Concept Based website navigation using a Tangible User Interface

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ABSTRACT

In this paper, we present a novel method for browsing an academic website using a tangible user interface. The problem is challenging since web-sites are page-centric making it hard for visitors to the academic unit determine the concept relationships. The concept relationships on a website change over time and this is captured in our framework. The tangible interface framework has four parts: vision-based acquisition, visual processing, tangible interaction and audio-visual feedback. We use abstract blocks to represent concepts and by mapping the visuals to the interaction surface, the visitors can determine concept relationships easily. The blocks are tracked using standard computer vision techniques. The auditory feedback uses bird sounds and is created dynamically, using generative models. User studies have provided encouraging results.

INTRODUCTION

In this paper, we present our approach to building a tangible user interface for concept driven navigation of an academic web site. The problem is interesting for two reasons – (a) web-sites are page-centric and make difficult an exploration based on concept relationships (people, projects, key ideas) (b) the affordances of tangible interfaces [3,4] makes understanding the research agenda of the academic unit easy for visitors to the unit. Our long-term goal is to create an interactive system that helps a user understand as well as manipulate the relationships between concepts. We call such multimedia systems that are situated, embodied and reactive [3], to be situated multimedia systems.

There has been much prior work in tangible interfaces [4,5,6,9]. In [4], the authors discuss the role of tangible interfaces in urban planning , as well as in ambient displays. They have also been used in story telling [6], as well as in website construction [5]. In [9], the authors discuss how tangible interfaces can serve as URL's for online information. In [7] the authors propose an approach to the automated generation of soundscapes in their work on Audio Aura. In [1], the authors have developed generative models for the automated synthesis of sonic environments and music.

We first model the web site concept dynamics in the following manner. A web crawler periodically crawls the academic web site, and determines dominant site concepts using term frequency. We develop novel concept metric that incorporates hop distance as well the page rank of the page. Our situated web-site navigation framework has four parts: vision-based acquisition, visual processing, tangible interaction and audio-visual feedback. We develop a tangible interface using blocks, where each block represents a concept. The blocks are tracked using standard vision based techniques. The block interactions are coupled to a visual and auditory feedback. The visual feedback is provided on the *same surface* where the blocks are kept, allowing the users to manipulate the concept relationships easily. The auditory soundscape is created using a generative framework using bird sounds.

This paper is organized as follows. In the next section, we present our problem in detail. We then discuss the construction and working of our current system. Finally, we present the results of our experimental evaluation and our conclusion.

PROBLEM STATEMENT

Our goal is to construct a system that enables a user to interact with the concepts in a website. Since websites today are not concept-based in structure, we need to

- extract concepts from the academic web site in question and devise appropriate metrics that help us evaluate the relationships between concepts.
- construct an interface for the interaction using various real-world objects to successfully explore relationships between concepts.
- organize the interaction so that it is rooted in the specific practices that have evolved around the objects used for the interaction.
- map the actions performed by the user on the objects to provide her visual and auditory feedback.

OUR APPROACH

In this section, we discuss our approach to building such a system. Academic web sites are usually organized around several large themes – research, teaching etc. However, relationships between concepts (people, specific ideas) are not apparent with the current hyperlinked system. By using tangible user interfaces we aim to create a situated, embodied and reactive system [3]– which will help a user perform tasks like finding the opposite of a concept, extracting and storing common information between two concepts, grouping similar concepts among others.

We first devised a simple way of extracting concepts by parsing a medium-sized website (http://ame.asu.edu) with approximately 200 web pages. The text on the web pages was parsed and stop-words were removed; all the phrases separated by stop-words were considered potential concepts. 100 dominant concepts were picked from these based on their frequency of occurrence. To maintain compatibility with the current hyperlink-based system, we picked the most representative webpage for each of these concepts based on the frequency of the concept on that page and the page rank [2] of the page itself. Finally we computed the distance between each pair of these concepts using their term frequencies, inverse document frequencies and the number of hops between their most representative webpages.

For interacting with the concepts, we use a tangible interface composed of colored wooden blocks. Blocks, can be stacked, inverted, joined together or even arranged in jigsaw formations. We aim to investigate the variety of interactions that can be performed using blocks.

DESIGN OF THE CURRENT SYSTEM

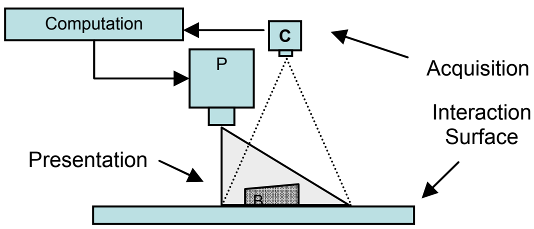

Figure 1: Set-up consists of key-stoned projector P, camera C and interaction blocks B

In this section we describe the design of our system (ref. Figure 1). Conceptually our design has four parts: vision-based acquisition, visual processing, tangible interaction and audio-visual feedback.

The interaction surface consists of a wooden coffee table and the objects that facilitate interaction are colored wooden blocks. The user's interactions are captured using a camera and a projector that are positioned vertically above the table. The user interacts with the system by manipulating the colored wooden blocks on the table. The camera captures a snapshot of the table. The system then finds the changes in the configuration of the blocks and provides feedback by projecting text and visuals on the table. Also auditory feedback is provided in the form of soundscapes.

Our system thus consists of a camera, a projector, a wooden coffee table and colored wooden blocks. The camera and the projector are positioned as shown in the Figure 1. The optical axis of the camera and the projector are kept parallel to each other. We used a method similar to the one used in [10] to calibrate the camera with the display. Diffused lighting and coating the blocks with retroflective material simplifies the problem of block detection and tracking. A simple tracking system is used to track the blocks over the interaction surface.

Interaction:

We have used wooden blocks as the instruments of interaction. The blocks in addition to bringing with them a set of affordances [8] are abstract signs and are *not iconographic*. This is crucial since each block represents a concept; we would like our framework to applicable to other sites with very different concepts. We have extracted 100 most important concepts from our website. Each of these floats on the table tracing a random path. At this stage the following things may happen

1. At the start, a random concept is assigned to every block.

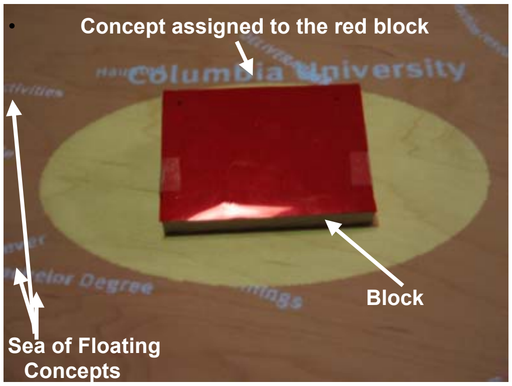

Figure 2: Blocks are assigned a concept and illuminated with a spotlight whose size and color is proportional to the importance of the concept assigned to the blocks

2. Every block is then illuminated with a spotlight i.e. an ellipse which is proportional to the importance of the concept is projected around it (ref. Figure 2). Ellipses are directional and can thus help a user get a sense of the orientation of the blocks. Also, the size of the ellipse tells the user the relative importance of the concept.
3. One of the blocks on the table is the pointer block (ref. Figure 3). The function of the pointer

block is to catch and hold on to the concept that is the closest to it. To change the concept assigned to any block (target block), we simply capture that concept with the pointer block and move the pointer block into the spotlight of the target block.

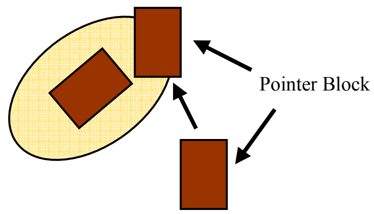

Figure 3: Highlighted concept gets transferred when pointer block is moved into the spotlight of another block

OPERATIONS ON BLOCKS

In this section, we mention the various operations that can be performed on blocks. A user can interact with a block in several ways. *Translation and Rotation*: A block can be moved around on the surface and additionally, have its orientation change *Withdrawal:* A block can be taken off the table or be covered so that it is invisible to the camera. We are planning to work with more complex block interactions – stacking, block inversion, simultaneous rotation, in the future.

COUPLING VISUALS AND SOUNDS

In this section we discuss the mapping of the block operations to the visual and auditory feedback. For our current system, we restricted ourselves to a limited set of operations performed on the blocks – translation and rotation of the blocks, and concatenation of a pair of blocks.

Figure 4: Visual feedback on the interaction surface

Visual feedback

The sea of concepts: The 100 dominant concepts float randomly on the interaction surface. Their brightness is made proportional to their importance. This gives the user an intuitive idea of the importance of any concept in the general scheme of things. A concept that has been "caught" by the pointer blocks is made much brighter than the rest of the concepts. The user can thus move the pointer block around the table, catch a concept he wants to and then assign it to one of the other blocks.

Tension between blocks: Except for the pointer block, all the blocks currently on the interaction surface are joined by lines. We think of these lines as springs. A spring is relaxed only when it is at its natural length; it gets "tensed" when compressed or expanded beyond its natural length and strains to come back to it's natural form. The lines between every pair of blocks have a natural length that is proportional to the distance between the concepts assigned to those blocks (ref. Figure 4). When the blocks are moved such that the distance between them exceeds (or becomes less than) this natural length, the line gets "tensed up". We show this tension in the line by coupling it with the thickness of the line.

Block Spotlights: An ellipse gets projected around every block on the interaction surface that is not a pointer block. The direction of the ellipse is the same as the orientation of the block while the size and color of the ellipse depends on the importance of the concept assigned.

Auditory feedback

Sound plays an integral role in this situated system as it augments and enriches the visual information that is present in the projections on the interface. However, we have been careful to ensure that the sonic feedback presents complementary information, and does not overwhelm users. To achieve this result, we have implemented a model for automatically generating dynamic soundscapes that are influenced by user interactions, while abstractly conveying information regarding the active concepts in the interface.

Given the strong visual impact of our tangible interface - where texts and blocks freely float across the plane of the interaction table - we were inspired to implement a soundscape comprised of bird sounds. This sonic environment extends the metaphor of the flocking visual objects, and provides a unique conceptual coupling between the sonic and visual elements of the interface. Movement of the tangible blocks provides input energy into the sonic feedback, while inaction will gradually result in a loss of energy. This energy is mapped to the amplitude of a database of short bird calls in the model.

For example, if the tangible interface is left untouched for several minutes, the soundscape will gradually grow silent. However, if a user moves one of the blocks, the bird call associated with that concept will be prominent in the soundscape while all others are silent. If all the blocks are moved simultaneously, a cacophonous collage of bird calls will result, and as certain blocks yield more activity, they will rise to the sonic foreground as the others recede into the background and ultimately toward silence. This generative soundscape provides user feedback regarding the activity of the interface in a manner that is sufficiently abstract to allow for focus on the more explicit relationships illustrated in the visual domain, while providing users with real time sonic information about the weights and resonances of their behaviors.

EXPERIMENTS

We designed a pilot user study to test the effectiveness of the audio-visual feedback in expressing the relationships between concepts.

Four graduate students were asked to interact with two versions of the system for five minutes each but were not told which version they were interacting with. One version, say system A, was the current system as described in this paper. The second one, say System B, was a random system. Both systems A and B had a "sea of concepts" floating around to be interacted with using blocks. However, system B had circles around blocks instead of ellipses, and the size and the brightness of the circles along with the nature of the lines connecting the blocks was entirely random. The auditory feedback was also random and did not reflect the nature of the interaction. Users were then asked a series of questions relating to the effectiveness of the visual and auditory feedback elements of the system. They were also asked to give their over-all opinion of the system as well as suggestions for improvement.

Table 1: User Response to the Effectiveness of the audio-visual feedback

Feedback element	Average Score
Brightness of text	5.75/7
Size of ellipse	4.25/7
Brightness of ellipse	4.75/7
Thickness of lines	5.5/7
Nature of soundscape	4.25/7

Three out of the four users preferred our current system to the random system. Two users alerted us to the fact that some of the elements of the feedback such as the text brightness completely escaped their notice. Another user told us that she had noticed very little of the audio feedback and had concentrated only on the visuals.

The users also offered us suggestions for improvement. One user found the "pointer block" distracting and suggested that it would be better if every block function as a pointer on its own. Another suggested that a stationary "sea of concepts" was better than a floating one. All of the users found the interaction interesting. All of them expressed interest in improving the system by incorporating additional intuitive interactions on the blocks.

CONCLUSION

In this paper we presented a prototype system for concept-based exploration of a website using a tangible interface. We reflected on the tasks to be accomplished - which included concept extraction, concept-distance computation, interface design and audio-visual feedback - and outlined our attempts to solve them. Our pilot user study shows that the interface was well-liked. We plan to expand on the set of block operations to include stacking, inverting etc, thereby making the interaction more natural and easy. We also plan to improve the nature of the audio-visual feedback so that it reflects the relationships between concepts in a much more intuitive and expressive way.

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