Zoomable user interfaces as a medium for slide show presentations

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Abstract

In this paper, the authors propose Zoomable User Interfaces as an alternative presentation medium to address several common presentation problems. Zoomable User Interfaces offer new techniques for managing multiple versions of a presentation, providing interactive presentation navigation, and distinguishing levels of detail. These zoomable presentations may also offer several cognitive benefits over their commercial slide show counterparts. The authors also introduce CounterPoint, a tool to simplify the creation and delivery of zoomable presentations, discuss the techniques they have used to make authoring and navigation manageable in the multidimensional space. Lastly, some of the visualization principles compiled by the authors for designing these types of presentations are presented.

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Introduction

Zoomable User Interfaces (ZUIs) have recently emerged as an alternative to traditional techniques for visualizing information. ZUIs display information on a conceptually infinite two-dimensional plane. They allow users to change their view of this plane through panning and zooming to access more information than can typically be displayed on a single screen.

A fundamental characteristic of these types of zooming and panning operations in ZUIs is that they are animated. These types of animations give a sense of physical movement by mimicking such physical acts as sliding a paper on a table (panning), looking at a paper more closely for detail (zooming in), or holding a paper at a distance for more context (zooming out).[1] ZUIs have been used in such settings as visualizing histories,[2] authoring children's stories,[3] traversing file system hierarchies,[1] and image browsing.[4] Yet another application of ZUIs with which the authors have experimented and that is discussed here is the slide show presentation.

Most current commercial slide show presentation tools consist of a linearly ordered set of 'slides' that can be shown in sequence to an audience. There are also special mechanisms for moving back and forth in the sequence, jumping to a slide out of order (based on its title), and authoring hyperlinks in advance from any one slide to another.

Through the authors' experience, it has been found that zooming presentations naturally address several common problems with these presentation tools. These problems include: navigating to slides outside of a direct linear sequence during presentation delivery, maintaining multiple versions of very similar presentations, and differentiating levels of detail in presentation content. Although aware of workarounds in current tools to solve these problems, the authors believe that the zooming paradigm offers more elegant solutions (Figures 1 and 2).

Figure 1 A presentation laid out with a Zoomable User Interface.

Zoomable User Interfaces address these problems in several ways. First, because it stores presentations in a single contiguous space, a ZUI can help make jumping out of a linear presentation sequence possible through animated spatial navigation. Second, ZUIs support multiple presentation versions by allowing multiple paths through a single zoomable space. These multiple paths are possible since navigation is not directly tied to the presentation content. Third, ZUIs intrinsically provide for differentiated levels of detail by allowing information to be displayed at varying zoom levels.

In addition to these concrete benefits, ZUIs may also facilitate more effective use of cognitive resources. Because they employ a metaphor based on physical space and navigation, ZUIs offer an additional avenue for exploring the utilization of human spatial abilities during a presentation. Likewise, the use of viewpoint animations in ZUIs offers similar opportunities for discovering more efficacious presentation techniques.

The benefits of ZUIs for presentations also have costs that are evident during both presentation authoring and delivery. ZUIs involve additional levels of complexity beyond traditional presentation tools since they require manipulating objects at multiple zoom levels and navigating a large zoomable space. As a result, a number of papers have specifically addressed problems with authoring and navigation in zooming environments.[5–9]

The authors have created a tool called CounterPoint (available to download at: http://www.cs.umd.edu/hcil/counterpoint) (Figures 3 and 4) to simplify the authoring, management, and delivery of ZUI presentations. CounterPoint has facilities for hierarchically organizing presentation content to help automate spatial arrangement and assist in visually distinguishing levels of detail. CounterPoint also offers techniques for creating and managing paths through a populated presentation space. Lastly, CounterPoint augments standard controls for delivering a linear presentation by providing simplified navigations to support improvisation. Through use of CounterPoint and ZUIs for presentations the authors have found that these tools offer tremendous freedom for creativity. However, as with any creative medium, this flexibility introduces the possibility for bad design. Consequently, the authors have also begun to identify principles, from related work such as concept maps[10,11] and their own experience, for the design of ZUI presentations.

In this paper, the authors begin by discussing previous work in the areas of slide show presentations and other scripted presentations. Then described are the concrete advantages of ZUIs along with evidence for their cognitive benefits. This paper also describes CounterPoint's
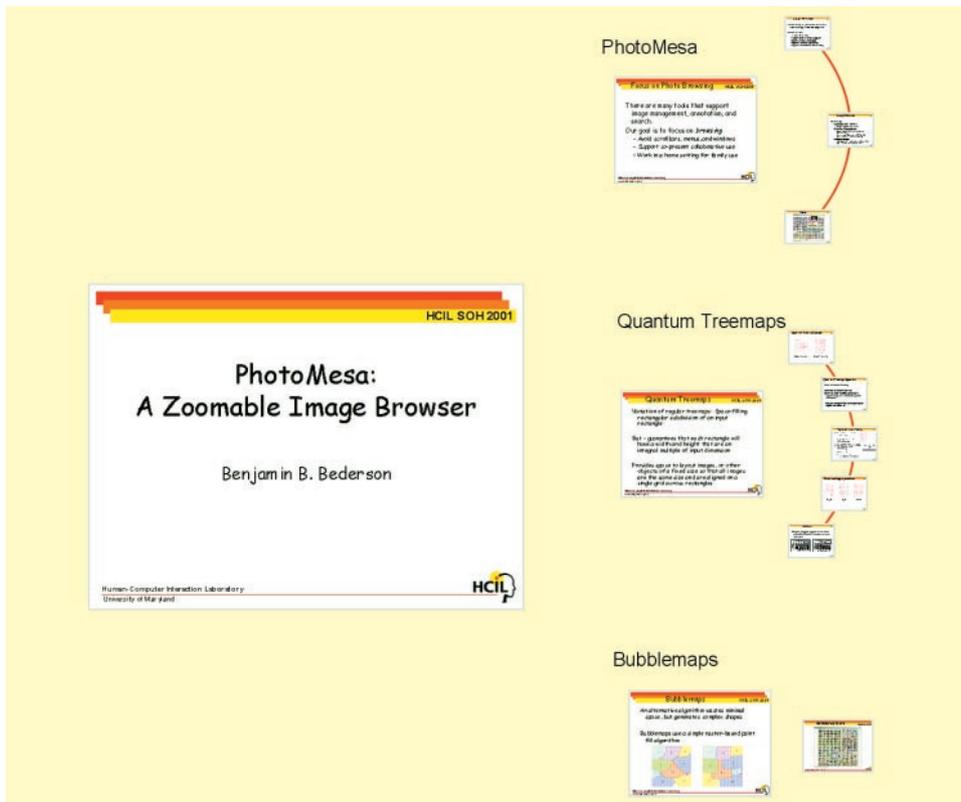
Figure 2 A presentation laid out with a Zoomable User Interface.
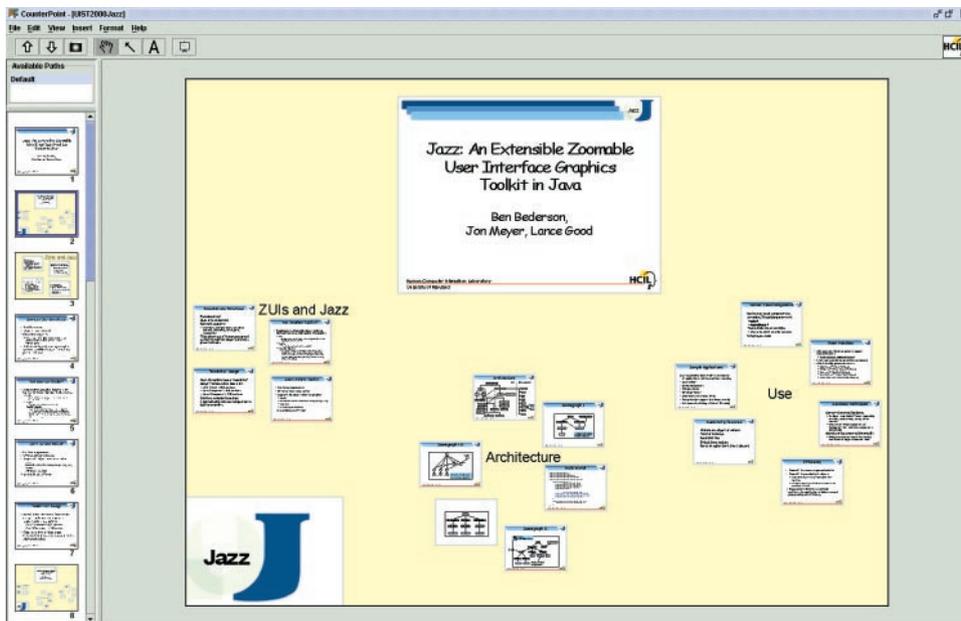
Figure 3 A screen shot of CounterPoint in spatial arrangement mode. The panel on the right, the 'Editing Canvas', is used to modify the positions and magnifications of pre-authored slides. The panel on the left is used to edit paths through the presentation.
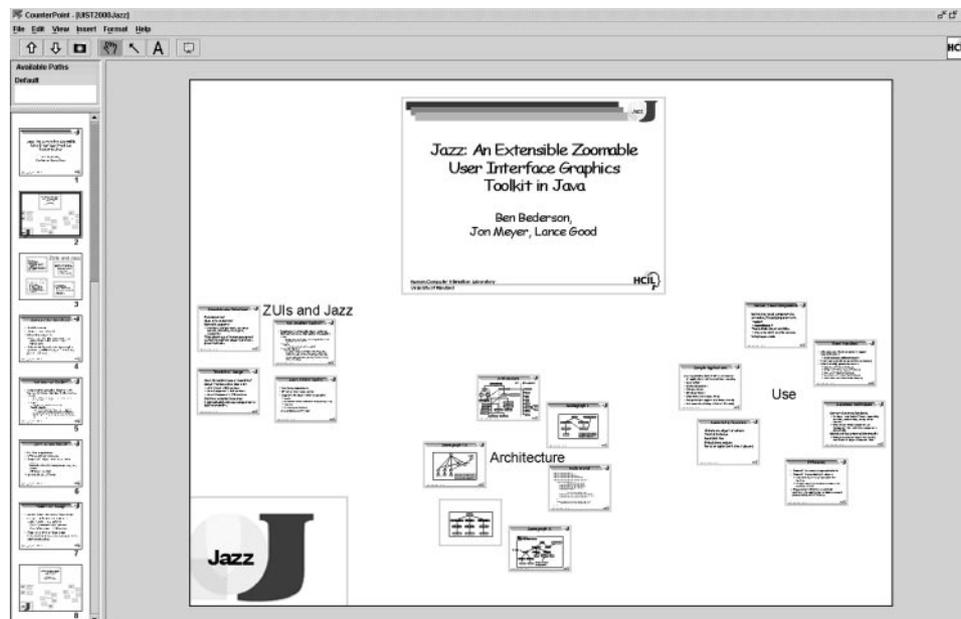
Figure 4 A screen shot of CounterPoint in spatial arrangement mode. The panel on the right, the 'Editing Canvas', is used to modify the positions and magnifications of pre-authored slides. The panel on the left is used to edit paths through the presentation.

implementation and its specific techniques for addressing the complexities of presentation authoring and delivery in ZUIs. The paper concludes with a discussion of principles for authoring ZUI presentations.

Previous work

This work came out of many years of ongoing research into ZUIs and the actual use of ZUIs for presentations. As such, it builds primarily on the results and experiences gained from both the Jazz[12] and Pad++[1] systems.

Naturally, this work also borrows heavily from concepts in Microsoft PowerPoint[13] and similar commercial presentation software. These commercial tools provide a software interface for mimicking physical presentation media such as 35-mm slides or overhead transparencies. A primary extension many of these tools add to this physical metaphor is the transition animation. Nevertheless, these animations usually provide little insight into the underlying content and are mainly used for visual effect.

Several systems have also addressed problems with, these commercial tools. The Palette system[14], for example, allows presenters to deliver a presentation using a barcode reader with paper copies of slides. This technique makes it possible to combine slides from multiple presentation files using only the paper representations and also to improvise slide orderings at presentation-time. While this type of a tangible interface has several desirable properties, it also requires users to manage both the physical and virtual representations of their slides. This technique only assists with slide management and does not help in content tasks such as distinguishing levels of detail.

Another tool suggested for improving slide show presentations is Hyper Mochi Sheet.[15] Hyper Mochi Sheet

employs a multi-focus distortion-oriented view to display a hypertext network. During a presentation, the system automatically resizes nodes in the network based on the presenter's current focus. While the multi-focus views allow it to show both an overview and detail, its dynamic nature makes it harder for the presenter to predict. Thus the authors feel it is less desirable for presentations where layouts and object sizes are often parameters of primary concern.

World Wide Web-style hypertext has also been proposed as an alternative to commercial presentation tools. A practical application of hypertext as a presentation media was Moore's use in teaching an undergraduate Computer Science course.[16] Moore found that this use of traditional hypertext facilitated better hierarchical organization than commercial tools and also allowed for better interconnection of related material. Nevertheless, the hyperlinks used by web-style hypertext (also found in several commercial tools) require an author to create them prior to giving the presentation. As a result, the presenter must anticipate all potential branches that might be required during a presentation. In addition, this type of hypertext may suffer from the traditional hypertext problem of audience disorientation.

Because a major component of the authors' work involves authoring paths through a zoomable space, it also builds on ideas found in several hypertext tools for authoring scripted presentation paths. One such tool was VIKI, a spatial hypertext tool for supporting emergent structure during authoring.[17] The particularly relevant application of VIKI was its use in gathering and organizing content for educational presentation on the web.[17] Here, preexisting web content and annotations

were combined to create directed paths through collections of related information. Authoring ZUI presentations is similar to authoring in VIKI in that it involves spatially structuring information. However, because they are displayed to the audience, the structures created in ZUI presentations are an end in themselves rather than just a representation of the author's current understanding. Moreover, paths in ZUIs are animated traversals through the author's explicitly defined spatial layouts whereas in VIKI the spatial layout defined the path itself.[17]

Some of the earliest work in scripted hypertext paths was Zellweger's Scripted Documents.[18,19] Scripted Documents allowed the author to define timed traversals through a collection of documents with specifiable actions performed at each stop in the traversal. The 'Audio-visual presentation' application of scripts described in Zellweger's earlier work[18] closely resembles the authors' use of scripted paths in ZUI presentations.

Trigg's Guided Tours and Tabletops also defined a hypertext path authoring and navigation tool.[20] This system provided tools for creating a collection of 'tabletops', each of which contained a spatial arrangement of hypertext documents. An author could then define arbitrary paths through these tabletops with any number of available branches at each point in the path.

Paths in ZUIs resemble Trigg's paths in that they can combine both scripted and dynamic components. However, the dynamic changes available on a scripted path in a ZUI presentation do not have to be specified when the path is created. In addition, while both systems allow for navigation through collections of spatially arranged objects, ZUIs present data in a single continuous space whereas Guided Tours supports sets of disjoint spatial arrangements.

Concrete benefits of ZUI presentations

ZUIs offer a number of concrete advantages over traditional slide show presentations. Below, the novel affordances of ZUIs for some common presentation authoring and navigation challenges are discussed. The authors distinguish these concrete benefits from the later cognitive benefits because they offer motivation for the use of ZUIs in the presentation setting without requiring experimental validation.

Simple navigation for improvisation

One of the fundamental tradeoffs in the design of a presentation tool is providing support for rehearsed scripting *vs* presentation-time improvisation. Too much control can require needless attention from the presenter for interface adjustments. Too little control restricts the presenter from quickly returning to previous slides following audience feedback or smoothly jumping past less important content for time constraints.

Current presentation tools provide adequate support for controlling rehearsed scripts. However, the controls for improvisation, including linear forward and backward

controls and popup menus, are often inefficient or visually unappealing. The one additional control that some presentation tools offer for more dynamic presentations is web-style hyperlinking. Nonetheless, the author must predefine these links, requiring the author to predict all required presentation-time improvisations.

Instead, ZUIs can potentially balance the need for both scripting and improvisation by allowing spatial navigation in addition to the standard presentation controls for traversing a scripted path. These navigational controls allow a presenter to navigate between arbitrary points in the presentation via zooming and panning. Of course, unconstrained navigation in multidimensional environments can be extremely difficult so this is one of the actions addressed in the authors' implementation of CounterPoint.

Decoupled paths and content

The authors have also informally found that a common presentation authoring task is to modify existing presentations for new audiences or different time constraints. In this situation, current presentation tools encourage presenters to create different presentations for different situations because of the coupling between the presentation content and the presentation path (One should note that although PowerPoint[TM 10] technically allows for the decoupling of presentation content and path through the 'Slide Show → Custom Shows...' menu, the interface is very primitive. Moreover, these custom shows do not offer the same features, such as independently modifiable transitions, available in the primary slide show). This duplication of data across multiple presentations not only requires unnecessary storage space but also leads to data synchronization problems when the presentation content is modified. These same issues also arise when an author wants to duplicate a slide within a single presentation.

While storage space may seem insignificant in the age of multi-gigabyte disks, this space becomes more important in the presence of limited bandwidth networks. In fact, anecdotal evidence suggests that PowerPoint presentation files are a significant cause of congestion on Defense Department networks.[21] Alternately, from the use of ZUIs, the authors have found that the clear distinction between content and paths encourages a different presentation management strategy. The authors' early use suggests that presenters may find it useful to organize larger collections of related information in a single presentation space, authoring customized paths through the space as needed for a given audience. This strategy will also facilitate the repetition of slides on a presentation path without actually duplicating the content.

One drawback to this decoupling is that it can be confusing or misleading for the audience. If content appears in a presentation space but does not occur on the presentation path, the audience may construct incongruent interpretations of the presented structure. In the future, the authors intend to address this problem by

fading out content that does not appear on the current presentation path.

A second drawback to this approach is that presentation files no longer correspond to a single presentation. This undermines the use of the presentation file as a historical archive. Instead, CounterPoint allows presentation authors to name the different paths within a presentation to serve this archival purpose.

Hierarchical support

One of the fundamental structures used in the presentation setting is the hierarchy. Hierarchies are a natural format for organizing data as they allow topics to be recursively subdivided into increasingly smaller units of information. In fact, current presentation tools often offer support for hierarchical bulleted outlines within slides, though they do not extend these hierarchical organizations to the slides themselves.

The authors have also found that though hierarchical language often metaphorically refers to spatial objects, trees for example, the depiction of these hierarchies often approaches linearity. These linear representations can be observed in the previously mentioned outline editors or in many other hierarchical authoring systems.

ZUIs facilitate a more spatial portrayal of hierarchies. Instead of depicting hierarchy levels through indentation, as is frequently done, ZUIs can present hierarchies in a format that more closely approximates a 2D representation of a tree (for example, see[2]). Alternately, ZUIs allow for visually distinguishing hierarchy levels by placing them at varying levels of scale or magnification. This change in magnification can naturally vary with the level of the hierarchy.

Creative control

Because they support the arrangement of presentation content in a two and half dimensional space, ZUIs offer an additional degree of creative freedom over current presentation tools. Additionally, unlike other novel user interface approaches such as Hyper Mochi Sheet,[15] ZUIs also support deterministic control over presentation layouts and transitions. This type of direct control ensures predictability, which authors are likely to expect for presentations.

Cognitive benefits of ZUI presentations

Although the authors have yet to empirically evaluate ZUI presentations, it is believed that these presentations will have several cognitive benefits over traditional presentations. Of course, since the authors have not experimentally verified the benefits of spatial layout and zooming specifically for slide show presentations, it is not known for certain that the evidence presented by the authors from other domains will apply to the presentation setting. Nevertheless, four people in the authors' laboratory have used ZUIs for about 10 public presentations, and a combination of their experience and informal audience reactions to actual zooming

presentations offer some validation of the authors' intuitions.

The authors are also aware that individual differences may affect the cognitive utility of zooming presentations. Indeed, animations[22] and spatial arrangements,[23] two elements of ZUIs, have been shown to support greater recall in users with low spatial abilities than in users with high spatial abilities. Fortunately these studies give some further evidence that animations and spatial arrangements do not negatively impact recall in users with high spatial abilities

Likewise, research into concept maps (see Figure 5), also called knowledge or node-link maps, suggests that subjects with low verbal ability may benefit more from a spatial display than from text.[24] Here again the type of display did not adversely affect the high verbal ability students. With these caveats in mind, listed below some potential cognitive benefits of ZUI presentations and supporting evidence from related tasks.

Dual encoding in memory

The most frequent use of a presentation tool occurs in combination with a presenter's oral discourse. Hence, the audience receives, usually simultaneously, visual input from the presentation tool and verbal input from the presenter. Therefore, an interesting question is whether humans learn differently from these two streams of data.

Psychological hypotheses suggest that human memory does encode spatial information distinctly from verbal information.[25,26,23,27] As a result, a presentation tool may exercise a larger portion of the memory resources of the audience if it employs a spatial, visual display in combination with the verbal discourse.

Robinson *et al* performed research into this phenomenon by comparing graphic organizers and concept maps with linear lists and outlines.[27] Graphic organizers and concept maps are simply graphical layouts of information, for example tables and flowcharts (see Figure 5). This research suggests that the information in the graphic organizers and content maps is encoded more spatially than the information in linear lists and outlines.

In an earlier study, Robinson *et al* also investigated the benefits of adjunct displays in a setting more comparable to that of presentations.[28] Here subjects were shown different visual displays while a related text was presented aurally. As in the other study, graphic organizers and concept maps facilitated a more spatial encoding of the information than the textual displays.

The spatial organization of data in ZUIs, though unconstrained, lends itself to structures similar to graphic organizers and concept maps. As a result, ZUI presentations are likely to allow for spatial memory encoding of the presentation data. Combining this spatial data with the conceptual encoding of the oral discourse may both reinforce this conceptual data and help reduce the audience's verbal load, ultimately increasing the retention of the presentation content.
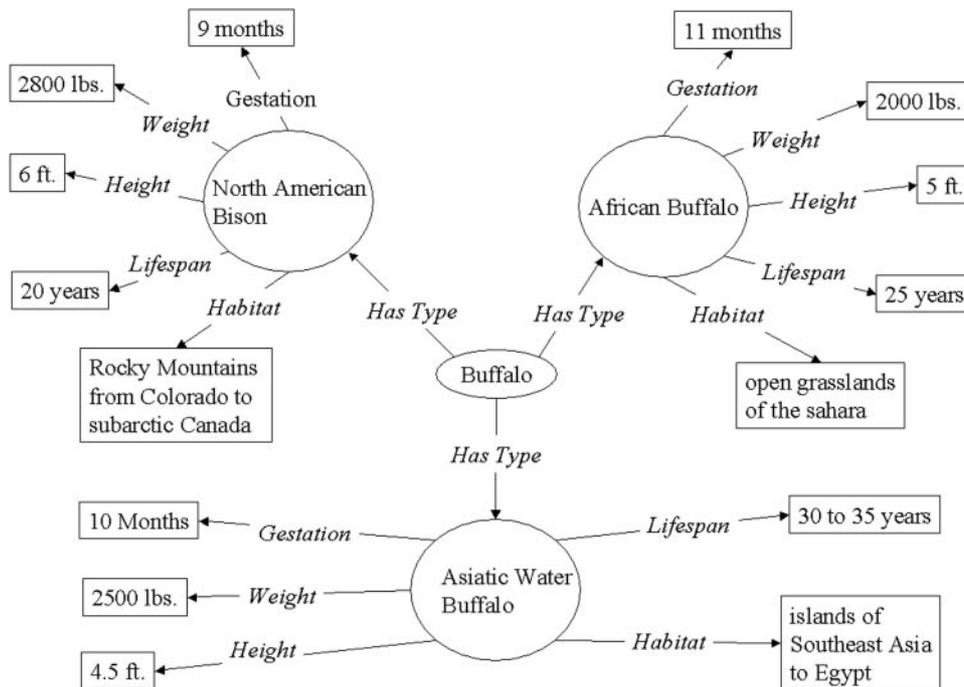
Figure 5 An example of a concept map taken from Robinson et al.[27]

The animated transitions in ZUI presentations may also benefit from another type of dual-encoding redundancy. Research has shown that animations accompanied by explanatory audio can improve understanding of abstract concepts over static graphics combined with explanatory audio.[29] This animation-audio combination also leads to better long-term retention than its static counterpart.[29] Because slide show style presentations almost always combine audio with the visual display, they may benefit significantly from animation.

Meaningful spatial structure
Research also suggests that, in certain situations, the memory for data and the spatial location of that data are correlated (summarized in[30]). For presentations, this implies that more meaningful spatial layouts may increase the retention of the underlying presentation content. As a result, one potential advantage of ZUIs over previous presentation tools is the ability to spatially organize data in two dimensions at different magnifications. This spatial layout may provide the audience with an additional attribute or memory pathway with which to recall the presentation content.

A related advantage of CounterPoint is that the structure or logical organization of the presentation can be incorporated into the spatial layout of the data. Then, because CounterPoint slide transitions animate through the space, this structure is itself revealed to the audience during the normal course of the presentation. Revealing the structure of a presentation in this manner exhibits a design principle similar to what Norman calls 'visibi-

lity'.[31] Likewise, Thüring et al suggest that presenting a hypertext document's structure to the audience is a necessary component 'for reducing the mental effort of comprehension'.[32] Rivlin et al offer a similar sentiment.[33]

This visual communication of structure has the potential to allow the audience to better understand the high-level concepts of a presentation and properly fit them into their own mental frameworks. Restated, the audience may be better able to incorporate the new knowledge with existing knowledge.

Landmarks
A well-known problem in traditional hypertext heard about anecdotally by the authors for slide show presentations is disorientation. Disorientation in traditional hypertext has been described as the point 'when readers do not know where they are, how they got there, or where to go next'.[32] For presentations, this generally corresponds to the point when the audience does not know how the current slide relates to higher-level points.

Needless to say, the development of orientation knowledge is a complex psychological phenomenon. However, one theory proposes landmarks as a fundamental component in this development.[30] That is, we know where we are in the larger space based on salient or memorable objects in our local surroundings.

One possible implementation of landmarks in the presentation setting is including such cues on every presentation slide. For instance, each slide could contain a thumbnail representation of important surrounding slides. This approach has several drawbacks, the most

significant of which is reducing the amount of screen real estate available for actual data. As a result, the authors have not explored this solution in current ZUI presentations. Instead, the solution that the authors adopted is to rely on spatial slide transitions. Because ZUI transitions provide animated traversals in a 2D space they can naturally reveal neighboring information including memorable landmarks.

Improved overview support

Spatial, hierarchical overviews of hypermedia networks have been demonstrated to improve recall of overview titles when compared to both hypermedia with linear overviews and hypermedia without overviews.[34] This suggests that displaying a more overt and meaningful spatial overview during a presentation may increase the memorability and possibly the comprehensibility, of high-level presentation concepts. Similarly, overviews have been shown to improve the understanding of concept maps (see Figure 5) over several disconnected views in subjects with low spatial abilities.[11] Consequently, including these spatial overviews in the presentation may improve the comprehension of presentation material in certain individuals.

Overviews are intrinsic to ZUIs. One of the previously mentioned capabilities of ZUIs is the ability to zoom out to get more context. As a result, it is always possible in a ZUI to zoom out so that all presentation data, or localized subsets of that data, are in view. Whether these overviews convey meaningful information, of course, depends on the structure of the presentation. Nevertheless, this overview visualization capability exists at arbitrary magnifications in the presentation without any additional effort or input from the presenter.

Here again, the authors had the option of making the overview persistent, that is, visible on all slides at all times. However, this was not explored as a design alternative because of the screen real estate it would sacrifice. In addition, such an overview could be a continual distraction in the context of a presentation.

Incrementally revealing content

One problem mentioned in the use of concept maps (see Figure 5), a specific type of spatial display, is map shock.[35] Map shock occurs when map-readers feel overwhelmed, confused, or unmotivated by the size or complexity of a map. To solve this problem, map content can be incrementally revealed to help make information seem less intimidating.

An early technique used for incrementally revealing content is the stacked map.[11] Stacked maps divide a large or complex concept map into smaller cross-referenced maps. One study compared these stacked maps to unsegmented whole maps to determine if they improve comprehension of map content.[11] The results of this study suggest that the utility of different map formats may depend on subjects' individual differences. Subjects with low spatial abilities performed better with whole maps while subjects with high spatial abilities performed better with stacked maps.

A more recent technique, applicable to computer-based displays, that tries to address some of the limitations of stacked maps is using animation to incrementally reveal map content. Here, the map presents a subset of the map content and incrementally animates more details into the display. A recent study compared these animated maps against plain text, animated text, and static maps.[35] The results of this study indicate that animated maps may facilitate better recall of high-level points than the other three displays.

Because they use animations, ZUIs can similarly mediate between stacked and whole map displays by incrementally revealing content. Meaningful chunks of presentation content can be arranged at different spatial locations to achieve an effect similar to disjoint, stacked concept maps. Then, spatial animations can be used to navigate between these disjoint maps in the 2D space. And because they support zooming, ZUIs can display overviews of the collection of stacked maps to support whole-map displays.

Presentation progress

Another inadequacy of current presentation software tools is that they provide no inherent notion of presentation progress for the audience. One common technique presenters use to compensate for this deficiency is to add text specifying, 'Slide n of N'. However, such a display does not indicate more localized progress, such as the number of slides remaining in the current topic.

In contrast, if the various pieces of CounterPoint's spatial metaphor function properly, such as overviews and landmarks, a sense of presentation progress may naturally follow. However, ZUIs can also provide a more explicit indicator of progress by visually altering visited slides. This concept builds on the concept of visited hyperlinks in a web browser. In the authors' use of ZUIs, the combination of these implicit and explicit progress indicators was found to be generally effective at conveying progress.

Animated slide transitions

Although animated transitions are included in several current presentation tools, these transitions are mainly used for visual effect and usually do not attempt to give any insight into the underlying data. Moreover, the authors' experience is that the most commonly employed transition is the most basic, where one slide instantaneously replaces another. As a result, these transitions do not help an audience relate the source to its destination.

As already mentioned, ZUI presentations implement slide transitions as animated viewpoint navigations through a presentation space. As such, these animations are able to display the changing spatial context as the system transitions from one point in the 2D space to another. Although the actual benefits of view-

point animation still require further investigation, initial research indicates that these animations are beneficial for learning spatial organizations and data relations.[36] This study further suggests that viewpoint animations allow for a more constant understanding of object positions and relationships than viewpoint transitions without animation. Research also indicates that animation may improve long-term understanding of various kinds of presented material.[22,29] This improvement was most profoundly observed in those with low spatial abilities.[22]

One of the biggest risks associated with animations is the time consumed by presenting extra intermediate frames during a transition. However, research also indicates that the extra time spent on animation does not result in longer task completion times,[36] which relates directly to comprehension time.

Of course, animated transitions also pose more subjective risks as well. For instance, some users may find these animations distracting or otherwise undesirable. However, there is some evidence to suggest a subjective preference for animated systems over non-animated systems.[37] Since user preference is a recognized quantitative measure of software usability,[38] these preferences require further study to determine their importance, both in general and specifically for presentations.

It is also important to note that there are a number of different types of animations (see [36] for a partial listing) that can make comparisons difficult across tasks. Similarly, whether a system's animation is automated or manually controlled can affect its cognitive utility. Therefore, these differences must be considered when comparing these results from other animated systems to our setting of animated slide show presentations.

Sense of semantic distance
A specific type of slide transition is one in which the presentation shifts from one topic to another. In this case, two adjacent slides may contain no semantic relationship though positioned in close proximity in presentation sequence. Here the presenter must bear the burden of orienting the audience to the context change. While this context switch seems a natural responsibility for the presenter, this switch is likely to be reinforced by a well-designed visual aid.

One type of visual depiction to which a ZUI's spatial layout lends itself is indicating the semantic difference between two slides by their separation in the virtual presentation space. Transitions between these two slides are able to portray this virtual separation through the distance traveled in the CounterPoint transition animations.

A similar example of this concept explored in hypermedia is the 'warp coefficient' suggested by Kaplan and Moulthrop.[39] Here a number is associated with each link on a hypermedia page to indicate the semantic difference

between the content of the current page and the link's destination page.

Implementation of CounterPoint
The inspiration for CounterPoint came from designing a number of zoomable presentations in existing zoomable authoring tools. The use of these tools for creating zoomable presentations can be likened to using a drawing program to create standard slide presentations. A drawing program offers relatively unlimited creative freedom but is not optimized for common presentation authoring tasks. With that in mind, the authors have designed CounterPoint to simplify or automate many common presentation tasks in a zoomable environment. CounterPoint is built on top of Jazz,[12] a Java toolkit for building ZUIs, and is available for download.

In building CounterPoint, the authors also wanted to take advantage of existing presentation tools. Although there are currently a handful of commercial slide show presentation tools available, the tool that clearly dominates the market is Microsoft PowerPoint™.[13] Therefore, to have the greatest potential impact on presentation authors, it was decided to create CounterPoint as a plug-in to PowerPoint. This connection to PowerPoint not only allows for compatibility with existing PowerPoint content, but also reduces the functionality needed in CounterPoint.

CounterPoint uses Visual Basic's COM hooks into PowerPoint to add a toolbar button and manipulate slide content. Because the majority of CounterPoint is built on top of Jazz in Java, one of the Visual Basic application's primary responsibilities is to start a Java application when its toolbar button has been pressed. Its other major responsibility is to start a TCP/IP client by which it will communicate with this Java application.

Similarly, the first responsibility of the Java application is to create a TCP/IP server to communicate with the Visual Basic component. Once a connection has been established, the PowerPoint slide contents are transmitted to CounterPoint. For both efficiency and convenience reasons, the slide contents are not transmitted via the TCP/IP connection but are passed instead via the Windows clipboard.

This transfer of PowerPoint slide contents is possible because PowerPoint uses the Windows metafile format (i.e. files with a list of drawing commands) for posting to the clipboard, rather than something similar to their proprietary file format. However, this metafile format also has positive performance implications for our application since Windows provides native support for metafile rendering.

Consequently, a third component of this application is implemented in Windows native code for managing and rendering Windows metafiles. The authors' Java code uses the Java Native Interface (JNI) to communicate with the native code and to switch between native and Java rendering as appropriate.
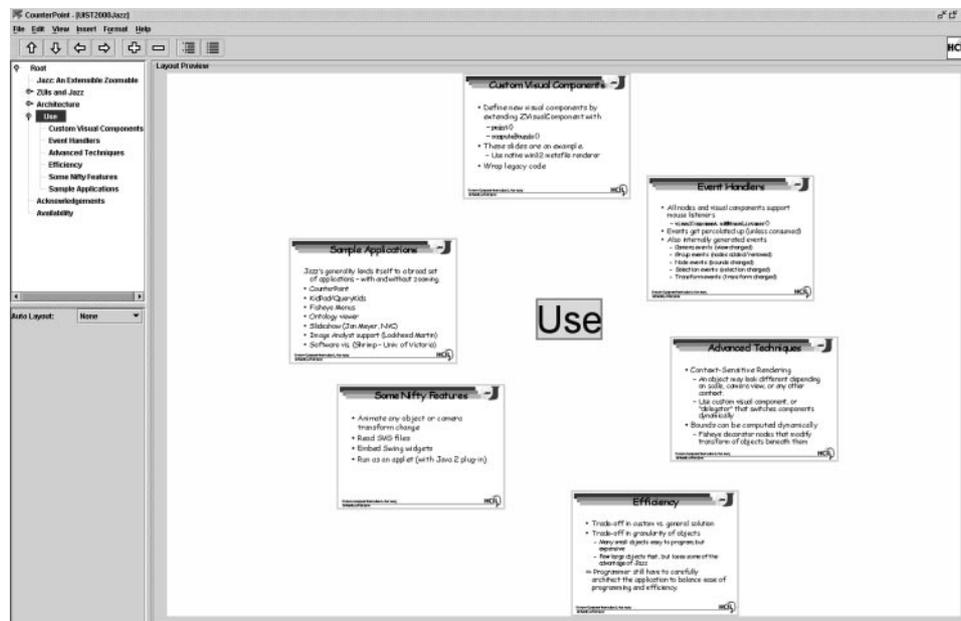
Figure 6 A screen shot of CounterPoint's layout hierarchy. The hierarchy is used to simplify both spatial layouts and interactive navigations.

The CounterPoint portion of the presentation data, such as slide border colorings, spatial layout parameters, and path orderings, are currently stored in a custom XML file residing in the same directory as the PowerPoint file. Because the format is XML, the file can be manually edited in a text editor in cases where the CounterPoint data has become out of sync with the PowerPoint presentation or for finer grain control over certain parameters.

Authoring in CounterPoint

Starting in PowerPoint
The model envisioned by the authors for using CounterPoint begins in PowerPoint. An author begins by creating slides in PowerPoint in much the same manner as if the slides were actually to be used in PowerPoint. The author can use almost any of the available PowerPoint tools for creating presentation content. One of the primary sets of PowerPoint features that is currently unsupported in CounterPoint is slide transitions. CounterPoint's animated navigation transitions are meant to replace any of the slide transitions in PowerPoint. Still, there are some transitions within slides, such as incrementally revealing slide content that we intend to support in future versions of CounterPoint.

An early decision was made not to try to replicate the functionality of PowerPoint in CounterPoint and to allow manipulations only at the slide level. While the authors feel that this was the best short-term solution, the long-term ideal for CounterPoint is to migrate the functionality of PowerPoint into CounterPoint (or vice-versa) for a finer granularity of control.

In the mean time, a single piece of the PowerPoint functionality that was found to be generally useful has been added to CounterPoint, namely simple text labels. Authors can use these labels to create landmarks in the CounterPoint space that highlight major points as indicated by collections of slides. For instance, the 'Architecture' label in Figures 3 and 4 was created in CounterPoint rather than PowerPoint.

Once the slides have been created in PowerPoint, pressing a custom toolbar button starts CounterPoint and transmits the slide contents from PowerPoint to CounterPoint. After the slides have been transmitted, the author begins working in CounterPoint to create spatial arrangements for the slides and author paths through the presentation space.

Creating spatial arrangements
When CounterPoint loads a presentation for the first time, the PowerPoint slides are arranged in a grid within CounterPoint's zoomable space. Hence, the typical first step in creating a presentation in CounterPoint is to modify the arrangements of the PowerPoint slides in the zooming space (see Figures 3 and 4). To arrange slides manually, one uses simple tools for manipulating objects in this space similar to those found in PowerPoint, drawing programs, and previous zoomable demo programs (e.g., PadDraw[1] and Jazz HiNote[12]).

A hierarchy editor (Figure 6) for automating these arrangements has also been provided. Using this editor, the author can organize the presentation contents into a semantically meaningful hierarchy. Then, for each parent in the hierarchy, the author can apply a modifiable layout template to spatially arrange the parent's children according to the template
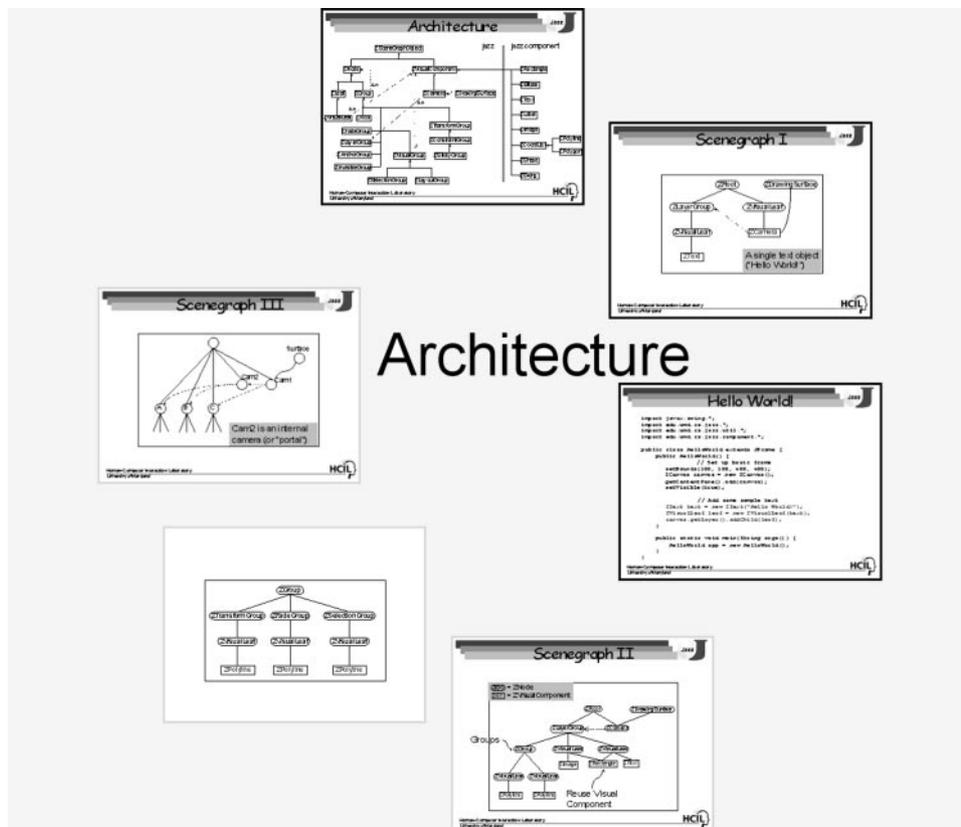
Figure 7 A screen shot of CounterPoint in presentation mode. Here, the presenter can alter pre-scripted traversals using various presentation-time interactions. Black borders indicate slides already visited during the presentation. This screen shot also represents a typical local overview in CounterPoint.

format. Currently, the authors provide layout templates corresponding to geometric shapes, such as lines, ellipses, arcs, and rectangles. For example, the slides that are children of the label 'Use' in Figure 6 can be automatically arranged using an ellipse layout to achieve this effect.

Creating scripted paths
The next step in the authoring process is to create paths through the presentation space. When CounterPoint loads a presentation for the first time, a single default path is automatically generated that visits each of the PowerPoint slides. In general, these paths are composed of two types of components. The first, more obvious type is the actual PowerPoint slide, which is inserted on a path to animate the slide to full screen size. These slides are inserted into the path using a simple scrolling list of thumbnails. Each slide can also be inserted multiple times in a single path.

The second type of path component is a view of a particular region of the zoomable space. These views are the more interesting path component as they allow the author to include views containing multiple slides and the structure of the presentation. Views are useful for

showing an overview of the entire presentation or focused overviews of particular subsections of the presentation.

The current mechanism used to create these types of views is similar to taking a picture or creating a screen snapshot. First, the author navigates to the particular region of space to be added to the path. The author then presses the camera toolbar button (Figures 3 and 4) and a new component, represented by a thumbnail image of the view, is added to the path. These thumbnails are actually implemented as live views onto the presentation space so that modifications to the zoomable space are reflected in the thumbnail.

While a one-dimensional representation of the current path is available in standard editing mode (see Figures 3 and 4), CounterPoint also provides a two-dimensional path editor that mimics the functionality of PowerPoint's slide sorter. The authors believe that this will allow for the transfer of pre-existing PowerPoint skills since the concepts of path editing and slide sorting are so similar.

Some indication of the current path is also available while spatially arranging slides. When the mouse is positioned over a slide on the editing canvas, the system displays arrows indicating the locations reachable from the slide in the current path. While this feedback is not

intended as a primary path-editing interface, it does give some coupling between the two tasks.

Multiple paths are currently managed using the simple list component in the upper-left corner of Figures 3 and 4. Selecting a path's name in the list loads that path for editing or for starting a slide show. Currently, when a new path is added to this list, it is initialized with all the PowerPoint slides. However, the authors also plan to include more sophisticated algorithms for creating a new path such as a depth first search of the layout hierarchy (see Figure 6).

Delivering presentations in CounterPoint

Perhaps the most interesting and novel interactions occur in CounterPoint's presentation mode (Figure 7). The default behavior of sequentially stepping through one of the author's predefined paths is still available. This default behavior is achieved with the standard Power-Point controls of left mouse button, the space bar, the page down key, or right arrow key on the keyboard.

However, CounterPoint offers two modifications to this standard interaction for improvisation. First, the presenter can press the up arrow key to navigate up the previously defined hierarchy. This zooms out enough to get an overview of a semantically meaningful group of slides. If the layout hierarchy has not been defined, pressing the up arrow key zooms out to give an overview of the entire space.

A second interaction allows a presenter to dynamically navigate to various interesting locations in the presentation. However, before navigating to a target location, the presenter must navigate to an overview where the location is visible. This is typically achieved by zooming out using the up arrow key. For immediate access to a PowerPoint slide, right clicking on the slide animates the view to that location. The authors have found that other than slides, views of sub-trees in the layout hierarchy (such as that seen in Figure 6) and views explicitly added to the path during authoring are also targets for navigations. As a result, CounterPoint offers shortcuts for navigating to these locations. When the presenter moves the mouse within the bounds of either a sub tree or view, the bounds of the target view highlight. Right clicking within these highlighted bounds navigates to that location.

In cases where a presenter alters the presentation path using one of these dynamic navigations, the system attempts to pick an appropriate point in the path from which to resume. In cases where the target appears in multiple places on the path, CounterPoint picks the path entry closest to the point at which the presenter deviated from the path. If the slide does not appear at all in the current path, the system does not try to infer a new path entry but rather resumes from the point at which the presenter deviated from the path.

One other traditional hypertext element that the authors have added to CounterPoint to improve usability is visited colorings. CounterPoint provides modifiable slide border colorings to indicate which slides have been visited during a presentation. The authors have found these colorings to be useful both for the presenter and the audience for providing feedback as to which slides the presenter has visited and to give a sense of the overall progress of the presentation.

Principles for authoring ZUI presentations

Although CounterPoint's freeform 2D space essentially offers an unlimited variety of information layouts, the authors believe that some layouts are more desirable than others. During the authors' use of CounterPoint, a few common principles that generally result in effective presentations have been identified.

The authors have also found evidence for these intuited design principles in the research of spatial adjunct displays such as concept maps (see Figure 5). Spatial adjunct displays also include other diagrams, such as tables, flowcharts, or hierarchies, traditionally, used to supplement texts. The authors believe that these diagrams are comparable to ZUI presentations because they involve the arrangement of information 'chunks' or 'nodes' on a 2D surface. These displays further parallel CounterPoint presentations in that they are intended to supplement a verbal source.

Visual chunking

One of the problems mentioned in the design of concept maps is map shock. This occurs when the intended audience is overwhelmed by the size or complexity of a visual display. Based on common presentation guidelines (e.g. referenced in[21]) and the authors' own informal experience, this also seems to be a problem in presentations. Consequently, the first principle for CounterPoint layout is to create visual chunks.

Naturally, the corollary to this principle is determining the size of a chunk. In WWW page design, using larger chunks, or breadth, has frequently been emphasized over using smaller chunks, or depth (see[40] for example.) However, this is partly due to the latencies inherent on the WWW. Menu selection also tends to favor breadth over depth although Norman suggests that the optimal chunk size often lies in the range of three to twelve.[41] A common recommended chunk size among PowerPoint users seems to be seven.[21] This also coincides with the authors' human capability for perceiving seven plus or minus two items.[42] Since this also seems compatible with the authors' own experience in CounterPoint, it is expected seven plus or minus two will be a reasonable guideline for CounterPoint chunks as well.

Spatial configuration

Once the presentation has been segmented into meaningful chunks, the next step is to arrange these chunks in space. This issue has also been considered in the design of concept maps. Lambiotte *et al* proposed using 'gestalt' perceptual principles for the layout of concept maps to distinguish symmetry, similarity,
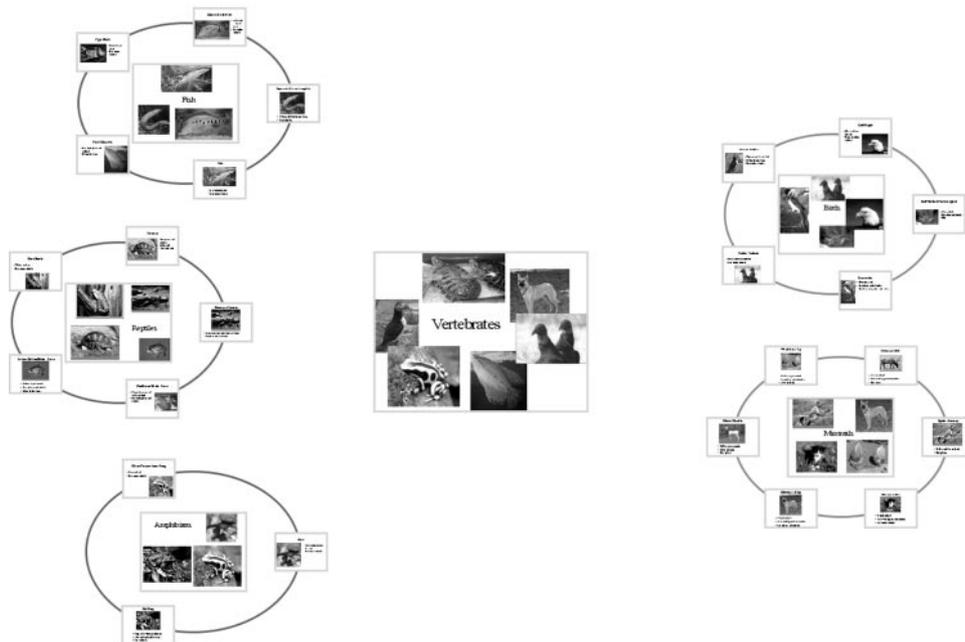
Figure 8 A presentation using hierarchy and clustering. This presentation depicts a sampling of the vertebrates, a sub-tree in the animal classification hierarchy. The sub-trees representing the different classes of vertebrates are then clustered according to whether the classes are warm or cold-blooded.
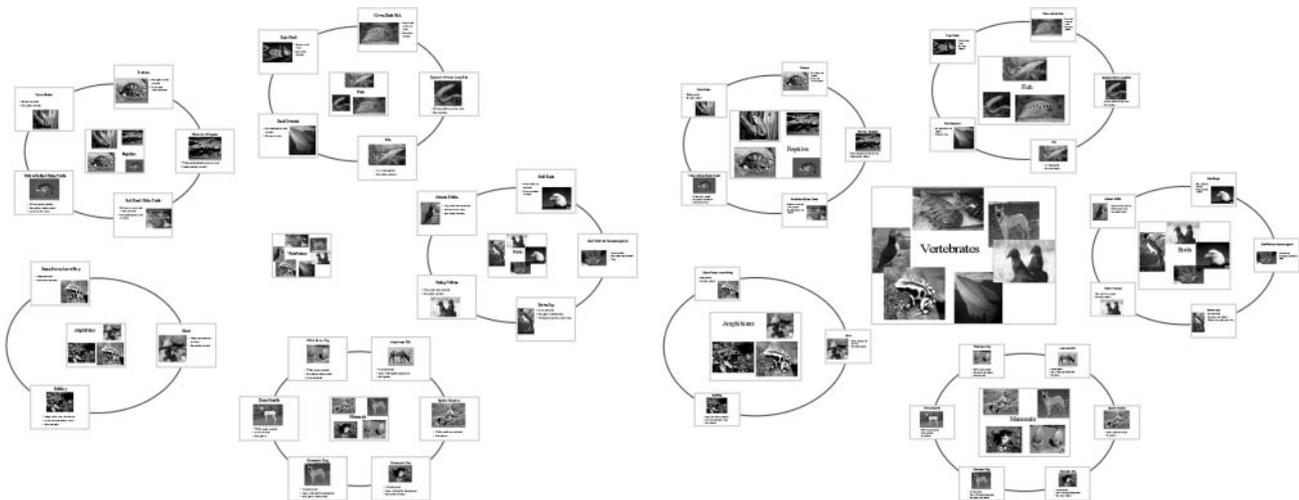
Figure 9 The presentation on the left uses only the 2D space and puts all slides at the same magnification. The presentation on the right also uses the zooming dimension by reducing the magnification of slides by 50% at each level in the hierarchy. This technique of combining area and scale often facilitates more meaningful overviews.

continuation, parallelism, and information gaps.[10] Wiegmann *et al* performed a study comparing concept maps designed with these gestalt principles to more randomly arranged concept maps.[11] The results of the study suggest that subjects using the gestalt maps had both better recall and understanding of the presented material.

The authors believe these gestalt principles can improve the design of ZUI presentations as well. Specifically, Lambiotte *et al* proposed several common layouts including hierarchies, chains, and clusters that the auhors have found useful in ZUI presentations. An example of hierarchy and clustering applied to a ZUI presentation can be seen in Figure 8. The authors recommend that

authors of ZUI presentations use meaningful layouts that adhere to these gestalt principles whenever possible.

Balancing area and scale

A final consideration in the design of ZUI presentations is the extent to which the use of area and scale are balanced. For instance, the presentation on the left in Figure 9 shows a ZUI presentation that spans a large area but essentially ignores scale. In contrast, the presentation on the right in Figure 9 demonstrates a more balanced use of area and scale.

To some extent, this tradeoff between area and scale is one of aesthetics and depends largely on the presentation content. However, as studied by Hornbaek et al,[43] multi-scale representations of visual data leads to faster navigation.

Conclusion

In this paper, the authors present ZUIs as an alternative medium for slide show presentations. ZUI presentations enable spatial navigations, paths, and distinguished levels of detail with multi-scale 2D spatial arrangements. ZUIs also allow for the replacement of the slide transition with animated viewpoint traversals through the multi-scale 2D space.

The authors have also suggested several potential cognitive advantages of ZUI presentations over more traditional slide show presentations. However, future empirical studies are needed to verify these psychological advantages.

Based on experience with authoring zoomable presentations in freehand tools, the authors have designed and built a zooming presentation tool called CounterPoint. CounterPoint offers solutions to common presentation authoring and delivery challenges in ZUIs.

Lastly, the authors offer a set of principles for zooming presentations. These principles suggest dividing the content into visual chunks, arranging these chunks according to gestalt perceptual principles, and balancing area and scale.

Future work

Primary future work lies in empirically validating the cognitive advantages of zoomable 2D spaces for slide presentations. The authors also intend to evaluate CounterPoint's usability for various presentation authoring tasks.

Future development work by the authors will mainly focus on enhancing these tools for authoring spatial arrangements. It is also the intention of the authors to design a set of zoomable and projector-friendly layout templates to further automate the creation of zooming presentations. Finally, the authors plan to create improved tools for awareness and navigation in zoomable 2D workspace.

Acknowledgments

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