Classification Model for Visual Spatial Design Guidelines in the Digital Domain

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Abstract: The process of spatial information visualization is shaped by various factors including interactive, perceptual, navigational as well as organizational and metaphorical aspects and as such requires an interdisciplinary approach. Therefore, in researching spatial visual design, it is crucial to use guidelines facilitating the process of sharing competencies among different disciplines. Furthermore, bringing the knowledge form different disciplines requires development of a model which host and classifies the interdisciplinary features important in designing effective spatial visualizations.

Note: This work is based on experience gathered as an architect designing interfaces for digital domain. Since in architecture the notion of the architectural patterns introduced by Alexander is considered to be controversial the author uses the term guideline to describe the 'vehicle' for sharing experience as information visualization designer.

Keywords: spatial visualization, abstract information, spatial design guidelines, classification model

1 Introduction

Common use of flat displays for interacting with large bodies of data very often forces interface designers to deal with complex spatial design problems. It is even more intensified today when the size of the display is constantly decreasing in contrary to the amount of information which is expected to be displayed on the digital device.

Information visualization refers to the design of graphical representations of information (often referred to as *abstract information*) that has no simple relation to known concrete or physical forms. Spatial perception plays an important role for cognitive processing when interacting with abstract information, since spatially organized information can be accessed and operated on rapidly and effortlessly, especially when a spatial arrangement reveals the conceptual organization of information.

Efficient visualization process requires that expertise be shared among experts in areas of visual communication, visual design, and computer media.

The process of spatial visualization in the digital environment is mostly based on the practical experience of a designer. That is why the majority of design know-how available is heuristic in nature. Formulating and organizing guidelines for spatial design can facilitate the process of sharing such expertise.

In this paper we briefly describe a classification model which embraces features important for spatial interactive design. Based this model we developed a framework for spatial design guidelines populated by more then twenty guidelines. These guidelines has been already presented in detail elsewhere (Bugajska 2003)

2 Spatial visualization

Abstract data easily becomes less comprehendible when it grows in size. Additionally, to be able to see patterns of similarities between single items marking tendencies in a data set, a well-designed visual representation is needed. An important benefit that improves quality of processing abstract data is the incorporation and use of spatial schemas while designing visual representation.

Tversky (Tversky 2001) notices that spatial schemas, by linking together elements, provide an organization which improves memory and can sometimes be a more powerful organizer of memory than time. Therefore, spatiality is an important feature for users interacting with the visual representation of abstract data.

Abstract data is lacking inherent spatial mappings and, additionally, the relationship between the data value and the data view is very often multi-faceted. As a result, it is challenging to create a spatial set up for this type of data since. Additionally, the effective spatial representation of data requires understanding the phenomena governing the perception of space. Although visual perception is still a subject of extensive interdisciplinary research, theories already developed can help to create spatial structures which are able to influence our cognition through visual modality.

As stated by Ware, "through an understanding of space perception, we hope to reduce the amount of poor 3D design and clarify those instances in which representation is really useful" (Ware 2000). Therefore, a successful spatial information design requires the contribution of researchers from various fields who need to share their specific and valuable experience. Consequently, we believe that the contribution of researchers from architecture and graphic design is needed. Additionally, spatial visualization methods developed already in architectural practice can greatly contribute to the excellence of spatial representation in the domain of information visualization.

For the purpose of this paper we would like to share our expertise in spatial visual design acquired through the architectural design practice.

3 Sharing Spatial Design Expertise

Due to the nature of the spatial visualization design process itself, sharing experience about the spatial design of abstract information is not an easy task. One has to secure the transfer of a complexity of factors influencing design matter as well as assure that the expressions used by various researches mean the same thing.

For the purpose of sharing knowledge for spatial visualization design many possibilities has been examine. The automatic approach of sharing expertise in visualization design was introduced by many researchers who aim at creating an automatic assembly for visualization components ((Mackinlay 1986; Senay 1994) (Card 1997). These automatic visual environments are built on already existing visual abstraction frameworks, well-documented visualization processes or design heuristics. Another approach is to create a methodology based on object-oriented types of design (e.g. OVID (Object, View, and Interaction Design) – a design methodology developed by IBM).

Schmid (Schmid 1999) points out architecture as an example of mastering various views aiming at designing habitable spaces. Schmid proposes to apply the idea of the Vitruvian Triad to design an information object, where firmitas denotes the goal of technology or science, utilitas can be understood as the goal of economy, and venustas indicates "the field of design or style". Also Schmitt (Schmitt 1999) proposes the Vitruvian Triad as a tool for guiding the design of online environments. In this spirit, we use it as a tool for creating the main structure for our classification model and group methods, visual features, and introduce spatial-visual relations important for sharing design expertise.

For the formulation of design guidelines, we proposed the structure based on the problem-solution pattern used in the software design domain and explored by Gamma (Gamma Erich 1995), Coplien (Coplien 1995) and further explored by Borchers in the area of HCI (Borchers, 2001). Consequently, a guideline is presented by introducing a context description, design problem explanation and demonstration of a potential visual solution. This structure assures that the guidelines are easy to use and that the set of guidelines can be further extended by other researchers. Design guidelines for spatial visualization of abstract information are formulated and grouped with the classification model described in this paper as a base.

4 Classification model approach for spatial design guidelines

Understanding the spatial visualization process in the digital domain requires awareness of the holistic nature of the act of space perception and spatial representation. Furthermore, the process of reusing and sharing design expertise requires a structured approach to facilitate the sharing of competencies among different design domains. The model we developed demonstrates the need for cross-pollination of expertise to ensure the quality of spatial visualization and serves as an initial map of the design space for spatial visualization of abstract information. This model serves also as an art of dictionary for describing the guidelines and as such may create a base for people interested in contributing to the existing group of guidelines.

The spatial visualization process is multifaceted. It is important to be aware of various levels that are involved in shaping the quality of the spatial information visualization output. These levels include, among others, perceptual, interaction and navigation levels as well as organization and metaphor levels. Until now, these aspects were investigated separately by various researchers (Marcus 1980; Kamada 1991; Lohse 1994; Senay 1994; Marcus 1995; Shneiderman 1995; Shneiderman 1996; Card 1997). We incorporate properties influencing spatial visualization from diverse present lines of research in our classification model. In the graphical representation of the model (Appendix 1) we mark them with color patches showing the main contributors. Properties and tree-structures of properties without colored patch represent our contribution to the classification model. By creating this classification model, we see our contribution as twofold. Firstly, we create a holistic structure for the entire model into which additional important factors influencing spatial visualization are incorporated. Such factors include various aspects of visual modality and human cognition investigated by researchers. Secondly, we define a group of visual Spatial Visualization Properties in the Object component (discussed elsewhere (Bugajska 2003)) which contributed also to the coherence of the natural language used for describing the guidelines.

Three elements create the core of our classification. We define these elements as follows:

- Object Group describes a graphic element or geometry which is used to represent elements in the physical world
- Context Group describes a graphic space which is used to represent relations between elements (Tversky 2001)
- Order Group defines a choice of spatial arrangement of objects in the graphic space

Additionally, Designer Goals and User Tasks are classification elements which, we believe, have an important influence on spatial visualization effectiveness. We visually represent the influence of these components by placing them as a circle embracing the Context, Order and Object elements in the graphical representation of our classification. We see Designer Goals as a group of methods which are governed by the Vitruvian Triad of Firmitas, Utilitas, and Venustas (Vitruvius 1960). For defining The User Tasks element, we adopted the cluster of tasks method formulated by Shneiderman (Shneiderman 1996), who defined seven items of "Information-Seeking Mantra" while working with the visualization environment.

4.1 Object Group

Object Group clusters graphical properties influencing spatial design. We describe shortly some of them here

Marks (first introduced by Bertin (Bertin 1974) refers to graphical elements visible on a display medium; they describe the most primitive blocks which encode information: points, lines and areas. Senay and Ignatius (Senay 1994) further extended the ordering of graphical elements by adding another group of marks called compound marks. They define compound marks as "collections of simple marks that form a single perceptual unit". On this level of classification we additionally introduce Negative Space which, in our opinion, is an important element of information visualization artifacts.

In our model, we classify objects in terms of the roles they play within a visualization artifact. We distinguish between three types of objects: Data Object, Process Object and Referential Object. By Data Object, we refer to any object that visually represents different types of data. Process Object refers to the type of object that supports interaction processes between a human and a machine on the visual level. We refer to Referential Object, which is based on the concept of Referential Component developed by Senay and Ignatius, as any type of visual object facilitating the proper interpretation of spatial qualities in a graphical scene but not encoding data items directly.

The Process Object group clusters Icon, Label, Filter, and Menu elements. We understand Icon as an object that graphically represents an item recognizable or learnable by the user. Icons can be used for communicating certain functions or processes within visualization artifacts. We refer to Label as an object attached to another object (data or process-related) describing this object, often using textual representation. Filter represents types of object used during the process of exploring visualized content for modifying the spatial and graphical parameters of objects (e.g. changing spatial configuration of objects according to the new rule established by the user). Finally, Menu refers to a wide range of processes collected in one set of functions available for use when working with visualization artifact.

In the Object group we also include visual properties which define visual features of objects engaged in spatial design. This is a result of reviewing research conducted in different visual design domains. It was interesting to study spatial visualization examples provided by the researchers of 'analog' pictorial media. Some of these examples displayed the level of visual effectiveness surpassing that of many the contemporary digital media representations. The group of Spatial Visual Properties is analyzed and described in more detail in (Bugajska, 2003).

4.2 Context Group

This group includes components that affect user's spatial exploration of information on the following levels:

- User level - contains the Mental Model group
- Community level - embraces Social Space group
- Environment level - includes Spatial Container, Orientation, Interaction styles, and Metaphor groups

<u>User level : Mental Model Group</u>

After Wickens (Wickens 1992) we refer to Mental Model as a basis for "understanding the system, for controlling its action and predicting its future behavior". It represents organization of data, functions, activities, and roles that users inhabit within computer-based environments of work or play. We distinguish two factors of the Mental Model group which have been already introduced by Donath (Donath 1995): Pattern of Presence and Pattern of Association.

<u>Community level: Social Space Group</u>

Social Space is a group of factors defining social aspects of a spatial multi-user environment. This group includes: Digital Portrait, Digital Conversation, Digital Crowd, and Social Networks. After Donath (Donath 1995) we refer to 'Digital Portrait' as a representation of the user within a spatial multi-user environment. Digital Conversation (Donath 1999) describes space and time-dependent conversation taking place between users of an online environment. Digital Crowd, an expression coined by Minar (Minar 1999) describes visualization of users simultaneously visiting spatially-defined environments of online documents or websites. Finally, Social Networks are patterns of relations or connections among individuals.

<u>Environment level: Spatial Container</u>

Spatial Container groups factors which describe qualities of constructs defining visualization scene. We propose Background and Spatial Setting as elements of this group. Background refers to the visual character of the background against which all elements of the visualization are placed. Using a polychrome or monochrome background for the visualization artifact influences the way in which the user perceives the rest of the visualization scene.

The Spatial Setting group describes the setup of the Spatial Container used in visualization artifacts. We define two ways of visually presenting Spatial Containers, namely by using the Inner Space or Outer Space of the Container as a spatial setup. By using the Inner Space of the container, the background image is not influencing the visual character of the spatial composition. On the contrary, by using the Outer Space the Background starts to play an important role.

<u>Environment level: Orientation</u>

Orientation relates to the set of factors influencing a user's ability to explore spatial visualization. We defined two groups of factors: View Point and Navigation. View Point clusters two elements in.world and out.world describing the manner in which the spatial information of the visualization environment is presented. in.world describes types of spaces resulting from the user's activity directly within a particular multi-user environment. Out.world refers to the type of space inhabited by representation of the users' group activity within the environment as a community (Wenz 1996).

Navigation factors describe user movements between pieces of information. We distinguish three aspects of navigation after Dourish and Chalmers (Dourish 1994): Spatial, Semantic and Social Navigation. Spatial Navigation refers to the user movement from one item to another within a computer-generated structure based on spatial relationships (e.g. right, left, above, outside). In Semantic Navigation the user movement through the environment is performed according to semantic relationships between items (e.g. bigger, faster, similar, alike). Social Navigation refers to the user movement from one item to another which is provoked by the activity of other users.

<u>Environment level - Interaction</u>

For the Interaction cluster, we adopt the taxonomy of interaction styles developed by Shneiderman. Shneiderman distinguishes Menu Selection, Form Fill-in, Command Language, Natural Language, and Direct Manipulation as interaction styles. decision-making process. See (Shneiderman 1995) for more detail.

<u>Environment level: Metaphor</u>

Metaphor in the computer environment helps to achieve a mapping between the digital environment and a reference system known to the user from the physical world (Nielsen 1994). Metaphor is a type of concept through which information is easily recognized, understood, and remembered. We adopt the classification of Marcus (Marcus 1994) who claims that metaphors may achieve their effectiveness through association of organization or operation. Association of Organization refers to the similarity of structure, objects or attributes, e.g. metaphor of a tree with roots, branches, leaves. Association of Operation refers to the similarity of processes or actions (e.g. selecting objects by touching them, grabbing items, or sliding items).

4.3 Order

The Order Group classifies design principles important in creating spatial environments for visualizing abstract information. To organize this group of properties, we adopt the classification set of 'visible language' principles introduced by Marcus (Marcus 1995). He distinguished three clusters (Organize, Economize, and Communicate) to group principles which provide guidance for designing user interfaces. We use this type of grouping to propose clusters of principles helping in achieving effective spatial visualizations. In our classification we use the term Organization to describe groups of principles which provide users with consistent and clear spatial structures. Economy groups concepts maximizing the effectiveness of spatial, visual expression using minimum input. Finally, Communication represents principles, which help to match a spatial presentation with the perceptive capabilities of the user.

4.4 Designer Goals

We have chosen the Vitruvian Triad of Firmitas, Utilitas, and Venustas as a classification instrument for defining the goals of a designer of spatial information visualization artifacts. We believe that creating environments for abstract information presented and shared through online networks can fulfill the criteria of designing physical architecture.

Firmitas - Firmness and Structural stability

In our classification we define firmness or the structural stability of a visualization artifact as an essential constituent of a spatial scene or formation of objects. We distinguish three types of structure representation: Exterior, Interior, and Compound. Exterior structure refers to the type of representation when the focus is put on an external part of the scene or arrangements of objects. By using this type of representation not all characteristics of the structure are revealed to the user. Interior structure refers to the representation of the structure when the focus is on its interior characteristics. In this case, the user does not obtain an immediate overview of the structure as a whole. Compound structure compromises the interior and exterior representation of the visual structure of the scene by composing them together in one arrangement demonstrating both the structural characteristics of the whole scene and its spatial details.

Utilitas – Utility

We define Utility as a logical arrangement of spaces planned for the convenience and comfort of users. The logic of Utility can be expressed using various modes of spatial visual appearance. We distinguish three types of arranging objects or spatial scenes: elementary, symbolic, and relational (compare (Bowman 1968)). An elementary type of arrangement is characterized by objects or scenes embraced into a simple spatial arrangement with an easily recognizable pattern of interrelationships. The symbolic type of arrangement focuses on objects or spatial scenes by assigning to them additional meaning (e.g. associative or conventional in nature) conveying the character of the arrangement. Finally, relational arrangement focuses on the character and arrangement of connectors between objects or spatial scenes to demonstrate the nature of the spatial relations between objects or scenes.

Venustas – Appearance and Beauty

We refer to Appearance as to the group of aesthetic features defining the visual character of the object or scene. Appearance groups three types of properties important for spatial visualization: Entertainment, Engagement, and Ambience. The importance for entertaining the user while he is visually exploring information has been already pointed out by Shneiderman, who stresses the importance of information exploration as a joyful experience. We refer to Entertainment as a spatial definition of a scene or group of objects, which users watch with pleasure, and which helps to engage users into the discovery process. Engagement refers to methods supporting the user in focusing on the spatial exploration of information while working within visualization artifacts. Design aspects of visual, spatial engagement enable the user faster and more effective work with the visualization objects. Finally, by Ambience we understand a particular visual 'climate' created for the purpose of visually influencing the user's exploration of visualization artifacts. Ambience can operate on the "periphery of human perception" and requires minimal attention and cognitive load.

4.5 User Tasks Group

During the spatial exploration of information, users perform a sequence of tasks allowing for the optimal discovery of patterns, clusters, and relations between visualized items. The kind of tasks which allow for effective information searching or browsing is strongly interrelated with the spatial character of visualization proposed by the designer.

For the User Task Group we adopt the taxonomy by Shneiderman (Shneiderman 1996), who presented seven tasks of "Information-Seeking Mantra" that information visualization applications should support. Shneiderman's cluster of tasks includes the following: overview, zoom, filter, detail-on-demand, relate, history, and extract. See Shneiderman for more detailed explanation of these tasks. The user tasks described here are at a high level of abstraction and should be understood as the general direction for creation of the spatial design guidelines.

4.6 Holistic approach in spatial design

As already mentioned before, it is important for us to demonstrate the significance of a holistic approach to the spatial design of abstract information. Therefore, in our classification model we stress interrelations between all five groups: Context, Object, Order, Designer Goals and User Tasks. User Tasks embrace all groups of factors we created for spatial visualization, meaning we believe the tasks performed by users while exploring a visualization influence the kind of spatial design and vice versa.

For a more detailed description and presentation of the reasoning behind the development of the model as well as relations mapped between the elements of the model see (Bugajska, 2003).

5 Spatial Design Guidelines

Spatial Design Guidelines framework uses the classification model presented above. The vocabulary used for the guidelines corresponds to the one used for the classification model. Defining and sustaining a common vocabulary becomes another important asset in creation of common platform for sharing expertise among different disciplines.

Spatial Design Guidelines framework is built around three main elements of the classification model: The Object, The Context and The Design Principles (belong to Order group in the model) guidelines groups.

We briefly describe the art of guidelines we developed. As an example we have enclosed the complete description User Activity Guideline from the Context Guidelines Group at the end this paper (Appendix 2).

5.1 Object Guidelines Group

Object Guidelines Group is built on spatial design guidelines presenting qualities of arrangements between elements (signs) used for communication processes engaged in visualizations. We distinguish three groups of spatial properties of objects: visual syntax, visual semantics, and visual pragmatics.

As presented in the classification model Visual Syntax group belongs to the category of visual semiotics. We refer to visual syntax as qualities of the arrangement between visual symbols used for conveying information. In this group, we propose guidelines relevant to the process of spatially arranging elements that represent information in a visualization artifact. In the guideline "Level of Detail" we propose a solution for ordering elements of a body of information, where elements with different levels of visual detail are presented on the display. Guideline "Rhythmical Organization" presents the value of composing visual symbols with the goal of maintaining and prolonging user attention to a visual presentation. Finally, guideline "Visual Quantitative Support" proposes visual support for the spatial arrangement of elements in the context of quantitative system introduced in a visualization artifact (e.g. Cartesian system, quantitative scale, etc.)

Visual semantics refer to the relationship that can be established between the sign/symbol and information it conveys. In guideline "Spatial Expressiveness", we propose to use the expressiveness of the visualization to modulate the ambience of the visualization environment influenced by data-related processes or user activity within the environment. Guideline "Visual Gradation" presents possibilities for using multi-plane spatial organization to gradate the importance of information for the user at a particular point in time while interacting with visualizations. Finally, "Visual Attention" guideline suggests visual methods for influencing user attention while acquiring information within a spatial environment.

In this paper we do not present pragmatics guidelines since all of our visualization work was exclusively created for displays (from laptop to wall size) and involved the use of standard input tools only (mouse and keyboard).

5.2 Context Guidelines Group

The Context Guidelines Group clusters guidelines referring to the visual context in which visualization elements are presented. This group is ordered into three clusters:

- User's Cluster
- Community Cluster (social space)
- Visual Framework Cluster (spatial container, interaction, navigation and orientation)

User's Cluster groups guidelines directing designers attention to the visual elements and techniques that support the visual presentation of user tasks, actions, and roles. It proposes guideline tackling the question: How to spatially define a user task within a dynamic, interactive, computer-generated environment?

To depict characteristics of spatial representations enhancing the user's cognitive model within dynamic environment, we present the following spatial design approaches:

- History of user's actions
- User's activity in the context of the activity of other users
- Spatial mental model of user actions within an environment

Community cluster concentrates on issues related to spatial presentation of activities of an online community within a computer-generated environment. It tackles the question: How to visually define activities of a community within a spatial online environment?

Organized within a volumetric space, an online environment requires spatial techniques to perceptually define activities of the community. These activities may be related to formation of a new community or to the process of supporting online community by underlining its common interests, enhancing communication activities, strengthening its identity. We group here examples for guidelines which support the formation of a community or spatially demonstrate the commonness of interest within a community.

- Common Activity Guideline: Image background as a visual construct with the function to visually support common interest activities within an online community
- Neighborhoods Guideline: Spatially linking users with common interests within a community (concept of neighborhoods within a community)

Visual Framework Cluster directs designers' attention to the importance of the referential component for spatial visualization artifacts.

General context of this set of guidelines refers to the use of appropriate visual properties which can be used to help the user decode spatial relations among elements in a two-dimensional interactive visualization artifact. It tackles the question: What types of referential components are capable of defining spatial properties of the information scene and help the user fulfill the task of successful interaction with visualized information? This cluster includes guidelines like Grid, Opaque Platform, Tunnel, Covered Platform, Pyramidal Space, and Background Image.

5.3 Design Principles Guidelines Group

This Group is built on design foundations grouped in clusters of organization and communication. In the organization cluster ("Spatial Manipulation" and "Spatial Navigation" guidelines) we presented guidelines dealing with the issues of spatial organization of the visualization elements and user navigation when exploring the visualization artifact based on a continuous space organization. Communication cluster ("Visual Transition", "Text Legibility" and "Private/Public Spaces" guidelines) grouped guidelines exploring the issue of legibility of a visual message, the role of spatial design in communicating semantic differences and the issue of visually communicating the change occurring within the visualization environment.

6 Conclusion

We have explained the importance of spatial design for visualization of abstract information. We have stated that especially for digital domain this heuristic in nature branch of visual design requires an expertise sharing among many disciplines including psychology of visual signs, art history or architecture. Such expertise sharing can happen through the creation and use of spatial visual guidelines. Presented here classification model helps significantly as a reference for already created guidelines as well as a base for further development of guidelines for spatial visualization of abstract information, and as such builds an extendable base for an infrastructure which becomes a step towards augmenting the quality of spatial information design.

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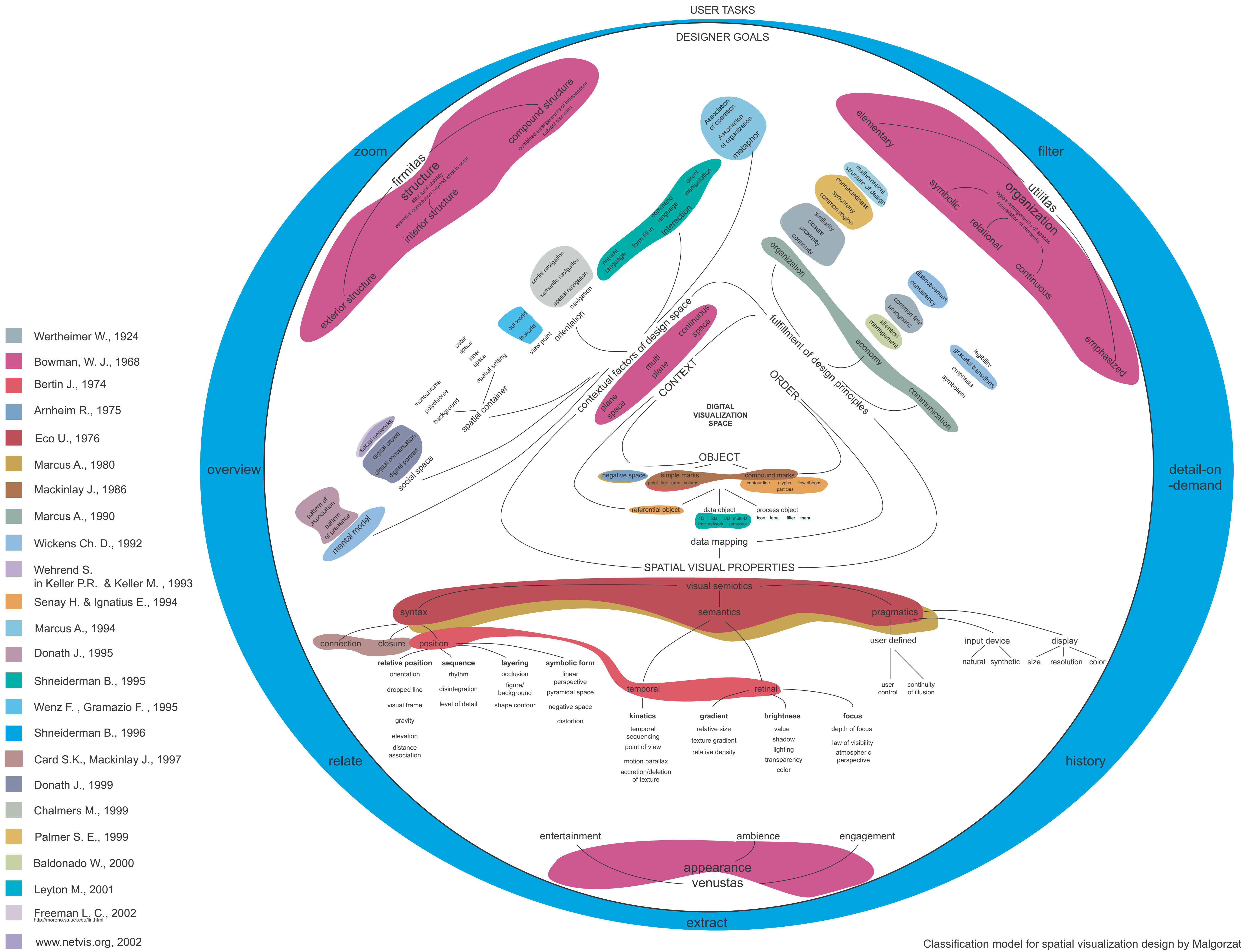
8 Appendix



Classification model for spatial visualization design by Malgorzata Bugajska

User Activity Guideline

Problem: How to visually present the user activity in the context of users activities within the system based on a continuous space organization?

Forces

Activity of every user is unique. It reflects the user's own task or role within the system. Therefore, it should be easy to visually and conceptually differentiate between the representation of his activities and that of other users. It is easier for the user to relate to the activities of other users within the system if he is visually aware of his own activities.

It is easier to make comparisons between different activities when it is possible to find out which activity belongs to whom.

User activities are space and time-dependent. Making comparisons in space and time enriches the learning process about the relations among activities of different users.

The act of browsing through information is very important, especially for novice users within the system and for obtaining an overview about the information collected within the environment. Additionally, information browsing is designed conveniently when there is a construct that allows for an overview of all activities within the environment and at the same time presents users with an easy to grasp cognitive model.

Solution:

Actions can be represented by a referential component, which has spatial and time-based properties. This makes such a component flexible enough to represent all types of actions undertaken by the user within an interactive environment. Such components should have properties visually documenting the sequence of user 'action steps' in relation to 'the steps' of other users (Bugajska 2001). Consequently, relations should be visually accessible in time / space when working with the visualization artifact. An item which represents user actions should be visually distinguishable from other items, but at the same time allow for recognizing the group of elements it may belong to (e.g. elements representing actions of other users)

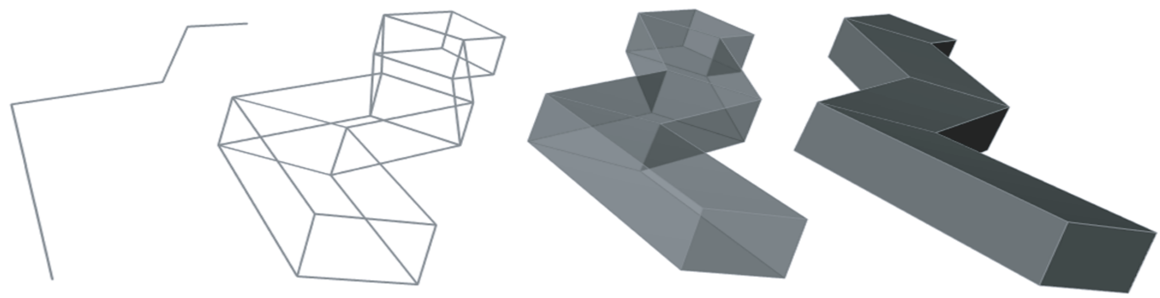


Figure 6.24 Gradation in representation for components within continuous space organization. Here we propose to use line, wire frame, volumetric-transparent structure and volumetric-opaque structure to show the difference among the actions – from less defined (line) to fully defined (volumetric transparent or opaque structure).

Resulting Context:

There is still a decision to be made regarding successful navigation through a continuous space organization. Navigating through such space should reflect the most convenient way of viewing relations between objects within a 3D environment.

Application example 1:

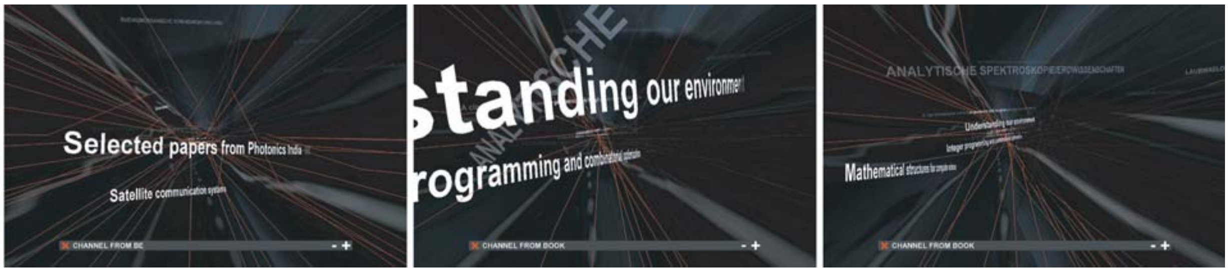


Figure 6.25 Document-browsing applet for Virtual Library environment. These views represent the 'private world' of one user in form of a semi-transparent channel-like construct. The activities of other users browsing in similar collection of books are represented as red lines appearing in the user's tunnel, in its close distance (to demonstrate closely related usage of the library) or further away form the tunnel.

Image source: Virtual Library- exhibition project, 2001, authors: Prof. Maia Engeli, Malgorzata Bugajska, Andrew Vande Moere, Kai Strehlke; Architecture and CAAD, ETH Zurich

Figure 6.26 Global view of activities within the Virtual Library. Red lines document searching activity of the library users. White elements show titles of the books the users are interested in.

Image source: Virtual Library- exhibition project, 2001, authors: Prof. Maia Engeli, Malgorzata Bugajska, Andrew Vande Moere, Kai Strehlke; Architecture and CAAD, ETH Zurich

Application example 2:

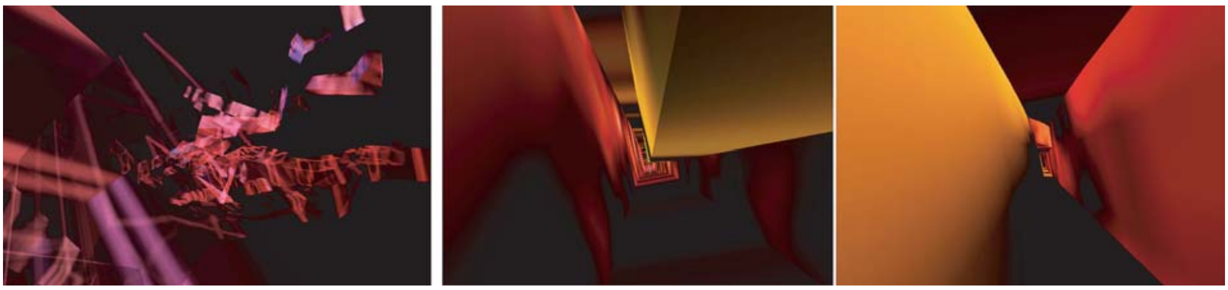


Figure 6.27 LINE library groups the channel-likes constructs representing activities of users within the library (image on the left). The middle image represents situation when channels of two users interested in similar books join. Image on the right represents channel of user activity, which does not cross with activities of other users.

Image source: LINE Library, 2000; competition project, author: Malgorzata Bugajska, http://caad.arch.ethz.ch/~bugajska; Architecture and CAAD, ETH Zurich