Assignment 4

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1 Provide an in-depth analysis of your primary research topic for this course (as selected in Assignment 3). In particular, you should provide the following elements. For each of these elements, provide a table that summarizes your findings.

1.1 A summary and categorization of the information visualization techniques employed.

Upon examining the research literature, four primary attributes of the data to be visualized can be identified: How similar different result items are to one another, what their relationship is, how relevant a specific result item is in respect to the search terms, what language the document is in, and how big items are in document size. The most commonly used techniques for encoding these attributes are based on position, connection, color, and size. For position, Self-organized Maps, putting items into distinct, unrelated areas, and plotting them in a multidimensional space - or grid - such as a coordinate system are used. Connection is always visualized by providing connecting lines. For color, items can be either colored using distinct color entities or a monotonous spectrum. The size can be either used by scaling the entire icon representing a result item, or by using the item's different dimensions.
Table 1 displays the utilized encoding techniques in research literature.

		Similarity	Relationship	Relevance	Language	Size
Position	Self-organized Maps	[1, 9]				
	Distinct Areas	[2, 4, 8, 12]				
	Multidimensional Grid	[5, 7, 10, 14]	[6]	[2, 3, 6]*		
Connection	Connecting Lines		[2, 4, 7, 16]			
Color	Distinct Color Entities	[2]		[4, 6]	[8]	
	Color Spectrum			[7, 15]		
Size	Scale			[7]		[16]
	Dimensions			[5]		[8]

Table 1: Encoding techniques

It should be noted, that ordinary search engines format their outcome as a one dimensional list ordered by relevance. This corresponds to position (*) in Table 1. Obviously, most literature concentrates on visualizing similarities and relevance of result items with position and color based techniques being the ones most commonly used.

1.2 A summary and categorization of the interaction techniques employed.

There are three different primary methods for allowing the user to interactively manipulate a visualization: Displaying additional details on demand, allowing the user to refine the data set that is to be displayed, and to enable him to customize the presentation. Most techniques presented in the research literature concentrates on the first, thus practically following Shneiderman's overview-zoom-detail paradigm from [11]. Figure 1 displays the different techniques found in the literature.

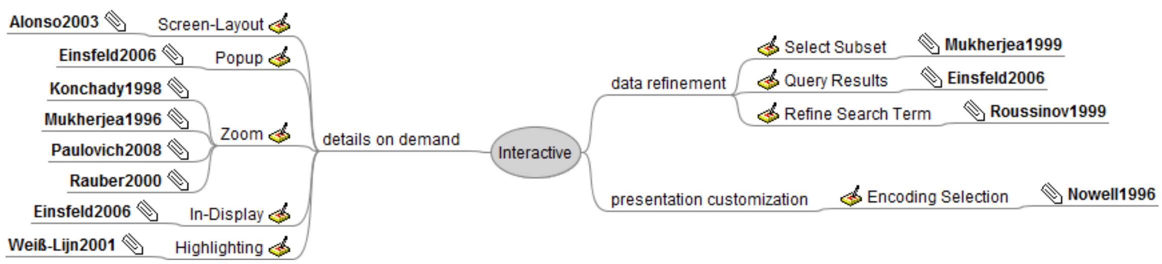

Figure 1: Interaction techniques

1.3 A summary of the evaluation techniques employed.

Three different primary domains can be identified that are evaluated by research literature: How well a visualization performs, how much it is accepted by users, and how easy it is for users to comprehend. Figure 2 displays the techniques discussed in literature.

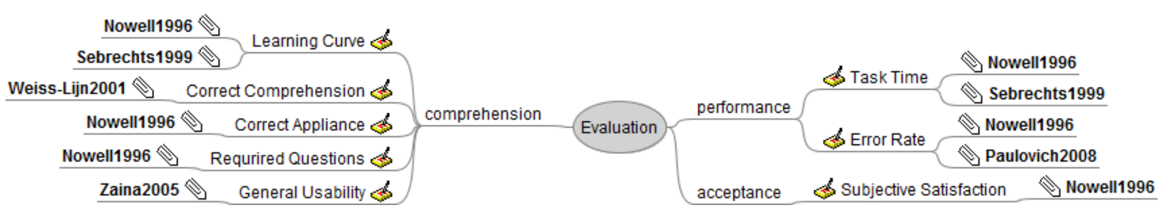

Figure 2: Evaluation techniques

2 Briefly describe your plans for your project. Note that your project should include some elements that are novel or interesting. These may be related to the visual representations, interaction techniques, or data processing needs of the target domain.

2.1 Introduction

Current progress in research literature fails to provide a model for visualization that is both highly usable and efficient. Target users for web search interfaces are mainly untrained users with partially little understanding of computer science and even less understanding of information visualization. A few truths have to be kept in mind when constructing a visualization:

- Performing web search is a subordinate task for users.
- Users will not be willing to spend much time on subordinate tasks.
- The level of utilization will differ from user to user.

These truths result in a number of consequences:

- Search visualization must be intuitive.
- Search visualization must be fast.
- Search visualization must be flexible.

Last, of course, the visualization must provide some benefit to search in respect to the current visualization. I believe that no current research incorporates all of these three consequences.

2.2 Visualization Encoding

Search results are an unlimited amount of objects. However, users are unable to comprehend more than 7 objects at a time. Shneiderman therefore suggests a overview-zoom-detail concept for large data sets in [11]. In my project, I aim to implement this concept. Existing literature already provides a number of algorithms for clustering search results, each representing different topics. The solutions, however, either map all results into a big map with different areas representing the different topics or display a vast amount of areas in different layers.

I propose the identification of only 5-7 high hierarchy topics. All result items relevant to a specific topic is assigned to it. This may result in a result item being assigned to more than one topic at the same time. As a query response, the user is only presented with overviews of these different topics (the exact nature of these overviews has to be determined, but I'm thinking of an interpolated topic title, number of hits, plus maybe one or two suggested links). One distinct color hue is assigned to each topic. This topic assignment is especially helpful for search terms that have more than one semantic domain such as “Java” or “Jobs”.

Upon selecting a topic the user is presented with the list of result items assigned to it. The result items are ordered by relevance to the general search term combined with the original ranking (how exactly

has to be identified). In order to visualize the relevance I propose a HotMap-like color encoding using colored squares. The Hue of the color is already defined by the topic. Either the brightness or the saturation can now be used for encoding the relevance.
Upon selecting a result item, the user is presented with a brief overview of the document content and possibly metadata (this is another issue that is to be examined). With these three layers of information visualization, the user can easily narrow down his search and identify relevant result items.

2.3 Visualization Interaction

Next to performing the drill-down analysis elaborated above by selecting topics and later on individual result items, I propose to allow a more elaborated query refinement. Current research always proposes adding or removing relevant keywords to a search term. I suggest a filtering of the already fetched result items. Instead of performing another query, the user can simply define simple filters that reduce the list of result items immediately at runtime to those containing the filter value. Another option would be to assign weights to the individual search terms thus identifying how much relevant they are for gaining the desired result.

2.4 Future Work

Future work would be the construct of a search canvas. Users could be allowed to drag&drop result items to a specific canvas. On this canvas, connecting lines could be used to show how documents are related to each other using their links. Additionally, users should be allowed to store these canvases and be provided with a RESTful link. This way, result item maps can be easily retrieved, shared, refined, and reused. An additional programming API would furthermore increase the reusability of the search interface. While the primary implementation would probably use only one specific web search API, the final product should aim to query multiple providers. The number of occurrences and rank of a result items in the different result lists of these providers could be used inside the internal ranking.

3 Briefly summarize what you believe are the four most important perceptual cues that allow us to perceive that objects exist in 3-dimensional space even when viewed on a 2-dimensional display. Justify why these four are more important than the others.

The following perceptual cues exist:

monocular static : *linear perspective, texture gradient, size gradient, occlusion, depth of focus, cast shadows, shape-from-shading*

monocular dynamic : *structure-from-motion*

binocular : *steroscopic depth*

artifical : *dropping lines to a ground plane, proximity luminance covariance*

I believe that the four most relevant cues are *linear perspective*, *occlusion*, *cast shadows*, and *shade-from-shading* for the following reasons: Both monocular dynamic and binocular require very specific visualization methods. Monocular static clues, however, can be applied to any visualization. They work with monocular and binocular methods as well as with static and dynamic ones. Therefore, monocular static clues should be preferred.

Dropping lines to a ground is a technique that is very similar to *cast shadows*. It too aids in the perception of the correct positioning inside a 3D space. In contrast to *cast shadows*, however, it uses an artificial visualization technique. A shadow is a natural phenomenon that is instinctively perceived and decoded by a human, thus promoting preattentive processing. Dropping lines, however, require active attention for a correct decoding since they are non-natural, artificial constructs.

Texture gradient, *proximity luminance covariance*, and *size gradient* modify the actual look of items displayed. Neither size, nor texture, nor luminance are purely artificial presentation attributes, but depend on the item that is actually displayed. Making these attributes dependent on position and shape within a 3D space would falsify the item perception. For the display of real items, this might result in compromising the perception of items. In case of artificial items encoding data, these attributes are usually used for encoding information. By using them for generating a 3D perception, the encoding domains are lost. *Depth of focus* does provide an encoding of the relative distance of items to the viewer. However, by blurring items, valuable information encoded might be get lost due to limited recognizability of the items.

Linear perspective on the other side allows the perception of a 3D positioning by looking at a 2D display. It actually adds one domain available for encoding information (the third dimension). *Cast shadows* aids in the correct perception of the dimensions. By dropping a shadow to a common plane, different items can be brought in context to one another more easily. *Occlusion* is one of the most powerful encoding techniques. It encodes the relative distance of items to a specific point of view. In the human mind, information encoded using *occlusion* actually dominates other encodings such as *stereoscopic depth* as elaborated in [13]. *Shape-from-shading* effectively encodes the 3D shape of the item displayed. For real items displayed, this encoding will be automatically provided. For artificial encodings in InfoVis applications, this allows the utilization of not only 2D shapes, but extends to domain to 3D shapes.

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