Part A

interaction
Motivating Example

Searching for an apartment

1. Newspaper
2. Web Forms - [http://www.jobwohnen.at](http://www.jobwohnen.at)
3. Interactive Applications
   - Hotpads - [http://hotpads.com](http://hotpads.com)
   - Attribute Explorer - [DEMO](http://hotpads.com)
InfoVis & Interaction

Two main components:
Visual representation
Interaction

Main focus of current research: finding novel visual representations

BUT: Increasing interest in interaction
Related fields: Human-Computer Interaction (HCI), Interaction Design
InfoVis Reference Model

Raw Data: idiosyncratic formats
Data Transformations: Mapping raw data into an organization appropriate for visualization
Data Tables: relations (cases by variables) + metadata
Visual Mappings: Encoding abstract data into a visual representation
Visual Structures: spatial substrates + marks + graphical properties
View Transformations: Changing the view or perspective onto the visual presentation
Views: graphical parameters (position, scaling, clipping, ...)
Human Interaction: User influence at any level

User interaction can feed back into any level
Why interaction?

„Interaction between human and computer is at the heart of modern information visualization and for a single overriding reason: the enormous benefit that can accrue from being able to change one's view of a corpus of data. Usually that corpus is so large that no single all-inclusive view is likely to lead to insight. Those who wish to acquire insight must explore, interactively, subsets of that corpus to find their way towards the view that triggers an 'a ha!' experience.“

[Spence, 2007]
I hear and I forget.
I see and I remember.
I do and I understand.

Confucius
Interaction facilitates active discourse with the data

see  think  modify

[Card et al., 1983]
Response Time

0.1 sec
   Animation, visual continuity, sliders

1 sec
   System response, conversation break

10 sec
   Cognitive response
Interaction levels

Conceptual level
What to be done?
*e.g. scrolling / navigating*
--> Task

Control level
How can it be carried out by the user?
*e.g. move scrollbar*
--> User interface

Physical level
How does the user physically interact?
*e.g. mouse wheel, touch screen*
--> Interaction devices
Norman’s execution-evaluation cycle

- **Goal**
  - Form intention
  - Form action plan
  - Execute plan
  - Change in world

- **Evaluate system state**
  - Interpret system state
  - Perceive system state

- **Gulf of execution**
- **Gulf of evaluation**

[Norman, 1988]
Direct manipulation

[Shneiderman, 1983, Shneiderman and Plaisant, 2005]

Visual representation (metaphor) of the "world of action"

Objects and actions are shown

Analogical reasoning is tapped

Rapid, incremental, and reversible actions

Replacement of typing with pointing and selecting

Immediate visibility of results of actions

GOAL:
Allow the user to **directly interact with the object**
Direct manipulation
pros/cons

Benefits over commands
Visibility of the objects of interest
Control/display compatibility
Less syntax reduces error rates
Errors are more preventable
Faster learning and higher retention
Reversibility of all actions
Encourages exploration
Replacement of complex command languages with actions to manipulate directly the visible objects
Immediate visibility of results of actions

Concems
Increased system resources, possibly
Some actions might be cumbersome; typing commands with the keyboard might be faster
Macro techniques are often weak
History and other tracing may be difficult
Visually impaired users may have more difficulty
Users must learn the graphical representations

[Shneiderman and Plaisant, 2005]
Interaction Techniques

Visual Feedback, pop-up tooltips (mouse over)
Zooming + Panning
Manipulate View
Details on Demand
Brushing (Selection, Highlighting) + Linking
Dynamic querying, Filtering
Magic Lens, Movable Filter
Annotation
...

WOLFGANG AIGNER
Interaction and visual analytics 15
Visual Feedback, pop-up tooltips (mouse over)

Hovering mouse cursor brings up details of item

[InfoScope, 2007]
Zooming + Panning

Size + position of viewport

Geometric zoom
e.g. Photoshop

Semantic zoom
e.g. Google Maps

Focus+Context
e.g. Fisheye zoom
Manipulate View

Rearrange view
e.g. move view position, sorting items in a table

Change representation
e.g. from histogram to scatterplot
Details on Demand

Displaying detailed information about data case(s) on demand to the user

- May just be more info about a case
- May be moving from aggregation view to individual view
Selection / Highlighting

Select or identify one or more elements
e.g. via point + click, region selection (click + drag), etc.

[InfoScope, 2007]
Brushing

More complex than simple selection

Brush is an interactive interface tool to select / mark subsets of data in a single view
  e.g. by sweeping a virtual brush across items of interest

Usually used to visually filter data (via highlighting)

Additional manipulation / operations may be performed on the subsets
  e.g. masking, magnification, labeling etc.

Different types of brushes [Hauser et al. 2002]
  e.g. simple brush, composite brush, angular brushing, smooth brushing

[Becker & Cleveland, 1987, Hauser et al., 2002]
Linking

Connection between multiple views of the same data space

Updating one view means updating all

Often mentioned in conjunction with “brushing” (Linking + Brushing)
Multiple Views: Brushing & Linking

A multiple view–system uses two or more distinct views to support the investigation of a single conceptual entity.

[Baldonado et al., 2000]
Dynamic Queries

Selecting value ranges of variables via controls with real time feedback in the display.

**Principles:**

- Visual Presentation of Query’s Components
- Visual Presentation of Results
- Rapid, Incremental, and Reversible Control
- Selection by Pointing, not Typing
- Immediate and Continuous Feedback
- Support Browsing
- Details on Demand

[Online DEMO](http://www.samuelwan.com/flashmx_repository/rangefinder/rangefinder_09.swf)

[Shneiderman, 1994 ff, Miksch LVA]
Dynamic Queries

Interactive Search

Abbildung 127: Rangeslider [Ahlberg94].

Farbabbildung 22: Der FilmFinder [Ahlberg94].
Dynamic Queries (cont.)

[Shneiderman, 1994 ff]

Details on Demand
RangeSlider

[Shneiderman, 1994 ff]
AlphaSlider

Used to rapidly scan through and select from lists of alphanumeric data

Small-sized widget to search sorted lists
Letter index visualizing the distribution of initial letters - jump to a position in the slider
Locating an items out of a list of 10,000 items ~ 28s for novice users

[Ahlberg and Shneiderman, 1994]
Data Visualization Sliders

Data distribution is shown within control
Dynamic HomeFinder

The yellow dots above are homes in the DC area for sale. You may get more information on a home by selecting it.

You may drag the 'A' and 'B' distance markers to your office or any other location you want to live near.

Select distances, bedrooms, and cost ranges by dragging the corresponding slider boxes on the right.

Select specific home types and services by pressing the labeled buttons on the right.

[Shneiderman, 1994 ff]
Spotfire

Christopher Ahlberg
1991: Visiting student from Sweden at the HCIL University of Maryland
1996: Founder of Spotfire
2007: Spotfire was sold for 195 Mio. $
Online examples

Immobilien Suche
http://immo.search.ch/

Diamond Search
http://www.bluenile.com

Amazon.com search via Treemap (Hive Group)
http://www.hivegroup.com/gallery/galleryapps_amazon.html

Spotfire Holiday Gift Finder
http://spotfire.tibco.com/testdrive/holidays/
Dynamic Queries Summary

Users can rapidly, safely playfully explore a data space - no false input possible

- Users can rapidly generate new queries based on incidental learning
- Visual representation of data supports data exploration
- Analysis by continuously developing and testing hypotheses (detect clusters, outliers, trends in multivariate data)
- Provides straightforward undo and reversing of actions

Potential problems

- Limit of query complexity - filters are always conjunctive
- Performance is limited for very large data sets and client / server applications
- Controls require valuable display space
- Controls must be fixed in advance
- Information is pruned
- Only single range queries and single selection in the Alphaslider
- Operations are global in scope
Magic Lenses, Movable Filters

Arbitrarily shaped area of an object and to manipulate this area with specific operators

cover only a part of the object

Can be overlaid and combined

Combination with Dynamic Queries  [Fishkin & Stone 1995]
Revisiting the InfoVis Reference Model

User interaction can feed back into any level

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Interaction devices

Keyboard devices

Pointing devices

  Direct control devices
    easy to learn and use, but hand may obscure display
    e.g. Lightpen; Touchscreen; Stylus

  Indirect control devices
    takes time to learn
    e.g. Mouse; Trackball; Joystick; Touchpad; Graphics tablet

Novel devices and strategies

  special purposes
    e.g. Foot controls; Eye tracking; 3D trackers; DataGloves; Boom Chameleon; Haptic feedback; Tangible user interfaces; Digital paper

Speech and auditory interfaces

Displays

Printers
Connecting Time-Oriented Data and Information to a Coherent Interactive Visualization

Ragnar Bade, Stefan Schlechtweg
Silvia Miksch

The Midgaard Project
Aims

Data

High-Dimensional and Time-Oriented Data and Information

Interactive Visualization Techniques

Reveal the Data at Several Levels of Detail and Abstraction, Ranging from a Broad Overview to the Fine Structure

Time Visualization and Navigation Technique

Connects Overview+Detail, Pan+Zoom, and Focus+Context Features to one Powerful Time-Browser
Midgaard Approach

Visualizing Time-Oriented Data
- Qualitative Scales
- Qualitative/Quantitative Hybrids
- Quantitative Scales
- Data Points & Their Dimension
- High-Frequency Data

Interacting with Data
- Browsing Data
- Browsing Over Time

Semantic Zooming
- Smoothly integrated
Qualitative Scales

**Color-Coded Timelines**

- °C: > 41.0, > 38.5, > 10.3, < 38.5
- °F: > 105.8, > 101.3, < 101.3

**Height-Coded Timelines**

- °C: + > 41.0, + > 38.5, +, < 38.5
- °F: > 105.8, > 101.3, < 101.3
Qualitative-Quantitative Hybrids

Color-Coded Regions

Mark Regions without Colors
Quantitative Scales

Read Exact Values

Include Knowledge of Qualitative Scales
Points and their Dimensions

Occurrence Time & Uncertainty

Valid Time

Deviations

Trustability
High-Frequency Data

Abstract vs. Expressiveness

Information Mural [Jerding & Stasko, 1998]

Tukey’s Box-Plot Redesign
Interacting with Data & Time
Fokus: Explorative Methods of Data Analysis

Interactive & Explorative Features

Abstract & Highly Structured Data Context

Task-specific & User-oriented (Personalized)

Interactive Information Visualization

Explorative Data Analyses (EDA)

supervised Maschine Learning
Aims & Tasks: in2vis Project

Explore & Compare Different Methods to Ease the Understanding

Find their Strengths & Limitations

Estimate How Combinations of these Methods can Contribute to More In-Depth Reasoning Processes

Develop Guidelines How to Explore & Visualize Data & Information Task- and User- Appropriately
Study

Psychotherapeutic Data Acquired during Cognitive Behavioural Therapy of Anorectic Girls

- Psychodiagnostic Praassessment
- 14 sessions Start of G-CBT
- 13 sessions Evaluation I after 3 months
- 13 sessions Evaluation II after 6 months
- Evaluation III after 9 months/End of G-CBT

Data

Complex, Different Data Types & Time-oriented

Task

Find Predictors
Data Characteristics

Data from Questionnaires
Each about 40 Questions
Filled out by Patients, Parents, and Therapists
Answers Range from 0 to 6
5 Time Steps (pre, eval1-3, post)

➢ Explore Highly Structured, Temporal Data
Gravi++

ListVis

TableVis

Spring-based Core

Attraction Rings

Traces

Star Glyph
Overview Visualizations

ListVis

Persons
- Person:1C
- Person:2C
- Person:3C
- Person:4C
- Person:5C
- Person:6C
- Person:7C
- Person:8C
- Person:9C
- Person:10C
- Person:11C
- Person:12C
- Person:13C
- Person:14C
- Person:15C
- Person:16C
- Person:17C
- Person:18C
- Person:19C
- Person:20C
- Person:21C

Questions
- Question:1xASW
- Question:1xBDI
- Question:1xBMI
- Question:1xBCL Treffen Fr
- Question:1xBCL Zähl Fr
- Question:1xMR-EVA
- Question:1xMR-SDC
- Question:1xRestraint
- Question:1xSDD
- Question:1xSPS
- Question:1xSIR Treffen Fr
- Question:1xSIR Zähl Fr

Overview

change

Persons
- choose

Times
- choose

Forms
- choose

Value

Persons
- sofa.circ

Value

Persons
- sofa.score
TableVis

Multiple Bar Graphs
(blue values visualizing values > 6)

Scrollbar

Detailed view of the current and selected Bar Graph

Value
Time
PB-A2

Value
Time
f(x)BDI
Overview Visualization
Spring-based Core Visualization

Visualize data by positioning, color, and size of icons

Positioning of persons with spring-based Method

Movement and finding clusters and outliers
Gravi++
**Gravi++**

**Question**
Icon representing a question.

**Person**
Icon representing a person.
Gravi++

ListVis
Overview visualization with linking and brushing.
Gravi++

Time Control
Videorecorder-like controls to navigate through time.
Gravi++

Details on Demand for questions and persons (on mouse over).
Gravi++

Toolbar
Quick access to the most important options.
Traces: Visualize Movements Over Time
Star Glyph: Visualization of Exact Values
## Study - Evaluation

<table>
<thead>
<tr>
<th>stage</th>
<th>method</th>
<th>subjects</th>
<th>aim</th>
<th>outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>usability</td>
<td>usability inspection</td>
<td>1 usability expert</td>
<td>spot most obvious glitches</td>
<td>31 usability problems</td>
</tr>
<tr>
<td></td>
<td>heuristic evaluation</td>
<td>27 students (semi-experts in usability)</td>
<td>in depth testing</td>
<td>447 reports documenting 576 problems (221 different)</td>
</tr>
<tr>
<td></td>
<td>focus groups</td>
<td></td>
<td></td>
<td>no new problems BUT different perspective</td>
</tr>
<tr>
<td>visualization technique</td>
<td>insight reports</td>
<td>33 students (domain novices)</td>
<td>patterns of insight &amp; cognitive strategies</td>
<td>909 reports</td>
</tr>
</tbody>
</table>
|               | log files             |                                            | used vis. options & exploration strategies | 56055 log file entries  
work in progress                                      |
|               | focus groups          |                                            | relativize findings & aids correct interpretation | transcription of 3x 100min                                  |
| case study    | interviews            | 2 clinicians (real users)                   | feasibility & usefulness in real life  | transcription of 1x 60min  
work in progress                                      |
|               | thinking aloud        |                                            |                                       | notes on 1x 180min  
work in progress                                      |
| transferability | interviews         | 14 experts of other domains                | usefulness in other domains           | transcription of 14x 60min                                 |
Part B

visual analytics
Motivation: Main Problems

Data Unmanageable – Loss of Overview

Missing Integration of
Various (Heterogeneous) Information Sources

Various Interdisciplinary Methods

Missing Involvement of
Users and their Tasks
Analytical Methods

Screen Resolution: 1024 * 768 = 786.432

Measurements of Water Level in LA Every Year: 5.256.000

Number of Cellular Phones in Austria (2005): 8.160.000

Transmitted Emails Every Hours (World-Wide): 35.388.000

Whole Data often not Presentable

Applying Analytical Methods (Data Reduction)

Visualization of Most Important Data and Information

Analytical Methods

Statistics, Machine Learning & Data Mining

Visual Analytics – What is it?

James Thomas & Kristin A. Cook:

NVAC (National Visualization and Analytics Center), Seattle, USA

„Visual Analytics is the science of analytical reasoning facilitated by interactive visual interfaces“
Visual Information Seeking Mantra

overview first, zoom and filter, then details-on-demand

... 10 times ...
Visual Analytics Mantra

Analyze first,

  show the important,

  zoom filter & analyze,

  then details-on-demand

Analyze first,

  show the important,

  zoom filter & analyze,

  then details-on-demand

Analyze first,

  show the important, ...

... 10 times ...
Application Areas

Economic & Business Data
   Business Intelligence
   Market Analysis

Medicine & Biotechnology
   Patients’ Data Management
   Epidemiology
   Genetics

Security & Risk Management
   Disaster Management
   Computer Networks
   Transportation
   Reducing Crime and Terror Rate
   Fraud Detection

Environment & Climate Research

etc.
Stock Prices

[Hochheiser, 2003]
WireVis - Anti Money Laundering

[Chang et al., 2007]
Useful resources

Books


Web Lecture by John Stasko ★

http://weblectures.cc.gatech.edu/videolectures/7450_Interaction_files/intro.htm
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