Chapter 8 - Text & Documents

Visualizing and Searching Documents

Vorlesung „Informationsvisualisierung”
Prof. Dr. Florian Alt, WS 2013/14

Konzept und Folien (4th revised edition):
Thorsten Büring, Andreas Butz, Michael Burch
Outline

• Characteristics of text data
• Detecting patterns
  – SeeSoft
  – Arc diagrams
  – Visualizing Plagiarism
  – TextArc
• Keyword search
  – Enhanced scrollbar
  – TileBars
• Cluster Maps
  – Visualization for the document space
  – WEBSOM
  – ThemeScapes
• Cluster map vs. keyword search
Cluster Maps
Cluster Maps

• Downscaling of n-dimensional document space to 2D
• Map of a document collection
• Similar documents are placed close to each other
• Dissimilar documents are placed far apart from each other
• Provide thematic overview for exploration (same concept as product arrangements in a store)
• How to - Vector space model and map construction
  – Create inverted index of document collection
  – Exclude stop words and the most frequent words (“and” may not be a good discriminator of content)
  – Matrix of indexing words versus documents gives you document vectors
  – A document vector reflects the frequency of index words occurring in the document
Cluster Maps

• How to - Vector space model and map construction (continued)
  – Compute similarity between pairs of documents (e.g. dot product of vectors)
  – Layout documents in 1D/2D/3D

• Common approaches
  – Spring model of graph layout
  – Multi-dimensional scaling
  – Clustering (e.g. hierarchical)
  – Self-organizing maps (SOM aka Kohonen map)

<table>
<thead>
<tr>
<th>Document vectors</th>
<th>Doc 1</th>
<th>Doc 2</th>
<th>Doc 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Artificial”</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>“Creativity”</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>“Java”</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Similarity Matrix</th>
<th>Doc 1</th>
<th>Doc 2</th>
<th>Doc 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doc 1</td>
<td>1</td>
<td>0.66</td>
<td>0</td>
</tr>
<tr>
<td>Doc 2</td>
<td>0.66</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Doc 3</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
SOM

• Unsupervised learning algorithm
• SOM map is formed from a regular grid of neurons (nodes)
• Each node has
  – An x/y coordinate in the grid
  – A weight vector of the same dimensionality as the input vectors
• Input vectors
  – Used to train the map
  – Represent collection of objects
• In case of visualizing text, input vectors are usually equal to document vectors
SOM - Algorithm

1. Start with assigning small random weights to the nodes of the grid
2. Choose a vector at random from the set of input vectors and present it to the grid
3. For each node: calculate the Euclidean distance between each node's weight vector and the current input vector - the closest node is called the Best Matching Unit (BMU)
4. Calculate the radius of the BMU (radius diminishes with each time-step)
5. For each node within the radius of the BMU: adjust the weights to make them more similar to the input vector - the closer a node is to the BMU, the more its weights get altered
6. Repeat step 2 for N iterations
7. When training is completed each document is assigned to its BMU
Cluster Maps

- Lin 1992
- Personal collection of 660 research documents
- 2500 learning iterations
- Labeled word show most frequent title words
- Size maps to frequencies of occurrence of the words
- Neighboring relationships of areas indicate frequencies of the co-occurrence of words
Cluster Maps

- Research interest changing over time
WEBSOM

- [http://websom.hut.fi/websom/](http://websom.hut.fi/websom/)
- SOM of Finnish news bulletins for exploring and retrieving documents
- Labels show the topics of areas in the SOM
- Coloring encodes density - light areas contain more documents
- Navigation via zooming and panning
- Documents can be retrieved on the lowest level of the visualization
ThemeScapes

• Wise et al. 1995
• Map document density to third dimension
• News article visualized as an abstract 3D landscape
• Mountains represent frequent themes in the document corpus (height proportional to number of documents relating to the theme)
• Spatial characteristics of the map should map to interconnections of themes

Cluster Maps vs. Keyword Search
Cluster Map vs Keyword Search

• Cluster Map pros
  – Facilitates non-targeted exploration and browsing by spatially organizing documents
  – Provides overview of document set: major themes, sizes of clusters, relationships between themes
  – Scales up

• Cluster Map cons
  – How to label groups?
  – What does the space mean? How to label space?
  – Where to locate documents with multiple themes: both mountains, between mountains, …?
  – Relationships within documents?
  – Algorithm (SOM) is time-consuming
Cluster Map vs Keyword Search

• **Keyword search pros**
  – Reduces the browsing space according to user’s interests

• **Keyword search cons**
  – What keywords do I use?
  – What about other related documents that don’t use these keywords?
  – No initial overview
  – Mega-hit, zero-hit problem
TagClouds

- Show the frequency of words in a text
- Frequency is mapped to size and/or color
- Often found as navigation aid on web pages
- example below generated by www.wordle.net
Chapter 9 - Presentation

Dealing with the presentation problem

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Outline

• Presentation problem
• Zoomable user interfaces (ZUIs)
  – Development history
  – Space-scale diagrams
  – 2.5D
  – Advanced ZUI designs
  – Orientation in ZUIs
• Overview+detail interfaces
  – Abstract overviews
  – Performance issues
  – View coordination
  – View Layout
  – Zoom factors
• Focus+Context
  – Generalized Fisheye View
  – Graphical Fisheye
Presentation Problem
Presentation Problem

• Very often information spaces have to be displayed, which are significantly larger than the screen size
  – Too many data cases
  – Too many variables

• Potential techniques to maximize the number of information objects that can be displayed
  – Data encodings (see lectures 3 & 4)
  – Interaction and view transformations
  – Hybrid approaches
Presentation Problem

• Most common workaround: scrolling interfaces

• Advantages
  – Many users are familiar with scrollbars
  – Navigation at different speed
  – Thumbs show position and ratio of information space and view size
  – Have been found effective to move small distances

• Disadvantages
  – Only horizontal and vertical shifts
  – Scrollbars usually do not preview the content of the off-screen space
  – Take away screen space
  – Limited to linear navigation
  – Does not scale (search times and interaction sensitivity increase)
Presentation Problem

- Interaction and view transformations
  - Zoomable user interfaces
  - Overview+detail interfaces
  - Focus+context interfaces
Zoomable User Interfaces
Zoomable User Interfaces

- ZUIs aka multiscale interface
- “Navigation in information spaces is best supported by tapping into our natural spatial and geographic ways of thinking” (Perlin & Fox 1993)
- “By moving through space and changing scale the users can get an integrated notion of a very large structure and its contents, and navigate through it in ways effective for their tasks” (Furnas & Bederson 1995)
- Data objects must be organized in space and scale
- Users can manipulate which part of the information space is shown, and at what scale
  - Panning: movement of the viewport over the information space at a constant scale
  - Zooming: altering the scale of the viewport such that it shows a decreasing fraction of the information space with an increasing magnification and vice versa (Spence 2007)
- Due to non-linear navigation ZUIs develop their full potential as the size of the information space grows
Zoom Accelerator

• Power of ten
• 10 million light years from the Earth travel in 40 zoom steps to the protons of an oak leaf in Tallahassee, Florida
• http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html
More Recent Example: Photosynth

- http://photosynth.net

“What if your photo collection was an entry point into the world, like a wormhole that you could jump through and explore...”
More Recent Example: Photosynth
2D, 2.5D and 3D

• ZUIs are NOT 3D but 2.5D applications

• Why not make them 3D?
  – Historical reason: developers of seminal ZUIs wanted to avoid special hardware requirements (by now 3D chips are standard)
  – Simplicity - 3D systems are usually hard to navigate using current 2D display and input device technology

• Still, it is hypothesized that high-quality 3D interfaces may better exploit the human capabilities of spatial cognition and thus can improve user performance

• Mixed empirical results in previous research
2D, 2.5D and 3D

• Example evaluation: physical and virtual systems to retrieve documents in a 2D, a 2.5D, and a 3D setting (Cockburn & McKenzie 2002)
• Results indicate performance advantage for 2D layout to locate images of web pages
• Participants also found the higher dimensional interfaces more cluttered and less efficient
Smooth Zooming

• Older systems only provide a two-level zoom or navigation via coarse jumps
• Smooth continuous zooming
  – More demanding to implement
  – Helps the users to preserve their orientation during navigation
  – Users build a mental map of the information space
  – May improve user satisfaction via hedonic qualities - flying through space metaphor
Semantic Zoom

- Most common is geometric zoom: simply magnifies objects
- Semantic zoom: objects change their appearance as the amount of screen real estate available to them changes
- Semantic zoom provided by a directory browser implemented with Pad++ ([www.cs.umd.edu/hcil/pad++](http://www.cs.umd.edu/hcil/pad++))
Goal-Directed Zoom (GDZ)

- Semantic zooming: users zoom in until the target objects show the desired representation.
- Goal-directed zoom: users choose a representation of an object and the change in scale and translation is automatically performed by the system (Woodruff et al. 1998b).
Orientation in ZUIs

• A common problem of ZUIs: the lack of context
• Continuous clipping of orientation cues during zooming
• Amount of context needed is hard to predict
• Depends on variables such as
  – Type and ordering of the information space
  – The users’ familiarity with the information space
  – The task the users want to accomplish
• Example city map navigation: context needed by local citizen versus a first-time visitor
• Most straightforward way to rediscover context in ZUIs: zooming out
  – May also refresh the users’ mental model of the information space
  – But: frequent zoom-outs can be tedious
  – Provide fast and precise interaction design to minimize the required effort
Overview & Detail Interfaces
Desert Fog

• Jul & Furnas 1998
• More severe orientation problem for large or infinite multiscale spaces
  – Users zoom into white space between information objects until the viewport goes completely blank
  – Blank screen could mean:
    • There are no more object to be found in that direction -> zoom out
    • There are objects to come, but they are too far away to be seen -> zoom in
  – What to do?
Desert Fog

- Add multiscale residues
  - Landmarks for each information object are drawn across scale (think of it as a beacon)
  - Blank screen always means that there are no more objects in that direction
  - Problem: clutter of multiscale residues
- Apply hierarchical clustering to reduce clutter
- Based on spatial proximity
- Problems
  - Where should a landmark be located?
  - Geometric center of a cluster? Meaningful?
  - Most representative object? How to identify?
  - How many levels of the hierarchy should be displayed when? Again, can cause clutter...
Desert Fog

• Concept of critical zones: provide residues of views not objects

• Single critical zone
  – Only views are highlighted, which contain objects
  – Bounding rectangle encloses all contained views
  – Dark rectangle means that the critical zone contains all objects in the world - no sense to zoom out further

• Problem: where to zoom in on inside a critical zone?

• Trial and error strategy
Desert Fog

• Improve navigation aid by showing multiple smaller critical zones
• At the same time limit the number of zones to not cause clutter
• M defines a size, above which a zone is split into smaller zones
Zoomable presentation tool: Prezi.com

- demo: http://prezi.com/b9fk1xyfbber/
Development History

• 1978 - Spatial Data Management System (SDMS) (Donelson 1978)
• Visionary system for visualizing (and zooming) visual database representations
• Relied heavily on custom hardware
  – Rear-projected color television display
  – Octophonic sound system
  – Chair with isometric joysticks, touch-sensitive Tablets and a digital lapboard
Development History

• 1993 - Pad, the first multiscale interface (Perlin & Fox 1993)

• Alternative to the Windows Paradigm
• Visualizes an infinite two dimensional information plane populated with information objects the users can interact with (e.g. text files, personal calendar...)

• Important concepts
  – Portals as customizable views to facilitate navigation
  – Semantic zooming (will be discussed later on)
  – Designed to run on standard hardware

• Screenshot shows quarterly report displayed using Pad along with portals to provide magnified views of details
Development History

• 1994 - Pad++ (Bederson & Hollan 1995), successor of Pad
• Mostly technical enhancements
• Smooth zooming with hundreds of thousands information objects
• Implemented in C++
• Supposed to support platforms ranging from workstations to PDAs and set-top boxes (scalability of ZUIs!)
• Improved platform independency was only achieved by later ZUI toolkits
  – Jazz (2000), Java
  – Piccolo (2004), Java, .NET C#, compact framework
• http://www.cs.umd.edu/hcil/jazz/
Space-Scale Diagrams

• Furnas & Bederson 1995
• Diagrams to understand and model multiscale interfaces
• Basic idea
  – 2D image represents information space
  – Construct diagram by creating copies of the 2D image at each possible scale and stacking them up to form an inverted pyramid
• Two axes u1 and u2 represent spatial dimensions of the image
• Vertical v axis represents scale (magnification from 0 to infinity)

Figure 1. The basic construction of a Space-Scale diagram from a 2D picture.
Space-Scale Diagrams

• Property I: viewing window
  – Fixed size window which is moved through the 3D space of the diagram
  – Models all possible views, which can be achieved by zoom and pan

• Note: alternative ZUI model could represent space as a fixed 2D plane on which the size of the view window is manipulated

Furnas & Bederson 1995
Space-Scale Diagrams

• Property II
  – A point in the original 2D picture becomes a ray in this space-scale diagram
  – Hence regions of the 2D picture become generalized cones in the diagram

• Property III
  – The only meaningful contents of the space-scale diagram are properties invariant under a shear
  – Do not try to read too much out of the diagram!
Space-Scale Diagrams

• Simplification of the diagram
  – Compress the two spatial dimensions to 1D
  – 3D to 2D diagram
  – Viewing window becomes a 1D slit
  – 6 rays represent six points in the 1D space
  – Example starts with a view of all 6 points and then zooms in on point q
Space-Scale Diagrams

• Study basic pan-zoom trajectories
  • (a) panning: position changes, scale remains constant
  • (b) pure zoom: central position remains constant, scale changes
  • (c) zoom-around: zoom is centered around some fixed point other than the center of the window (in the example point q)

*Figure 6. Basic Pan-Zoom trajectories are shown in the heavy dashed lines: (a) Is a pure Pan, (b) is a pure Zoom (out), (c) is a “Zoom-around” the point q.*
Space-Scale Diagrams

• Joint pan-zoom trajectory
• Use case: automatic navigation to a pre-defined point
• Naive approach: calculate pan and scale distance separately and execute them in parallel - does not work!
• Reason
  – Pan is linear
  – Zoom is logarithmic
• Space-scale diagram shows how the trajectory s needs to be modelled
• View monotonically approaches a point in both pan and zoom
• Scale factor z must change hyperbolically with the panning of x
Space-Scale Diagrams

• Shortest path between two points
• Not a straight line, i.e. no pure panning!
• Remember: zoom is logarithmic, i.e. provides exponential accelerator for navigating very large spaces
• Arrows of the trajectories represent units of cost
• Diagram shows: to travel a vast distance the following strategy is fastest
  – Zoom out to a scale at which the old and the target position are close together
  – Short pan
  – Zoom back in

Figure 8. The shortest path between two points is often not a straight line. Here each arrow represents one unit of cost. Because zoom is logarithmic, it is often “shorter” to zoom out (a), make a small pan (b), and zoom back in (c), than to make a large pan directly (d).
Overview+Detail

• Overview+detail (O+D) interfaces are characterized by multi-window layout
  – Detail view presents details
  – Overview window provides overview information of the information space
  – Overview windows are usually also enhanced with visual cues

• O+d interface with field-of-view box give users direct and constant feedback on their position in the information space

• Thus context information is preserved

North & Shneiderman1997
The cars did not separate us. “(P21)

Again this is about travelling together, feeling as “one big group,” although being separated. This time the communication is verbal (through the walky-talkies) but still a quite similar reflection on the value of a restricted communication is apparent. Both cars needed to stay close, the group needed to “earn the communication” by paying attention to each other. This seems a crucial aspect to the feeling of belonging.

This participant also described the “dynamics of separation”, the moment they heard their friends before they saw them. Another participant shed light on those dynamics:

“1 went on a weekend trip together with a couple of friends. We used two cars for the trip. On the highway, we quickly lost sight of our friends in the other car. A couple of hours later, a short time before we had to leave the highway, I suddenly saw the other car again. I was surprised, because I didn’t expect the others to be that close to us. Happily, I took my cell phone and called a friend in the other car. They were also happy to be close to us again.” (P19)

This story further details this play of loosing and finding each other again, and the resulting pleasure. And also this story is about the same experience:

“After a weekend of wedding celebration, the guests all said goodbye to each other and went on their way in their cars – each one heading for very different cities in Germany. None

DESIGN

From a story headline to the Experience Story and the Storyboard

Based on the "motorcade" pattern we started to specifically design the experience to be created through the envisioned interactive product. First, we created a "story headline", which summarized the most important ingredients of the experience to be created:

Clique Trip provides the experience of being one group even when being in different cars - as if the interiors of the cars unite. To create this experience Clique Trip offers a communication channel, which is restricted and needs some effort to be established and maintained. In addition, Clique Trip plays with the tension between the feeling of separation and closeness.

Based on this story headline, we developed an Experience Story. This designed story is told from a user’s point of view while interacting with the envisioned product. It already describes interactions with the product and the (ideally) resulting emotions and experiences. It is this explicit focus on emotion and experience that distinguishes an Experience Story from scenarios used, for example, in extreme programming [1] or in interaction design [16]. Another important aspect is that the story must be compelling for every involved person in the design process [6]. As a narrative provides an overall structure [25], the Experience Story thereby facilitates communication between the different people involved in the design. The non-technical character of the story is crucial to the
O+D in Google Maps