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The Uexküll Approach:

Evaluation of Multivariate Data Organizations for Support of Visual Information Retrieval

1 Introduction

Information retrieval is the activity of searching for documents, searching for information within documents and searching for metadata about documents, with the purpose of acquiring information and knowledge. A necessary, but not sufficient, pre-condition for successful retrieval is the suitable storage and organizing of documents, so that they, and information in them, will be easier to find. Information retrieval research is to a high degree concerned with the construction and evaluation of retrieval approaches, systems and components.

In recent decades, information retrieval has been increasingly understood as electronic retrieval, meaning that documents, or at least references to documents, are stored and organized digitally, in document databases. Such document databases are indexed, meaning that words, occuring in – or as-signed to – documents are linked to these documents, so they can be used in searching. The search for documents is mostly done against computer terminals.

Search through interaction with computers entails some problems that are not present when a user searches with the help of a human intermediary, for example a librarian.

2 The Uexküll idea

2.1 Problem to be solved

When users search for books, or other types of documents, two main cases are usually considered:

1   Search for a known item: users know the identity of the book or document they require, but need to know where the book or document is to be found.

2   Search for information about a subject, without knowing the title or any other identification of relevant documents.

The latter case is called subject-based search, and it is here my dissertation is applicable. Subject-based search is dificult for many reasons. Two important reasons are.

*Even though users "know" what kind of information they need, they often have problem to provide a precise description of this need. This is true even when the formulation or description is given orally to a colleague or a librarian. In this context it is relevant to bring up Belkin's words about the natural mismatch between a document that expresses what an author knows, and a request that expresses what a user does not know.

*Computer programs often require users to address them quite precisely, but users do not even know how the document database is indexed.

The two problems listed above tend to add up when using computers for information retrieval, making subject-based information retrieval a dificult task both to perform and to facilitate.

2.2 Idea for solution

The Uexküll approach, and this dissertation, is one of many proposed approaches to a relief of these obstacles.

The approach is named with reference to the Estonian biologist Jacob von Uexküll's UMWELT theory that is used as a metaphor and an inspiration. Uexküll was interested in how living beings subjectively perceive their environment(s). He dis-

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tinguished between UMGEBUNG, the objective spatiotemporal environment, and the UMWELT, which is the subjective way different organisms conceive of it. A fly will see a meadow differently than a human, even tough their eyes are located and pointed equally.

The idea of the Uexküll approach is to present the document database to the user in 3D configurations, where documents are located along coordinate axes (also called dimensions or concept axes), enabling the user to navigate in the information. Such a configuration we also refer to as a scene. The configurations, stemming from the same database (UMGEBUNG) will vary depending on the UMWELT, which is the particular user's information need when accessing the retrieval system.

2.3   Searching and navigating in an Uexküll-based system

Instead of having to guess the vocabulary of the system (how the system indexes the documents), the user commences the search by choosing from constituting concepts that the system presents to him in the form of menus or lists. Choosing from these concepts, the user limits the number of documents to be presented, confining it to documents presumably related to these concepts, and thereby his information need. Already at this stage, the system takes more responsibility of presenting to the user the material contained in a certain database, redeeming the user from the need to acquaint himself with the indexing.

The chosen subset of documents is presented to the user as a scene, a 3D-space, of which the chosen concepts constitute the coordinate axes. The chosen axes may be seen as directions that define the content of the database, and have names. Moving along an axis called "History", the user will encounter documents on his way that are are increasingly related to History. In a scene defined by the axes "History", "Norway" and "The middle ages", documents can be related to one or more of these concepts. A document about Norwegian history focusing on the middle ages, will presumably reside far out along all three axes.

2.4   Examining and retrieving documents

The intention is that the user, while navigating in

the scene, will use the mouse to point at potentially interesting documents, so that further information about them is displayed. Relevant documents may then be retrieved by clicking on them. At any time during the search session, the user can modify the navigation environment. He can choose new concepts that download a new scene. The new scene can either be related to the previous one (having one or two of the concepts in common), or it can have entirely disjoint scene. A new scene will have a diffeerent set of documents, some of which may be the same as in a previous scene, possibly differently located/oriented.

2.5 Organizing data to support Uexküll-based retrieval

To construct a system as described above, the data (index terms and documents) must be ordered in a certain way. There are several methods to organize data that may support such a presentation of documents, and those methods (below referred to as *data organizations*) exhibit different properties.

3 Evaluation of Uexküll

Being a novel approach, an important aspect of taking a system based on Uexküll into use is the evaluation of it. This is a difficult challenge with a number of facets. First and foremost the approach as such needs to be evaluated, so that a sound decision may be taken whether to invest in implementing it. Should the evaluation render the approach worthwhile trying, one or more prototypes of systems based on the approach may be built and evaluated.

This dissertation addresses the evaluation of Uexküll as an approach. Any system based on the approach would have two parts, each of which needs to be evaluated separately:

*The data organization part -as mentioned above, in order to attain the desired functionality, the storage and organization of the documents (the document database) must support displaying of documents in the prescribed way.

*The user interface part -the facility that enables the user technically to access the mentioned data organization.

This dissertation addresses the evaluation of the data organization part.

3.1 Evaluation traditions in information retrieval

Evaluation is an important aspect of information retrieval research. Evaluation can be divided in two: system-oriented and user-oriented. System-oriented evaluation has relatively long traditions, and has had long time to develop. As its name indicates, It solely evaluates the technical aspects of information retrieval, mainly the matching of the user-given search request against the documents the system returns. User-oriented evaluation is younger of age, and seeks to also incorporate the user as an actor, e.g. accounting for differences among individual users or types of users. Somewhat simplified, one may say that system-oriented retrieval evaluation uses methods from mathematics and computer science, whereas user-oriented evaluation tends more towards the social sciences in choice of methods. To summarize so far:

−We choose to evaluate Uexküll as an approach rather than as a system

−We use a system oriented evaluation approach (the laboratory model) rather than a user oriented approach

−We evaluate data organizations, not user interfaces

3.2 Data organizations

It was quite early decided that the data organization would be brought about by statistical analysis, in a way that renders the index terms and the documents as points in a multidimensional vector space. In such a space, documents' relatedness to topics is expressed by the points' coordinate-values on the axes representing the topics. If we, from a multidimensional vector space, choose 3 dimensions (a process called a projection), we get a 3-dimensional vector space that can be rendered as a scene.

Data organizations may be created and implemented in different forms.

- They can have different numbers of dimensions (number of concepts that define the space and that users can choose from)

-They can be modified by rotations to form rotated organizations. Rotated organization will often have clearer and simpler associations between documents and axes, and are expected to perform better.

The different forms will have different properties, advantages and disadvantages when 3D-projections (scenes) are extracted from them through user choices. It is the data organization that determines the potential quality of retrieval. It determines the technical accordance between topics and documents that pertain to these topics. Therefore we wish to evaluate the data organizations in this dissertation.

4 Evaluating Uexküll data organizations

4.1 Using laboratory evaluation model

We chose to evaluate system aspects (the data organization part) of the Uexküll approach, using the (system-oriented) Laboratory model for IR evaluation as applied to best-match retrieval. Such an evaluation uses a test collection, which is a document database for which a number of user requests − with sets of documents judged relevant by experts − exist. A certain system will return documents as a response to any of these queries, both relevant (identical to the documents judged relevant by experts) and non-relevant. The evaluation compares the Query result (list returned from the system) to the recall base (list of documents judged relevant). It checks the accordance between the returned list and the list of relevant documents: how many of the documents judged relevant are rendered prominent by the system? Standard measures, precision and recall, characterize the quality of the systems. Such an evaluation is dependent on a query and a system returning a relevance-ranked list.

4.2. User simulations

We would like to test the potential of an Uexküll data organization as much as possible as if used by end users. This, without having access to end users. To achieve this, we mimic the way a user would access this organization when searching and retrieving scenes. This we call user simulations. A computer program uses the test requests from the collection to select axes. For each of the test-requests a scene is created.

A "perfect" data organization would place the documents judged relevant (members of the recall base) for this request prominently in

the scene. Our organizations are not perfect, and place documents judged relevant, as well as other documents, prominently. Our aim is to measure "how imperfect" our organization are, by comparing the list retrieved from the organization with the recall base. Here, the laboratory evaluation model comes into play. But first we need to convert our "unordered" scene into an ordered (ranked) list of documents, so that prominent documents come before the less prominent ones.

When the 3D-scene is being generated we translate the 3D-layout of documents into a linear list. This we achieve using a special model called a location model. The location model calculates a number for each document, that indicates the position of the document in the list (its prominence). In this way we are able to use the standard measures to evaluate how well relevant documents will render prominent in the list.

In addition, we wish to evaluate the extent to which relevant documents will be visible in the scene if they are rendered prominent. For this purpose, we use two specially designed measures. The result is an extension of the standard evaluation model into taking account of visual usability aspects.

We see this form of simulation as an important part of our contribution.