Usability Issues
in mixed initiative visual analytics

Alan Blackwell
Advait Sarkar

University of Cambridge
Outline

• Defining the class of system
• Mental models and user models in mixed initiative systems
• Cognitive factors in mixed initiative usability
  – Perception of control
  – Investment of attention
• Design patterns for structuring analytic interaction
• Open questions
The class of system (as intersection set)

- **Intelligent Discovery Assistants (research)**
  - CITRUS (Wirth et al 97)
  - AIDE (St Amant & Cohen 98)
  - IDEA (Bernstein et al 2005)
  - HAMB (Livingston et al 2001, full autonomy)
  - (...)

- **Visual Analytics (commercial)**
  - Omniscope
  - Tableau
  - Spotfire
  - Qlikview
User models $\neq$ Mental models
Cognitive ergonomics as execution/evaluation

- **GOALS**
  - **EXECUTION**: what we do to the world
  - **EVALUATION**: comparing what happened with what we wanted to happen

- **THE WORLD**
What is going on inside that thing?

How can I get it to do what I want?

Mental model
What is going on inside that thing?

How can I get it to do what I want?
A probabilistic view of user interaction

• **Machine:**
  – I know how to do several things.
  – I wonder which one the user wants me to do?

• **User:**
  – This machine can do a whole bunch of stuff.
  – What is most likely to make it do the right stuff?

• **Machine:**
  – I think the user has made a mistake

• **User:**
  – I think the machine has made a mistake
Bayesian inference of user intention

Probability that user wants to delete all files, given that they just typed `rm –rf`

(Prior) probability that user wanted to delete all files before we saw this.

If user does want to delete all files, how likely is it that they would type `rm –rf`?

\[
P(D|R) = \frac{P(R|D)}{P(D)}
\]

What is the probability user would type `rm –rf`, under all possible hypotheses?

D: User wants to Delete all their files
R: User has typed `rm –rf`
The case of Clippy

It looks like you're writing a letter.

Would you like help?
- Get help with writing the letter
- Just type the letter without help
- Don't show me this tip again
Dasher as a user model
Cognitive Factors
Helping the user with "semantic pointing"
Perception of control

User choice

"gravity"

delusion/paranoia symptoms

---

Graph showing the impact of user assistance on delusion and paranoia symptoms.
Attention Investment and abstraction use

• In using computers to get work done, attention (not information) is the scarce resource.
  – Mixed initiative systems reduce attention by automating operations
• But configuring the automation takes attention
  – In data analytics, this is an investment, and the payoff is reduced cost relative to manual analysis
  – Not all costs are investments, e.g. reading flashing advertisements that appear while I’m doing something else.
• There is a risk that the cost will be lost if the program/model doesn’t work.
Investment parameters

- The economics is based on attention units and probabilities:
  - Cost = attention units to get the analysis done (presumably doing the analysis has value, but this is external to the theory).
  - Investment = cost if there’s a potential pay-off in reduced future cost.
  - Risk = probability that a future cost will be imposed as a result of the way I’ve chosen to spend my attention.
Example: I am thinking of creating a statistical model ("program"): 
- This will **cost** me some **attention** (attention units ~ time).
- This is an **investment**, because I could use the model again instead of calculating things manually.

There is a **risk** (probability) I’ll get it wrong, and this will cost me a lot of future attention to unravel.
Motivation for use

• If we build it, they will come?
• But, will users really ever create new abstractions? Why should they?
  – It costs attention to go explore what these things are, and I need all my attention to get my work done!
  – Further, there is risk that exploring models will be a waste of attention.

• Design strategy:
  – Encourage guidance (requires attention investment, but smaller due to timely assistance)
    • At an appropriate time consistent with user’s activity.
  – Reward (pay off +) the investment.
Summary

• Attention investment is a way of understanding user problem-solving behaviors on computers.
  – Fills an important need for understanding “deep” problem-solving, like programming.
  – As opposed to simple usability of controls

• Provides a coherent design-time mechanism of making informed design choices.
  – And is much cheaper than finding big problems after building a system.
Design Patterns
Pattern Languages for Information Structures

• Christopher Alexander’s “Pattern Language”
  == Systematic Description of User Experience
  – e.g. Light on Both Sides of a Room
  – (not How to Rebate a Window Hinge)
• Interpretation activities: reading information structures
  – Search, Comparison, Sense-Making
    (viewing and navigating output visualisations)
• Construction activities: building information structure
  – Incrementation, Transcription, Modification, Exploratory Design
    (authoring with mixed-initiative tools)
• Social activities: sharing information structure
  – Illustrate a story, Organise a discussion, Persuade an audience
    (collaborating via mixed-initiative analytics)
Experiences of Visibility

• The information you need is visible
• The overall story is clear
• Important parts draw your attention
• The visual layout is concise
• You can see detail in context
Experiences of Structure

- You can see relationships between parts
- You can change your mind easily
- There are routes from a thing you know to something you don't
- You can compare or contrast different parts
Experiences of Meaning

- It looks like what it describes
- **The purpose of each part is clear**
- Similar things look similar
- You can tell the difference between things
- You can add comments
- The visual connotations are appropriate
Experiences of Interaction

- Interaction opportunities are evident
- Actions are fluid, not awkward
- **Things stay where you put them**
- Accidental mistakes are unlikely
- **Easier actions steer what you do**
- It is easy to refer to specific parts
Experiences of Thinking

- You don’t need to think too hard
- You can read-off new information
- It makes you stop and think
- Elements mean only one thing
- You are drawn in to play around
Experiences of Process

• The order of tasks is natural
• The steps you take match your goals
• You can try out a partial product
• You can be non-committal
• Repetition can be automated
• The content can be preserved
Experiences of Creativity

- You can extend the language
- You can redefine how it is interpreted
- You can see different things when you look again
- Anything not forbidden is allowed
Open questions / further (actual) work!

• Controlling the mix of initiatives
  – (regulating the autonomy of the interface agent)

• Addressing barriers to entry:
  – Domain knowledge
  – Representational expertise

• Visualising/navigating the analysis space

• Reconciling exploration and hypothesis testing
Questions?

Alan.Blackwell@cl.cam.ac.uk
Advait.Sarkar@cl.cam.ac.uk