

Redefining the Focus and Context of Focus+Context Visualizations

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Abstract

The increasing diversity of computers, especially among small mobile devices such as mobile phones and PDAs, raise new questions about information visualization techniques developed for the desktop computer. Using a series of examples ranging from applications for ordinary desktop displays to web-browsers and other applications for PDAs, we describe how a focus+context technique, Flip Zooming, is changed due to the situation it is used in. Based on these examples, we discuss how the use of “focus” and “context” in focus+context techniques change in order to fit new areas of use for information visualization. By doing so, we hope to enrich the understanding of how focus+context techniques as a whole may be further developed.

Keywords

Information Visualization, Personal Digital Assistants, Focus+Context techniques

1. Introduction

Computers are soon being used in almost every kind of situation. Especially, mobile information technologies such as PDAs and mobile phones have recently introduced a major breakthrough of computer use in everyday situations. These new devices are rapidly becoming more powerful, matching the computational power and memory storage of desktop computers only ten years ago. However, they are used in situations where computers have not been used before, and are limited by small displays. While aspects of information technology design such as having an eye-catching or trendy exterior are rapidly becoming more important, there is still much work to be done on how to develop interaction design such as information visualizations that fit the many different situations people want to use them in. This is likely to be an important issue since the recent success of new and most notably mobile forms of computing indicate that there is a great interest for “off the desktop”-technology among consumers. If this interest corresponds to a real need among users, it is not unlikely that this use may constitute the majority of all computer use in the near future.

The approach to modify computers and their software to the environment they are used in has been labeled “situated

computing”. As the term situated computing may be given many interpretations, and the research community has yet to give an explicit definition of the term, we will here stay with a rudimentary notion of situated technology as technology developed for a specific situation or setting with the aim to make it more transparent in relation to a task or situation. This implies not only that interaction designers have to customize the information visualization as such, but also that they have to choose the proper platform for presenting the information, may it be an ordinary desktop display, a wall-sized information board or a PDA (cf. [37]).

As an illustration of the challenges and constraints posed by situated computing, we will present experiences on how the Flip Zooming focus+context visualization technique had to be adapted for various situations, including use on PDAs. The aim of this paper is to highlight some of the implicit presumptions of focus+context techniques we have identified while working with Flip Zooming. Even though these presumptions also can be found in other researchers' work, they have become obvious to us when developing the technique in new application areas. To illustrate the presumptions, we first present a number of Flip Zooming applications developed for different areas of use, in which the necessary adaptations are identified and described. We then discuss ways of re-interpreting the terms focus and context in focus+context techniques.

2. Focus+Context Visualization

The basic idea with focus+context visualizations is to enable users to have the object of primary interest presented in detail while having an overview or a context available at the same time. Following the early work of Furnas [12], Spence & Apperley [34] and others, a number of visualization strategies have been developed. The *Graphical Fisheye Views* [27] and the *Rubbersheet View* [28] display two-dimensional maps and images using graphical distortions. The *Perspective Wall* [20] and the *Document Lens* [26] make use of perspectives to give a combined overview and detail presentation. The *Table Lens* [23] uses a spreadsheet-like presentation to visualize information. Techniques developed to visualize graphs and hierarchies include the *Continuous Zoom* [1], the *Hyperbolic Tree Browser* [18], and *Cone Trees* [25]. Although

not pure focus+context techniques, zoomable user interfaces (e.g. PAD++ [2]) allow the user to have a detailed presentation of selected information and, at the same time, present an overview by using portals (c.f. [21]) or context layers (c.f. [22]).

In some ways, the early work on focus+context visualization was “situated”. For instance, the Fisheye View [11] by Furnas used the structural properties of programming languages to support the many different levels a programmer has to work on simultaneously. Further, the BiFocal Display [32] by Spence and Apperley was designed to meet the needs of the “office professional” who has to deal with a number of different kinds of information more or less simultaneously. This work opened up for a perspective on “context” as something that well may be outside the document or application in focus. Since then, however, most focus+context techniques have been based on a rather static notion of what the context should be, often leaving it at representing the pages surrounding the page the user is reading in a long document.

2.1. Definitions

In order to be able to use different situations of usage to discuss and redefine focus+context visualization, we first need to clarify what focus+context visualizations are. As an introduction, it might also be useful to see how the terms “focus” and “context” are defined in general. “Focus” has been defined as *a center of activity, attraction, or attention* [10], and *a position, or condition, of sharp definition of an image* [9]. “Context” has been defined as *the interrelated conditions in which something exists or occurs* [10] and *the parts of a discourse or treatise that precede and follow a special passage and may fix its true meaning* [9].

Work to classify and categorize the various focus+context techniques developed have used a number of analogies including *space-scale diagrams* [13], *rubbersheets* [19], *non-linear magnification fields* [17], *multiple dimensions of transformation* [33], and *higher-order visualizations* [6]. Tweedie gives a description of information visualization techniques as *interactive externalizations* [35]. For a more complete categorization of both focus+context and other information visualization techniques, see [8].

In case there exists a definition of focus+context visualization that researchers agree upon, it is implicit in the literature. However, the following description of focus+context techniques comes rather close to being such a definition:

“[focus+context] start from three premises: First, the user needs both overview (context) and detail information (focus) simultaneously. Second, information needed in the overview may be different from that needed in detail. Third, these two types of information can be combined within a single (dynamic) display, much as in human vision.” [8, p. 307]

2.1.1. Initial Remarks. Assuming that the description from [8] is an accurate description of how researchers define focus+context, one can make some initial remarks on what the premises are. First, the users requirements are described as needs of information, and that there is a need to access information on at least two levels of detail simultaneously. There is also a more implicit premise that the information visualization will provide both of them. This can be contrasted with a situation where sources of information outside the computer provides contextual information to something displayed on the screen or when the computer supports the user with contextual information about something outside the computer. By designing information visualizations that provide both levels of detail, one makes an implicit assumption that the computer will have the users, more or less, complete attention.

Second, the fact that the information needed in the overview and in detail may differ, does not only imply that the actual presentation may be different (which is the case in most focus+context visualizations), but that the very kind of information may be different in the two cases. Finally, we can see that the notion of focus and contextual information combined within a single display does not imply that it is the best solution at all times. However, neither do many focus+context techniques allow the user to choose between having a focus-only view or having a focus+context view.

Looking at the focus+context visualization techniques that have been developed, there seems to be some implicit requirements and limitations. Even though we do not think that any of these are due to the premises in the “definition” used above, they can be explained by using this definition as a basis. For the areas of use that these techniques have been developed, these limitations are often motivated, but in order for focus+context techniques to be applicable in other types of situations, it may be necessary to modify or abandon them. To do this, one must first explicitly state the limitations.

3. Applications

In the follow examples, we will show how the notion of focus+context changes as a visualization technique is used in a number of different applications developed to support a variety of tasks. The technique in question is Flip Zooming. Briefly, the Flip Zooming technique is an information visualization technique that presents discrete and sequential information in a number of tiles. These tiles are presented in a left-to-right, top-to-bottom fashion that maintains the sequential structure of the information and allows the user to select one tile as the focus. This focus is placed in the center of the display area and is given more screen space. The other tiles are moved so that the sequential ordering is maintained.

The examples are given in the chronological order they were developed. This should not, however, be seen as a description of a kind of evolution where the later examples are superior to the previous examples. Even though Flip Zooming has been refined during the whole development,

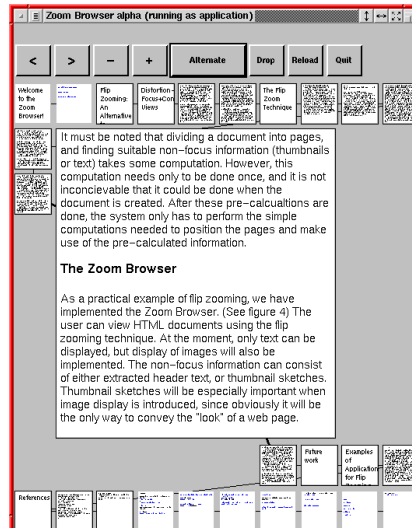


Figure 1. The Zoom Browser, providing a view of several different web pages divided into a number of tiles.

the later examples mainly differ in terms of their area of use and not in the perfection of a technique.

3.1. The Zoom Browser

The first application to use the Flip Zooming technique was the Zoom Browser [14]. In this web browser, each web page is split into a suitable number of tiles and the tiles constituting a web page are linked together by a line (see figure 1). The user can gain detailed information about a tile by selecting it. New tiles are added to the visualization by following the hyperlinks in the tiles.

The Zoom Browser conforms to the basic notions of focus+context techniques. It provides the user with a focus and a context, the presentation of information in the focus tile and in the context tiles differs, and the two types of presentation are combined within a single display. However, it offers the user the possibility to view the context information in three different ways: as thumbnails, as summaries, or as a mixture of both. Further, the user can choose to not

have any focus, creating a view where all tiles are given an equal amount of screen space.

3.2. The Hierarchical Image Browser

One feature of Flip Zooming is that it allows for hierarchical information visualizations [3], i.e., that Flip Zooming visualizations can be visualized within one another. In the Hierarchical Image Browser [15], the Flip Zooming technique was used to present images of paintings and sculptures. The images were placed in Flip Zooming visualizations according to their style, and the visualizations themselves were grouped in outer Flip Zooming visualizations representing the different sections of a museum (see figure 2). Since users might want to take a closer look at the details of a painting, it is possible to make the object in focus fill the whole screen.

The Hierarchical Image Browser has the basic functionality of focus+context techniques, such as providing a

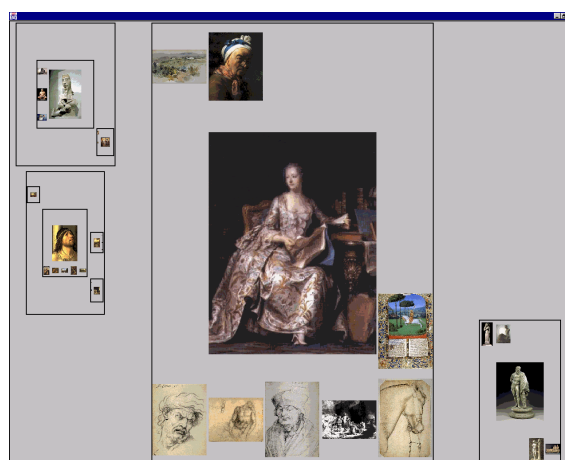


Figure 2. The Hierarchical Image Browser. Flip Zooming visualizations are shown within other Flip Zooming visualization, creating a hierarchy where every node has its own focus.

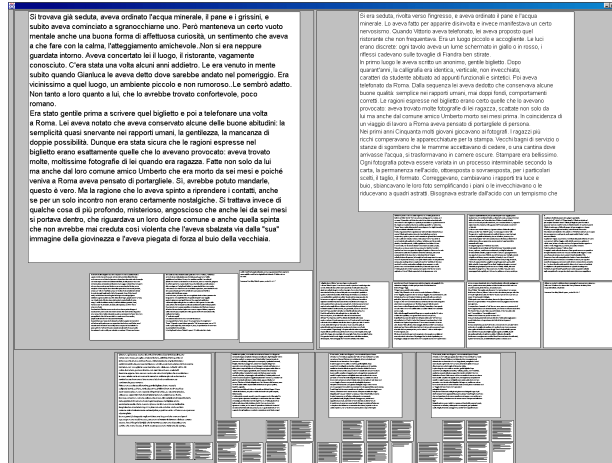


Figure 3. The Digital Variants Browser. The top level Flip Zooming visualization uses two foci in order to facilitate comparison between two different texts.

focus and a context, but allows the user to manipulate the appearance of both the focus and the context by manipulating the inner visualizations. Further, since the context is divided into several levels by the use of a nested visualization, there is a clear distinction between different levels of context, ranging from local to global. As the user can hide the context in each of the visualizations, the appearance of the context as a whole can be manipulated without changing the focus.

3.3. The Digital Variants Viewer

The Digital Variants Viewer [4] was developed to support literature research on variants of the same texts, e.g. to compare translations, study a text's development or classify the lineage of texts. Each text is shown in a Flip Zooming visualization by dividing the text into a number of tiles comparable to pages in a book. These presentations were then placed in an outer Flip Zooming visualization, creating a two-layered visualization. To provide comparison of two of the inner visualizations, the outer visualization provided two foci placed together at the top of the display area. The user selects one of the two outer foci as locked, indicating that when an outer context is selected, the unlocked focus is

changed. To ease the comparison of the two focus tiles of the inner visualization that had been chosen as foci in the outer visualization, the layout strategy of these inner visualizations had to be modified (see figure 3).

In addition to deviating from “normal” focus+context techniques in the same way as the Hierarchical Image Browser did, the Digital Variants Viewer has two foci in the outer visualization. Further, all visualizations of the documents place the foci slightly separated from the context, but still combine them into a single visualization.

3.4. WEST

The WEST (WEB browser for Small Terminals) application [7] was designed for browsing web pages using PDAs. A basic assumption was that, due to the very small screen, users would be more focused on retrieving specific information from familiar pages than on general browsing. Similar to the Zoom Browser, web pages were divided into small parts that were shown in different tiles. However, the very limited screen display, 160*160 pixels, meant that only a few of the tiles could be shown simultaneously. The tiles were ordered hierarchically, in order to provide an efficient and structured navigation. To further aid navigation,



Figure 4. The Web browser of Small Terminals (WEST). All three views are shown in their actual resolution of 160*160 pixels. The views are, from left to right, the thumbnail view, the keyword view and the link view.



Figure 5. PowerView application showing a heterogenous context.

each tile could present its information in three ways: thumbnail, summary or link view (see figure 4). These different views were designed to support different ways of navigating the information. The thumbnail view supports navigation when the visual appearance of the web page is known and enables users to search for visual landmarks. The keyword view enables users to gain an overview of the content of the page. Finally, the link view was designed to support the search for specific links to other information, for instance to the individual articles on a news service.

WEST was a further step away from the traditional focus+context techniques. It is a hierarchical visualization, but only shows local context as it only presents one level at a time. Further, the user can adjust the view on, i.e., change the appearance of, both focus and context depending on how the application is used.

3.5. PowerView

The PowerView application [5] was developed to provide access to the most common information on PDAs, i.e. address entries, meetings, e-mail, and to-do lists. As PDAs often are used in public areas when the user is interacting with other people, for instance by having a conversation or a meeting, we developed the application to be used in a supportive role to provide information for other activities. In other words, it was assumed that the information presented was used to accomplish something that would take place “outside” the device. The application was built around a number of information views, in which several different types of information could be presented simultaneously. Each view was designed to support a task, e.g., to retrieve information about a meeting or a person.

To provide the user with a relevant context once an individual piece of information had been retrieved, we intro-

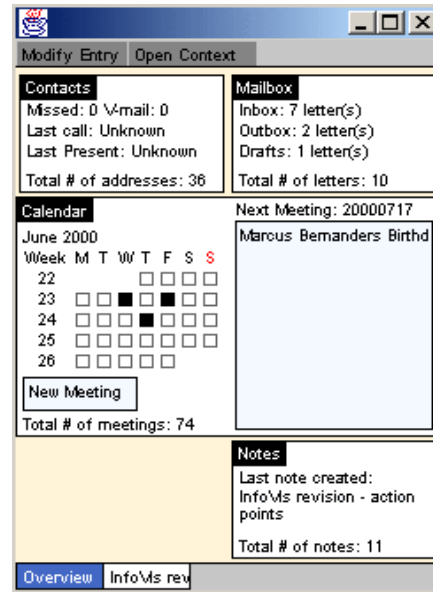


Figure 6. The initial view in the PowerCom application.

duced information links between items to enable the user to indicate a relationship between two pieces of information, regardless of information type (see figure 5). Thus, the information links form a semantic layer on top of the information structure that enables the application to customize what is shown in the context objects depending on what is in focus. Similar to the WEST browser, it only provides local context in each view, but due to the information links, PowerView can have heterogeneous contexts where several different types of information are mixed in one view.

3.6. PowerCom

Based on PowerView, the PowerCom application was developed with the aim of exploring how functionality such as telephony and *context awareness* [29,36] can be incorporated with an integrated presentation of information normally stored on PDAs. One of the main ideas was to make the application provide contextual information about activities and events taking place in the users environment. Such support includes presenting relevant information when the user receives a phone call, or meets someone and has a spontaneous meeting. This was achieved by making events such as phone calls trigger the generation of a new context view in the same way as when the user selects an item in order to retrieve information. The main difference in the visualization compared to PowerView, in this respect, is that PowerCom handles several context views simultaneously since there might be several activities and events taking place at a time. By having these context views available, the user can easily switch between them without having to select the relevant entry and retrieve the information manually (see figure 6).

The PowerCom application goes one step further in trying to match the focus and the context of the information visualization with the user's focus of attention and the user's context. As this focus can quickly change between different activities and any activity can require several types of information to perform, the application is designed to support rapid changes of focus, and to provide a unified presentation of several different kinds of information.

4. Discussion

When developing the applications described above, we have each time been forced to expand, reduce or modify the Flip Zooming technique. During these modifications, we have exposed a number of preconceptions about Focus+Context techniques in general. These preconceptions should not be seen as negative in themselves; in fact, in most cases they are probably the most sensible approach. However, in some new areas of use alternative methods or variations may be advantageous or even required for a technique to be feasible, and in these cases, the preconceptions may limit the usability of the technique.

4.1. Focus

4.1.1. Focus or Foci? A seemingly trivial observation of the name focus+context visualization is that focus is not in its plural form, foci. In most applications, this might be a natural limitation since users often only work with one object at a time. However, some activities require users to directly compare objects or switch between several different objects very rapidly. As long as a focus+context visualization technique requires explicit user input to change focus between different parts of the visualization, there always exists a small interaction overhead cost, making it more difficult to switch between activities. One way to remove or mitigate this overhead is to allow several foci at the same time or to make it very easy to switch between different foci.

In its original form, Flip Zooming did not allow users to work with several foci in parallel. However, multiple foci were enabled in the Digital Variants Viewer in order to support the comparison of documents. In the PowerCom application, multiple foci were also introduced but were not visualized simultaneously as they represented the different activities the user was switching between, but not performing at once. The RubberSheet view [28] exemplifies another variant of having multiple foci, useful when the user needs to gain more detail from several places within a visualization of continuous information, e.g. a map.

Of historical interest, it should be noted that the idea of polyfocal visualization has actually been introduced before any information visualization techniques were developed for computers [16].

4.1.2. Focus vs. center of Attention. Traditionally, focus+context techniques change focus when a user has selected a new point of interest, in the form of a particular

position on the display or a distinguishable object. However, when the user is performing an activity or task involving other applications, or even people and objects outside the computer, the focus of the visualization does not match the center of the user's attention: while the focus selected by the user in the visualization still is a focus in that it might be close to describing the user's interest, it is not the only focus that interaction designers have to acknowledge in order to create usable technology. In the case of traditional focus+context techniques that have been developed for use on a desktop computer, the difference between the focus of the visualization and the user's center of attention might not have been a great problem, since the PC is usually occupies its users more or less complete attention. However, when designing for mobile users, or for any setting where the environment has to be acknowledged, understanding this distinction might be important.

When working with the PowerView and PowerCom applications, we tried to design with this distinction in mind. Some consequences of this line of reasoning were that several different information types should be presented together, and that every view in the applications should focus on helping the user with a simple task. Looking at related work, Spence and Apperley designed the BiFocal Display [34] as an information visualization technique dealing with a number of different kinds of information more or less simultaneously.

4.2. Context

4.2.1. Differentiable context. When using a hierarchical visualization, the distinction between local and global context and the possibility of many levels in-between, is almost trivial: some pieces of information are more closely related than others, depending on where in the hierarchy they are located. This can be used to create different presentations of the context objects depending on how far from the focus they are located. This is, for instance, used in the Fisheye View [11] and in several graphical focus+context techniques based on distortion, where the distortion increases with the distance from the object in focus (c.f. [18]). However, the activity at hand might also require the user to be able to manipulate how the context is presented.

Focus+Context techniques are based on the assumption that a user needs both overview and detail information. For most activities this is true, but not necessarily all the time. Sometimes only the focus is required to complete a task, sometimes only the context, and sometimes only part of the context. Taking the example of working with pages in a book, just reading a page requires only the focus. To see how many pages the text consists of, or how the pages are distributed in chapters, the whole context is needed but to see where a page is in a chapter only requires the context of the chapter. We define a context as being a differentiable context if one can distinguish and manipulate different parts of the context independently.

Due to the modularity of hierarchical Flip Zooming visualizations, both the Hierarchical Image Browser and the Digital Variants Browser automatically support differ-

entiable contexts. By selecting a full-focus view on the outermost, middle, or inner visualization, the user can effectively zoom in by removing the global context, remove the “middle” context while still maintaining a local and a global context, or remove the local context. The granularity with which the user can manipulate the context using this type of interaction is equal to the depth of the hierarchy. Looking at related work, Sarkar and Brown [27] use a function $G(x)$ to determine where context objects should be placed, giving two examples (based on Cartesian and polar geometric transformations). By introducing variants of these functions with parameters that the user can control, these techniques could be extended to allow the user to modify the presentation of the context in a fashion similar to that found in dynamic queries [30]. However, it is difficult to see how the user would have proper feedback in the visualizations without the introduction of new visual elements, e.g. boundaries, to differentiate between the different parts of the context. Giving the user some form of control over the degree of interest (DOI) function in [12,23] would also enable user-defined context presentations, but would be most beneficial if the context is easily differentiable.

4.2.2. Multiple Views of context. Similar to the point made about focus, the word context is in singular form in focus+context visualizations. This is often intuitive, as the context of something is everything that is perceived to be near it. However, what is near it depends highly on the viewer's point-of-view. Changing the point-of-view may radically change the perception of the context (and the focus) without changing what is the focus of the visualization. Translated to focus+context visualizations, changing the point-of-view becomes the possibility to easily change the whole context, or the presentation of the focus and context, while maintaining the same focus.

The Zoom Browser and the WEST browser both used multiple ways of presenting the same focus and context in order to provide the user with several ways of accessing the information visualized. This was partly because the user could be assumed to need several different ways to solve a task and partly because all information in each individual tile could not be presented clearly at once. The PowerCom applications also used multiple context but for another reason. As it enables the user to rapidly switch between different activities, each represented by a selected object in the application, it is only natural that each of these has its own context. Viewed in this fashion, PowerCom can be described as an application using the personal role manager approach [31].

Although not a focus+context technique, dynamic queries [30] can be used in combination with such techniques to allow multiple views of a context. In this case, the dynamic queries would not be used to filter information but rather to select different view modes of the presentation.

4.2.3. Homogenous and Heterogeneous contexts. Most information visualizations only visualize one type of information, or present different types of information using the presentation visualizing the highest common denominator.

The use of such a homogenous context makes it possible to use the inherent structure of the information, e.g. to sort files and contact lists alphabetically, emails and meetings chronologically, in order to create a structured presentation. By doing so, understanding the context becomes easier and navigating through the information simpler. However, many times one can find different types of information that have a common connection, e.g. an email from a person and the entry in the contact list denoting that person. Presenting such information together as a context creates a heterogeneous context.

As mentioned in the section about focus limitations, both the PowerView and PowerCom application used heterogeneous contexts. The different types are presented and interacted with depending on the specific attributes of the information type. In doing so, they differ from most visualization techniques, which may show different types of information, but either merge all information into one presentation or treat all information as belonging to a more general type that incorporates all types present. In the first case, the interaction is performed by manipulating the presentation as a whole, while in the second case, all objects are interacted with in the same fashion and respond identically. By presenting a heterogeneous context, where manipulating different objects give different results, PowerView and PowerCom allow for a more task-oriented approach to information visualization.

With the PowerCom application, the use of audible information (in the form of phone calls) was introduced as a part of the system. A phone call is quite different from other feedback from the system such as the sounds that accompany error messages, since it is not only a complement to some information already available in visual form but a channel of communication that may or may not be supported by visually presented information. By creating a system that makes use of additional perceptual modes such as hearing, more possibilities are added to what might constitute the focus and the context. This expansion can be seen as a tentative step towards what Card, et al. [8, p. 7] calls information perceptualization.

5. Concluding remarks

Using a number of examples from our own experiences, we have illustrated how methods and principles from information visualization can be applied in novel settings and be made to fit constraints posed by situated computing. It has been our ambition to illustrate two issues that interaction designers will have to face when even more forms of computer use enters the agenda. First, to what extent existing techniques might be applied, and second, to learn more about the existing techniques by using them in new areas of use. As for the first ambition, we have described what modifications had to be made of the Flip Zooming technique and how they turned out. As for the second, we presented a number of preconceptions or premises of focus+context visualizations that seem to have been restricting development of focus+context visualization in novel use situations.

Such premises include the use of one focus only, the use of homogeneous contexts, to consider the interaction between man and computer only and not involve the users environment as a whole, to name a few.

While the applications presented here differ from more traditional focus+context visualizations in some ways, we still think that they qualify as such. While the notion of “focus” and “context” has been given partly new interpretations, this has been in order to pursue the basic ideas of focus+context visualization. In other words, in order to realize the essential ideas of focus+context techniques in new situations of computer use, one must move beyond the traditional notion of focus+context.

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