EXPLORING DATABASES FOR TASTE OR INSPIRATION WITH INTERACTIVE MULTI-DIMENSIONAL SCALING

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The verbal interfaces of current databases are not well suited for searches based on taste, intuition, or complexity (such as selecting a wine, a colour, or a product with many attributes). MDS-Interactive is a visual interaction method, based on multidimensional scaling (MDS), where people manipulate a set of sample objects to navigate through a large collection. In the development of MDS-Interactive, attention was given to the balance of constraint and freedom, of inspiration and information, of verbal and visual interaction styles. We discuss the basic ideas of our technique, its relation to ecological display theory, and experiences with a prototype interface for a consumer recommendation service.

QUERYING DATABASES

In the information society, making choices on the basis of complex information is a frequent task. TV guides list programmes on dozens of stations, supermarkets and restaurants offer a wide variety of wines, e-commerce sites offer millions of books, music CD's, toys, furniture, etc. Especially on the internet, catalogues are made available for almost every category of product.

Currently, users can search such databases by using text-based search engines that allow them to specify combinations of desired attributes. These verbal interaction methods work well when the user's queries can be explicitly formulated in terms of attribute values. Users of scientific libraries can usually phrase their questions in terms of the year of publication, the name of the author, and explicit jargon words which should or should not appear in the title or abstract.

However, text-based search engines are less helpful when the search criteria are vague, or complex, or the criteria involve taste and subjective appreciation. Putting the question into words may be difficult, impossible, or distracting. Not many wine-drinkers understand the jargon used to describe wines. Someone looking for wallpaper may not know exactly what colour is meant by 'medium orchid' and can do little with its specification in a colour system. Searches in these areas are better conducted by judging samples, and questions formulated in terms of samples, or by a combination of samples and attributes: "a wine somewhat sweeter than a Burgundy," or "a colour inbetween this ochre and that red." The problem in these query-by-example systems is to determine which samples should be shown out of the many thousands of objects in the database. Paint catalogues, which present hundreds of colours can be quite overwhelming.

In such cases, where people compare samples, many attributes are judged simultaneously. Judging samples and their overall similarity is a task that people do well.

Several systems already use similarity judgements for communicating with databases. Especially for databases of photographic material, multidimensional Scaling (MDS) techniques have been used to produce overview maps showing all the objects in the database and their relations based on a similarity criterium. MDS has had a long and succesful history in the visualization of the relation between objects which differ in many properties at the same time (see, e.g., Kruskal & Wish, 1978; Borg & Groenen, 1997). Based on similarity ratings alone, it produces a 'landscape' in which the similar objects are shown together, while the dissimilar ones are placed far apart. The photographic database viewers show a cloud (MacCuish, McPherson, Barros, & Kelly, 1996) of all their pictures in miniature, where the ones which contain, e.g., a lot of red, are grouped together. But the sheer number of images can confuse the user, and reduces quality and speed of the MDS (see below).

Dynamic query systems, such as ThinkMap™ and Aquabrowser™, also display all their objects as a spatial arrangement. In these systems, related objects are placed together and a single object is shown in the center of the screen. The user can view detailed information on this object, or click on an object close by to bring it to the center. In this way, the user can move from association to association, and slowly navigate the database. The problem with these systems as product databases is the lack of overview: the user remains focused on a small window on the database, and can only move slowly to other parts.

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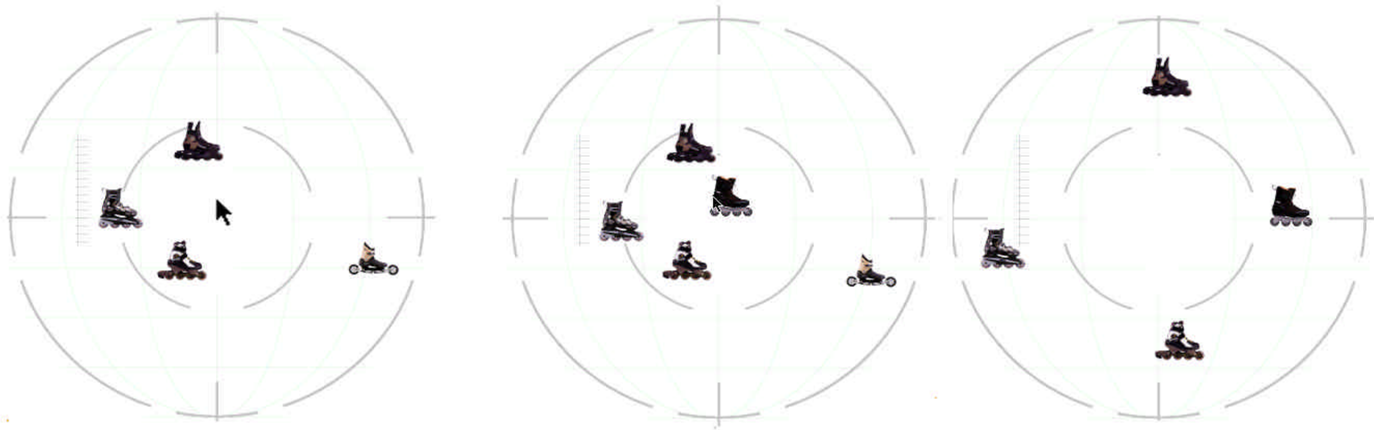

Figure 1. Three images from an MDS-Interactive display. Left: the user clicks between the samples to request a new sample. Middle: the best fit is added to the display; the samples shift a bit to accommodate the new sample. Right: when the two-wheeled skate from the middle display is dragged off-screen, the view zooms in on the current set. Note: the circles and axes are part of the interface context of a specific implementation (see Figure 2), but do not carry any specific meaning.

MDS-INTERACTIVE

We propose MDS-Interactive as a method that overcomes the problems mentioned at the end of the previous section. Its query dialog is designed specifically for digital product catalogues (Stappers & Pasman, 1999). It was developed as a database interface for designers seeking inspiration from existing products in the early phase of the design process. In this phase, visual thinking (McKim, 1980) plays an important part, as opposed to deductive reasoning. Therefore, the interface aims to minimize verbal distraction. However, the product database contains a lot of expert information, formulated in jargon terms possibly unfamiliar to the user. For instance, two products could have values ‘Rococo’ or ‘Art Nouveau’ for the attribute dimension ‘historical style’. Whereas the designer would know what ‘historical style’ means, he might not know the precise definition of the values, although he could see the difference in the samples. For this reason the interface makes use of the product attributes, but plays down the visual appearance of the verbal attribute dimensions and attribute values.

These problems are not specific to designers. They apply to many consumer product catalogues as well. For one example, the attributes representing a colour may be the component intensities for red, green, and blue (or coordinates in another colour coding scheme), but people don’t always judge or reason in terms of separate attributes.

What MDS-Interactive does

MDS-Interactive conducts the user-database dialogue through a dynamic, small, and interactive set of samples, shown as an MDS configuration reflecting their similarity relations, as shown in Figure 1. The points in this configuration are dynamically updated by moving them to their optimal location whenever the user removes samples, adds new samples, or changes the similarity criterium. Through these three actions, the user can navigate the whole database. The number of samples can be kept down to about twelve, which is both helpful for the user and the system. The user can form the landscape by picking the most expressive samples while retaining the overview. The system can achieve a rapid and tight solution for the MDS configuration because only a small number of samples need to be reconciled. A key innovation of MDS-Interactive is using the MDS display for user input: by indicating a position in the field, the user requests a new sample that ‘belongs’ in that position (the transition from left panel to middle panel in Figure 1).

How MDS-Interactive is done

Within the scope of this paper we can only briefly outline the technical principle of how MDS-Interactive works. Detailed aspects of MDS, such as data normalizations and iterative procedures require an advanced statistical treatment, for which the reader is referred to Borg & Groenen (1997).

The database is represented as a set of objects, where each object i is described by an array a_{ik} of attributes k=1..M. The number of objects N can be very large. A small subset of n sample objects are shown in the MDS display. The number of attributes M should be large enough so that sufficient varability in the set of objects is retained. For examples, M=3 is an appropriate choice for representing colours in a colourspace.

The dissimilarity δ_{ijk} between objects i and j on attribute k is calculated using a function the attributes a_{ik} and a_{jk} . The dissimilarities are combined into a single overall dissimilarity δ_{ij}=sqrt($\Sigma_\kappa(w_k\delta_{ijk}^2)$), where each w_k is a weight factor indicating the relative importance of attribute k for the overall judgement.

The MDS procedure is an iterative algorithm optimizing the positions P_j of the n points on the 2D screen, such that the distance d_{ij} between points i and j match the calculated overall dissimilarities δ_{ij} between samples i and j.

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When the user clicks on a position Q, the n distances r_j are calculated from the points p_j to the point Q. Then, the database is searched for object i whose overall dissimilarities δ_{ij} best matches this distance profile r_j : a search of $(N\text{-}n)\times n$ comparisons.

ECOLOGICAL DISPLAYS

In Gibson's ecological approach to perception and action (1979), the basic units of analysis are the person-environment interactions. This is formalised in the notion of affordance. The affordances of a specific environment for a specific actor are the possible actions that that actor can undertake in this environment. For instance, a certain size of chair affords sitting comfortably, a vending machine affords getting a cup of coffee. In this framework, it is the task of the designer to express these affordance in the form of the product. Good design can enhance a product's functional readability, inviting succesful behaviour implicitly through its form, rather than explicitly by way of prescriptions in an instruction manual.

This theory can be used on a small scale: the shape of the grip of a knifeinvites holding it in the most efficient manner; the 'button icon' in a graphical interface invites 'pushing' it by clicking (Gaver, 1991). It can also be used on a larger scale, as Flach (1991) argued. Vicente's (1990) 'ecological display' for controlling a chemical power plant visualizes the abstract constraints governing its operation through geometric elements such as angles, connections, areas and line widths. The idea is that such displays are easier and more efficient because the state of the system and the operators' control actions are expressed in a unified, concise and 'to the point' format.

The development of an ecological display consists of two steps. First, the constraints, actions, and relevant information parameters are determined. Second, these elements, and their relations, are mapped onto a single coherent configural graphical display expressing the state of the system and the control actions.

MDS-Interactive as an ecological display

Multidimensional scaling displays can be regarded as an ecological display for the expression of similarity through distance. Moreover, such a display does not just represent the relations between the samples shown in the display, but creates a landscape of meaning between the samples. Through the coherence of the configuration of samples, points in this landscape become suggestive of new combinations and interpolations, of new samples that may be hidden in the database behind the screen.

In this, the MDS display resembles the abstract, distorted maps used in cartography. The map of the London Underground is an illustrative case, where the geographical distance (meters as the crow flies) is replaced by another functional distance (number of stations the train stops). The ease with which people can move between the two types of maps shows how powerful our ability to interpret distance in visual configurations is (see, e.g., Monmonier, 1991).

The difference between conventional MDS and MDS-Interactive is that the latter shows only a small set of samples, shows them dynamically and interactively. Unlike the static MDS display, it is a dialogue controlling the user's navigation through the database. The dialogue proceeds through tentative suggestions rather than hard prescriptions, and several display characteristics help to express this. First, whenever a new sample is added to the display, all samples rearranges themselves in a new optimal configuration. The way objects move resembles a system of magnets or springs, and the dynamics of fast and slow movement itself conveys information about the relations in the display. It is hard to theorize exactly which perceptual principles are at work, but the intuitive appeal of the patterns is striking in every demonstration we gave.

User testing

Four prototypes of MDS-Interactive interfaces were built, for databases of roller skates (71 objects, 21 attributes), colours (190 objects, 3 attributes), whiskies (50 objects, 3 attributes), and investment funds (40 objects, 4 attributes). Because of space we will limit our description here to the database of roller skates, because it had the most sophisticated design, and we learned a lot from its user test. Figure 2 shows the skates interface as it was used in testing. It was designed to look like a real-life commercial application. The aesthetics were chosen to appeal to the subjects in the experiments, 12 design students who used

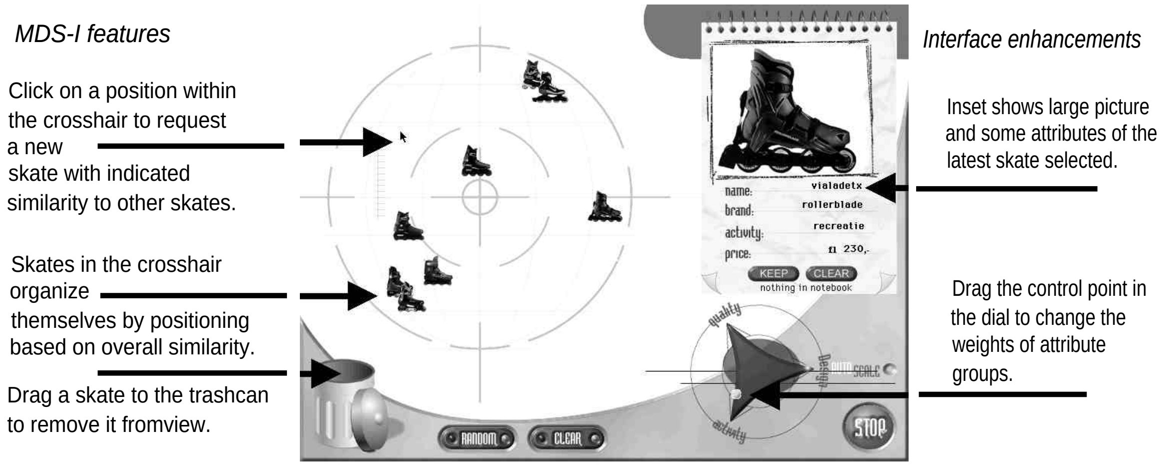

Figure 2. MDS-Interactive interface to a database of roller skates (design: Bram van den Nouweland).

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roller skates, but weren't complete skating experts. The samples were displayed in a crosshair of three circles, a trashcan in the lower-left corner indicated how samples could be removed. The 21 attributes were combined into the three groups 'quality' (including reputation of the brand, price, and quality of materials) , 'activity' (e.g., speedskating versus off-road), and 'design' (outward appearance, e.g., colour and type of shoelaces). This had two advantages. First, it reduces the amount of verbal information presented to the user. Second, the relative weight of the three groups can be set using a single weighting triangle, rather than a set of sliders which draws the user's attention from the samples to the individual attributes.

Finally, the interface lists some key verbal attributes, such as name and price, of the latest sample that was selected. Earlier tests with the colours and whiskies databases (which listed no attributes) showed that for colours the image samples suffice, but that for the whiskies, some verbal information was needed: when setting the criterium to 'price' the user would see the samples separate into two groups, but couldn't tell which group contained the expensive whiskies.

The evaluation was exploratory in nature. The user-testing served as much to optimize the graphic design of the interface as it did to evaluate the feasibility of the MDS-Interactive method.

Six subjects took part individually, the other six worked in pairs. Before trying out the system, they were given a one-minute demonstration, followed by the instruction that they were to find the skates that best fit their own interests. Their interaction with the system was observed. Finally they answered a list of questions regarding the ease of use of the system, their satisfaction with their search result, and their opinion on this way of working.

Preliminary results

Both the observations and questionnaires showed that the subjects could fluently work with the method and enjoyed using it. However, several parts in the interface caused confusion in some of the subjects. First, the crosshair form of the MDS display appealed as 'real cool' to the subjects, but especially the center circle suggested that the 'best' skate ought to appear there. Second, some subjects thought the objects at the top would be the 'best' ones. Third, the weighting triangle was sometimes confused for a filter. Two subjects set it to 'quality' and expected that only 'high quality' skates would then appear. Finally, several subjects wanted to read more of the attribute values. The current implementation listed only 4 out of 21 attributes.

Observations of the users that worked in pairs were especially hopeful. Because of the interface's visual simplicity, both subjects all the time could see what was happening, and they could take turns calling up new samples. Unlike text-based search engines, where one user is typing the phrases and the other is often lagging behind, not following exactly which words flew by or what commands were given, the collection of samples has the clarity comparable to the situation in a shop, where an assistant has just placed a few samples for you on the table.

Finally, users learned about the attributes from the samples. For example, many did not know of the existence of 'off-road' as a class of skates until they saw the attribute pop up (with the two-wheeled skate in Figure 1, middle); by setting the weight to 'activity' and clicking near that skate, they could call up the other off-road skates until they noticed that the set was exhausted when new appearances moved off to other groups in the display.

Based on these findings, we are currently revising the visualisation styles, and working on ways to further integrate visual and verbal interaction styles, making it possible for users to switch between explorative visual browsing and concentrated analytical text-based methods. The design challenge here is to add the verbal aspects while maintaining the coherent graphical framework provided by the MDS display. Also, we are working on ways to let the user move the samples into a spatial configuration, both as a method to determine weights, and as a method to input new attribute information.

CONCLUSIONS

MDS-Interactive shows an example of an ecological display in which similarity visualised through distance is used as the coherent graphical principle. Here visualised constraints are the relations between the samples, the affordances are the query actions. Feedforward occurs because the positions in the field suggest what type of sample the user can expect to find if he clicks there, feedback is provided through the animation of the new sample seeking its place in the display, and the movements of the reacting objects.

In a practical product setting, there should be a way to alternate between visual browsing and verbal searching. Such mixed interface styles hold promise to make searching in product databases more efficient and more pleasurable than it is with the current tools.

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