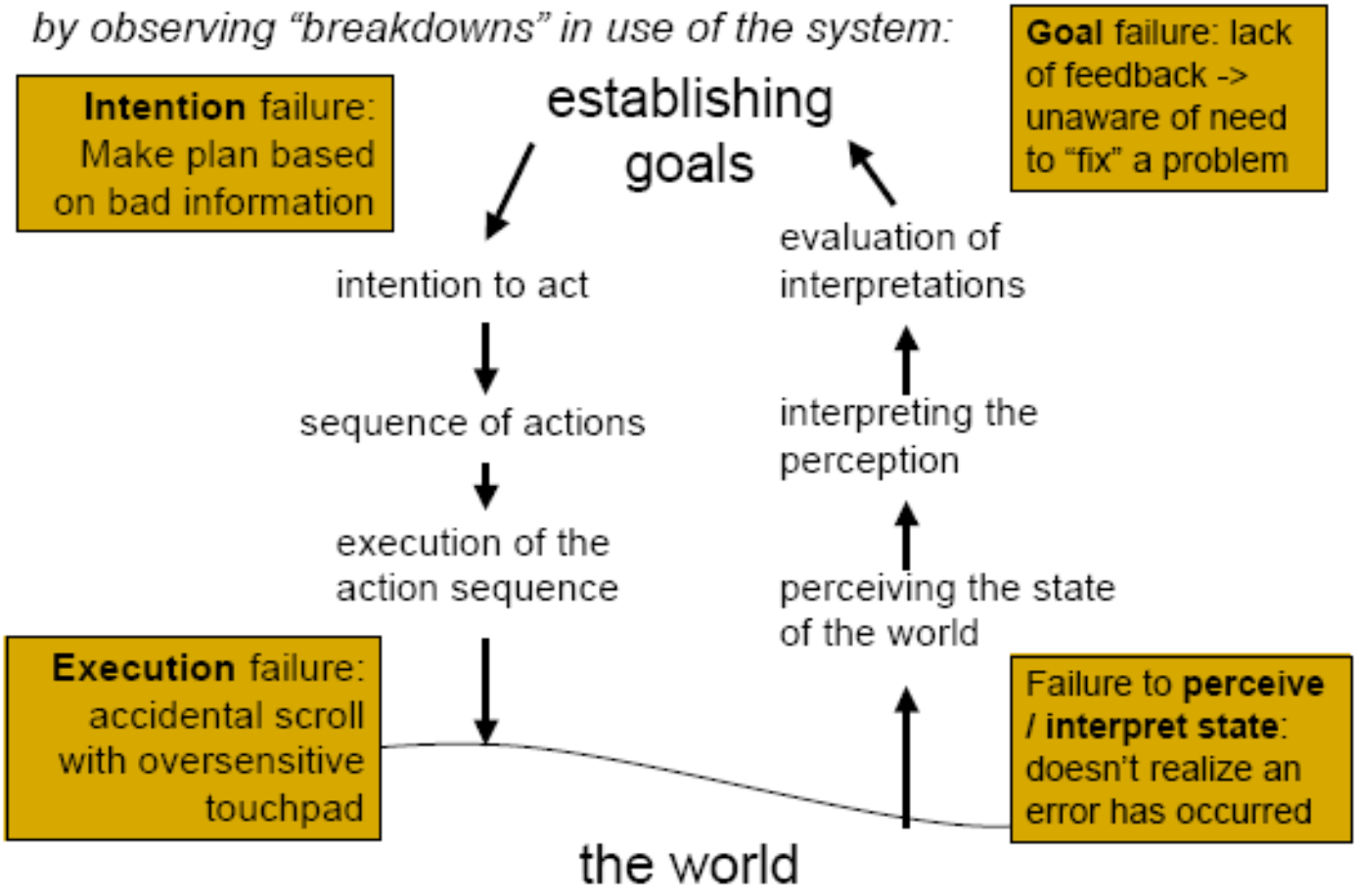
Topic: Mental models and user interaction

- Recap on previous lecture on mental models
- Mental models and user interaction

What mental models tell the user



How do designers identify a user's mental model?



The system image

- **We have control** over what users see
  - Responsible for turning the system model -> system image
  - Choose a system image to foster a good mental model
- Some interfaces **literally display the system model**
  - All objects and actions may be visible at all times
  - Automobile dashboard provides a system image of the car … sensor displays, physical controls
- **Currency** (up-to-date-ness) is important
  - The system image has to reflect the actual current state
- **Consistency** is important
  - Adaptive Microsoft drop-down menus violate consistency

When a simple mental model might be better:
Hiding system complexity

- Many systems have messy low-level details
  - These may not be relevant to the user's activity
  - The full functionality of the system may not be required

- Example: MS Word has hundreds of commands
  - Many users need only a small subset of these commands
  - Users themselves can hide complexity by customization
  - IT administrators may provide macro capabilities
    - Macros bundle low-level commands into a single concept
  - Wizards allow a user to "do what's right", skipping details
  - One approach: "**training wheels"**

Examples of where it helps to hide system complexity

- Water faucet
  - The [real] **system model** has independent hot & cold
  - The **system image** provides variable temperature
  - Some taps allow separate temperature control & volume control
  - Both “hot & cold” and “temperature & volume” are 2 DOF

- Audio-video conferencing link
  - The real system model has four independent channels
  - Users might want to combine these in standard ways:
    - “Glance” has two-way video only
    - “Office Share” has two-way audio and video
    - “Phone” has two-way audio only

Presenting the system image

- Explicit representation
  - Provide a current and consistent map of everything
- Implicit representation
  - Provide cues about the system model
  - Progressively expose/reinforce the system model
  - Telephone voice mail example:
    - Good: *You have three new messages. Press 2 to hear your first new message.*
    - Bad: *Press 2 to hear new message.*

Conceptual models in design Guideline #1

Provide a good conceptual model

Allows user to predict the effects of their actions

- Problem:
  - *Designer's conceptual model is communicated via **system image.***
    - Appearance, instructions, system behavior through interaction transfer, idioms and stereotypes.
  - If system image does not make model clear and consistent:
    - User will develop inconsistent conceptual model.
- "wrong" vs "simplified"?

Conceptual models in design
Guideline #2

- **Make things visible**
  - **Relations between user's intentions, required actions, and results are sensible and meaningful.**
  - Employ visible affordances, mappings, and constraints.
  - Use visible cultural idioms.
  - Remind person of what can be done and how to do it.
- Narrow your gulfs!

Conceptual design heuristics

(Remember: heuristics are prescriptive not descriptive)

- Choose an intended mental model **early in design.**
- Link choice of **mental model to style of interaction.**
- **Hide system features** that conflict with user's activity.
- **Exploit system image** to foster intended mental model.
- Ensure that **system image is current and consistent**.
- Take into account users' **existing mental models**.
- Allow for both **novice and expert** mental models.
- Use **simple, concrete, familiar metaphors**.
- Obey "**Law of Least Astonishment**" (Occam's Razor).

Mental models & paper prototypes: Revealing a mental model to the user

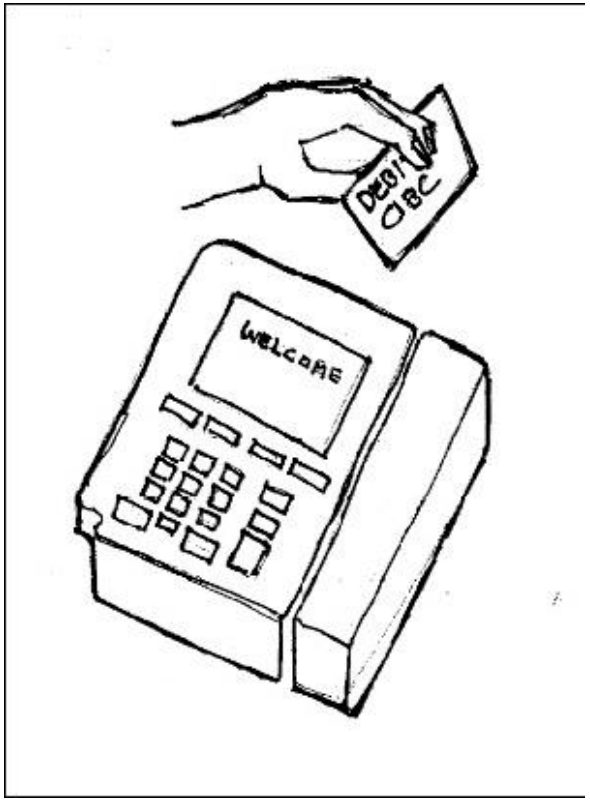
- A storyboard or paper prototype is one way of illustrating / documenting an intended or observed mental model.

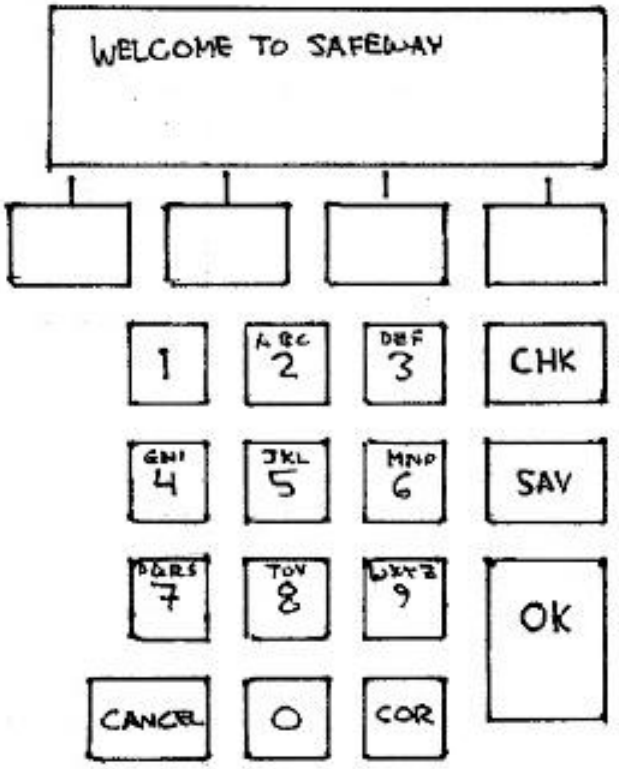
- Useful for design, communication, analysis.

Interesting for your upcoming report?

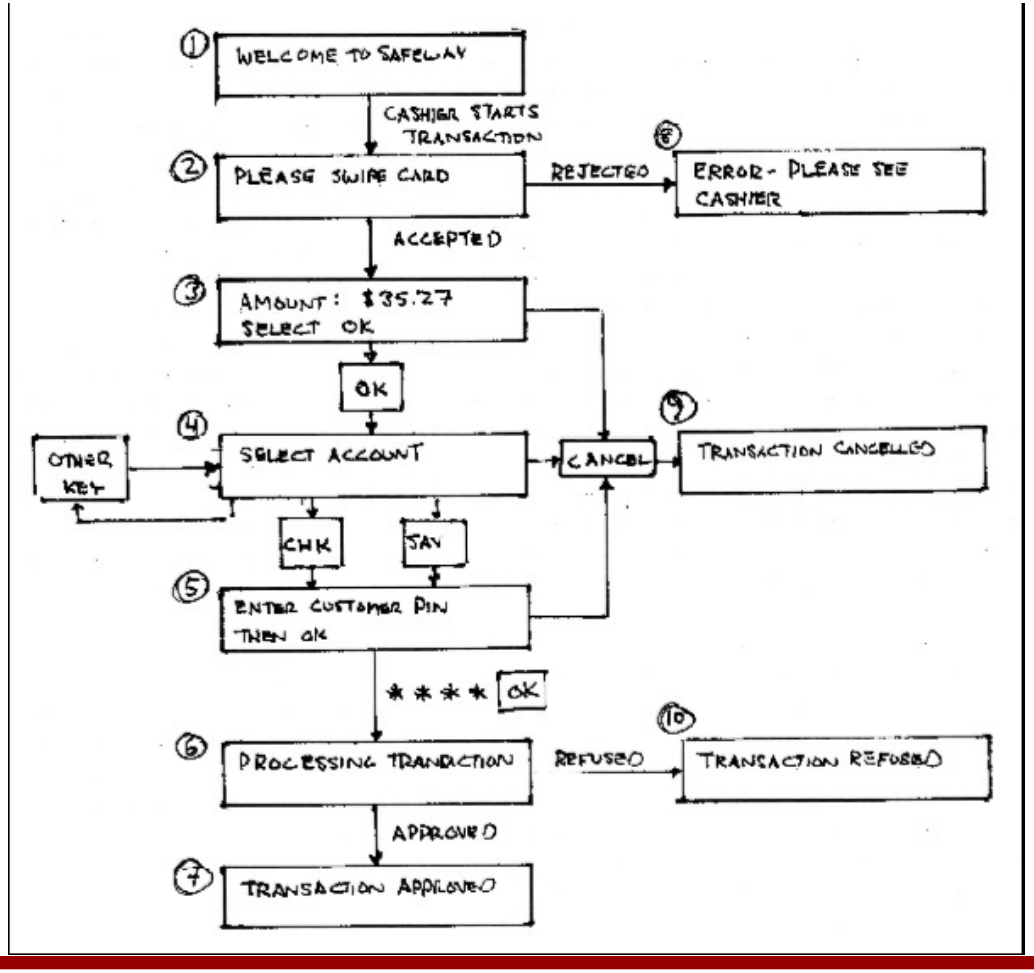
Grocery ATM (example of a paper prototype)

First, the task:





One way to prototype the mental model



How will you prototype your project assignment?

Summary

- Designer creates **conceptual models** and **system models**.
- User models (**mental models**) are developed by the user.
- Common mental model: **object-action model**.

Resources

1. Kellogg S. Booth, Introduction to HCI Methods, University of British Columbia, Canada http://www.ugrad.cs.ubc.ca/~cs344/current-term/