Perspective+Detail – a visualization technique for vertically curved displays

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ABSTRACT

This paper describes the perspective+detail visualization concept, which extends the conventional overview+detail pattern by adding a perspective viewing area and a further, text-based area containing partial details. Known problems of such extensions are mitigated using a vertically curved display. Our concept aims to bridge both the geographical and the content gap between the two main display areas and to provide an improved overview. An experimental case study based on a typical traffic control room operator task provided first insights on our visualization. These initial findings revealed that perspective+detail assists users in fulfilling their tasks and keeping their orientation in the information space.

Categories and Subject Descriptors

H5.2 [Information interfaces and presentation]: User Interfaces: Input Devices and Strategies.

General Terms

Design, Experimentation, Human Factors.

Keywords

Curved Display, Interactive Surfaces, Map-based Interaction.

1. INTRODUCTION

Large information spaces such as maps including additional detail information (e.g. points of interest) are widespread nowadays. They require special visualization patterns to allow easy and efficient interaction. A visualization technique which supports the exploration of such spaces is overview+detail. This pattern offers two different views of the information: (1) an overview of a particular, mostly scalable area of the information and (2) a detail view showing more details of certain elements located in the information space. While the overview allows rapid navigation through large information spaces, important details can be retrieved in the detail view. Another way to support navigation through large information spaces is based on multiple views using different visualization techniques. One approach to this is the bird's eye perspective used by Lorenz et al. [7]. This visualization provides a simple top-down overview as well as a perspective view of the data (e.g. a map) combined on one single display. On the one hand this enables the user to explore information using two different viewing angles simultaneously (e.g. two-dimensional map information and three-dimensional height information). But on the other hand it leads to an unnatural change of the viewing perspective. The information seems to be bent around a hidden virtual rim, possibly leading to difficulties and errors while interpreting the visualized data.

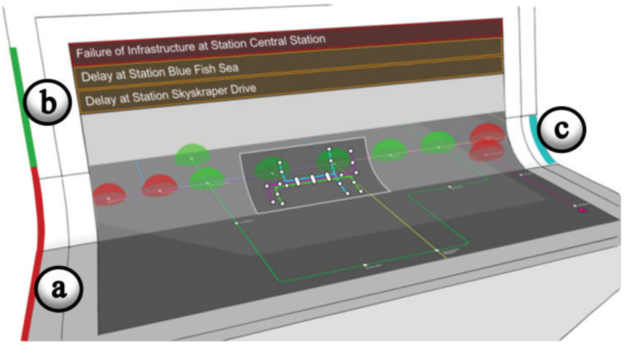

Figure 1: Perspective+detail map visualization: (a) Overview area on the horizontal segment; (b) Detail view on the vertical segment; (c) Head-up display on the curved segment.

In this context we propose *perspective+detail (P+D)*, a visualization technique using a vertically curved display. *P+D* is based on three different interface elements: (1) an overview on the horizontal display segment of the curved display, (2) a detail view area on the vertical display segment and (3) a head-up display (HUD) in the connecting curved segment (see Figure 1). The overview of *P+D* continues the idea of the bird's eye perspective [7]: a three-dimensional perspective extends a two-dimensional overview area. This provides an enlarged field of view as well as a second viewing perspective on the same information space simultaneously. However, using a vertically curved display eliminates the problem of an unnatural distortion of the view: the three-dimensional extension seems to grow naturally into the space behind the display surface (see Figure 1) due to the curved display connection. The detail view and the HUD are seamlessly integrated with this extended overview by a transparent transition in the overlapping areas. In this paper we describe the basic interface design, its implementation and how it exploits the characteristics of a vertically curved display. We also discuss a possible usage scenario for control room operators in the context of traffic surveillance and describe initial insights we gathered in an experimental case study. Finally we discuss some problems which can arise using a *P+D* visualization, and identify areas of potential improvement in the current implementation.

2. RELATED WORK

Our work relies on related work in the area of information visualization and non-standard interactive surfaces. In the first instance it is based on multiscale applications [4] and corresponding visualization techniques such as overview+detail and focus+context (e.g. [1, 11]), of which Cockburn et al. give a comprehensive overview [3]. Other projects improve standard two-dimensional overviews using three-dimensional visualizations to display additional information [6, 10]. A smooth transition between a two-dimensional and a three-dimensional visualization [7] was also the basic concept behind the augmented

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windshield display [5]. By projecting (two-dimensional) navigation information onto a vehicle's windshield which seamlessly blended into the driver's view of the actual road, navigation errors were significantly reduced. Beside this, our work also relies on Benko's description of interactive surfaces [2] – especially the potential application areas for tabletops. Additionally Morris' [8] considerations regarding combination with common desktop displays are relevant for our work. Recently introduced non-planar interactive surfaces [12, 13] even combine a horizontal and a vertical screen into one smooth surface, minimizing the haptic, visual and mental gap between the differently oriented display areas.

3. CONCEPT OF PERSPECTIVE+DETAIL

In this section we describe the basic principle of *P+D* and how it utilizes a vertically curved display to provide a naturally extended perspective view. The basic principle of our approach is similar to the bird's eye perspective [7], where a planar display is used to show a combination of a top-down view and a three-dimensional perspective view of an information space (e. g a map). Even though different perspectives on the same information space can be useful, they can also be confusing due to the unnatural change of perspective on a single planar and merely two-dimensional screen. For this reason we propose using a vertically curved interactive display to (1) seamlessly combine a two-dimensional top-down view with a three-dimensional perspective view (see Figure 2) and (2) integrate important details from the information space.

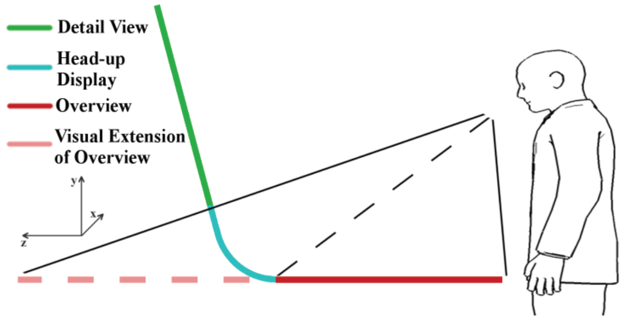


Figure 2: A schema of the P+D user interface: overview, head-up display and detail view.

The differently oriented segments of such a non-planar display help to avoid a break in perspective within the visualization. We refer to this continuous visualization as *overview* (see Figure 2). Following the idea of an overview+detail pattern we combined this overview with an additional *detail view*, which is located on the vertical display segment of our curved display (see Figure 2). Finally we merged both views in the curved segment of the display using a *head-up display* showing a combination of the most important information from the overview and the detail view (see Figure 2). We will describe each of these areas separately to clarify their visualization and interaction capabilities.

3.1 Overview

The horizontal display segment is used for a two-dimensional overview of an information space, or more precisely a particular section of that space (see Figure 1). It allows a very natural visualization similar to a physical map on a table or a conventional two-dimensional map display. To enlarge the overview we extended it using a three-dimensional perspective view located within the curved display segment as well as the lower parts of the vertical display segment. This view is a continuous perspective extension along the Z axis of the two-dimensional overview on the horizontal display segment (see Figure 2). Due to the seamless transition within the curved display segment, this enhanced overview extends the two-dimensional overview without any visual break. Consequently *P+D* offers an overview similar to a large map in the real world: while it allows a top-down view on the information in front of the user, it also offers a natural perspective view on information far away from the user. In addition to this, our perspective extension also offers a visualization of additional three-dimensional information: we use semi-transparent hemispheres placed upon certain points in the perspective extension (see Figure 1). The respective domes help to highlight these points and to enhance the user's attention for problems located in the perspective extension, which otherwise might be missed due to the perspective viewing angle. As the horizontal display segment can easily be reached by a user sitting in front of the display, it is used not only for visualization but also for direct-touch interaction. It supports conventional interaction options such as panning and zooming, which affect the overview visualization including the perspective extension.

3.2 Detail View

The vertical display area is used to visualize details of individual elements located in the information space, as it offers a convenient viewing angle for reading tasks. In contrary to the horizontal display segment, this display area is also suitable for long-term reading in a similar way to common computer displays. The detail view features two different types of detail information: (1) global detail information during interaction with the overview and (2) details about a certain element following selection of that element. Although the overview (including its perspective extension) does not suffer from any occlusion caused by the detail view, this does not necessarily apply to the 3D domes as they arise from the perspective area. Therefore the detail information becomes transparent during ongoing interaction with the horizontal display area, assuming that the user is mainly focused on the overview while performing interactions such as panning and scaling. This reduces possible distractions and occlusions and allows the user to benefit from the visualisation offered by the 3D domes. Additionally we aimed to avoid laborious (touch) interaction on the vertical surface. Consequently the interaction options available there are deliberately limited to simple selection commands initiated by tapping or scrolling through lists by dragging.

3.3 Head-up Display

The third interface element – a semitransparent head-up display – is located in the arc of the curved display. It is superimposed on the three-dimensional extension of the overview, similarly to an HUD in a car or airplane. Our HUD shows information from the overview area as well as some of the details from the detail view. The transparency of the HUD helps users keep their orientation in the perspective overview while simultaneously showing frequently needed detail information. This avoids an extensive use of the more comprehensive detail view. The HUD also includes a miniature map of the entire information space. To ensure correct visualization we developed a specific flashlight metaphor to accurately represent the area visible in the overview (see Figure 5 (a)). The area in the miniature map which is "illuminated" by the flashlight marker hence corresponds to the area in the network plan which is located within the selection area of the HUD.

3.4 Implementation

In order to extend the two-dimensional overview, a texture showing the information space is mapped onto a three-dimensional model using the MT4j framework (www.mt4j.org) (see Figure 3).

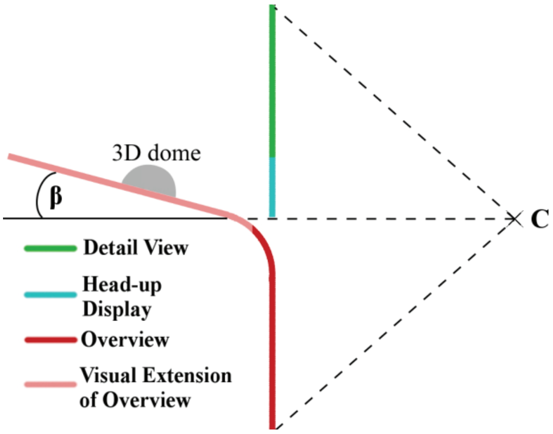


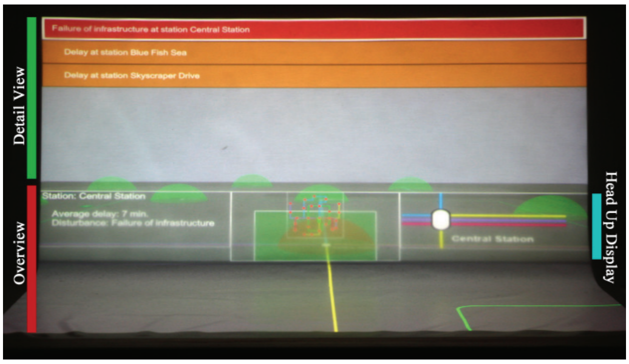
Figure 3: Layout of the implemented 3D scene used for P+D.

The model is bent away from the virtual camera (C) analogously to the surface of the non-planar display. The angle (β) can be adapted depending on the height of the user's eyes and the desired viewing angle. The projection area for the HUD and the detail view is placed above the curved model. Consequently it superimposes the perspective view looking from the camera's position.

4. SCENARIO

In this section we present a possible real-life scenario for a *P+D* visualization. We outline a control room application in the context of rail traffic monitoring, and the possible content of each display area (see Figure 4). We also describe additional interaction techniques implemented in our prototype.

The *overview* area shows an imaginary railway network including stations and differently colored railway lines. 3D domes are placed at stations to heighten awareness of their location and status. Three different colors (green = fault-free; yellow = low-priority fault; red = high-priority fault) support fast recognition and localization of serious faults in the railway network (e.g. a failure of infrastructure).

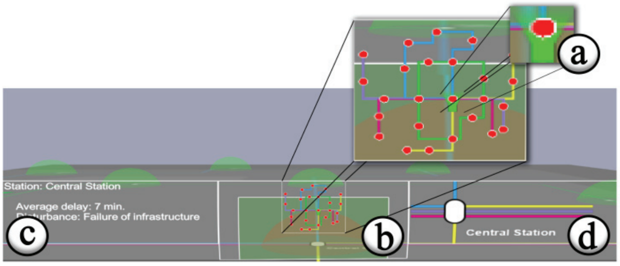


Failure of infrastructure at station Central Station
Delay at station Blue Fish Sea
Delay at station Skyscraper Drive

Station: Central Station
Average delay: 7 min.
Disturbance: Failure of infrastructure

Figure 4: Perspective+detail map visualization.

The *detail view* shows textual information regarding the entire network in the global mode and information on individual stations in the local mode. In the global detail view, which always is displayed when no station is selected, a list of system messages indicates faults and failures in the network. These messages are color-coded according to their priorities, using the same coding as for the 3D domes. If the operator selects a message via a double tap, the overview map automatically scrolls to the corresponding station by means of a smooth animation and selects it. The local detail view of such a selected station (showing e.g. track problems and associated messages) can be opened in the vertical display area using a dragging gesture from the HUD into the vertical display area. It allows the operator to intensively monitor additional information, possible malfunctions and related problems with regard to the selected station. The local detail view will be closed if the operator interacts with the overview area and the detail view grows more and more transparent, becoming totally transparent after 2.5 seconds. This gives the operator an unimpeded view of the railway network in the overview. When interaction in the horizontal display area comes to an end, transparency gradually recedes in the detail view and it becomes opaque again.



Station: Central Station
Average delay: 7 min.
Disturbance: Failure of infrastructure

Figure 5: The three sections of the head-up display with magnified miniature map: (a) Flashlight metaphor; (b) Marker section; (c) Textual information section; (d) Graphical information section.

The HUD in the curved display segment connects the overview with the detail view. It is subdivided into three sections. The center section of the HUD (see Figure 5(b)) serves as a selection marker, whose selection area varies depending on the current zoom level. To select a station using this marker, the operator interacts with the map (by zooming/panning) until the station is within the selection marker. Successful selection is indicated by the selection marker's color turning into a light shade of green. If no station is selected, the selection marker appears completely transparent. Beside this, the center section of the HUD contains a miniature map of the railway network as described in section 3. The left section (see Figure 5(c)) contains detailed text information on the selected station (local context) representing a subset of the entire detailed information available. Our prototype showed the name of the station, the average delay and the reason for disturbance at this station in this section. The right section of the HUD (see Figure 5 (d)) shows a non-distorted top view of the selected station. This two-dimensional projection provides more details of the nearby surrounding area, as it is not affected by any perspective distortion.

5. CASE STUDY

The concept of *P+D* was evaluated in an experimental case study conducted with 12 participants from different occupational backgrounds: one rail traffic control operator, three usability engineers with experience in the context of control rooms and 8 students with a usability engineering background. The main goal was to test whether the extended visualization of the overview supports users in different tasks related to the scenario described above. Therefore we logged the zooming and panning movements made during the study. After being introduced to the different interaction techniques and visualizations, each participant performed six different tasks involving all interaction and visualization concepts. Once a task was finished, the participant's subjective assessments of the visualization were recorded using a questionnaire followed by a semi-structured interview. In the questionnaire several aspects of the visualization were evaluated with the help of 5-point Likert scales. In the report given here, we merged the two best and the two worst ratings (i.e. '(dis)agree' and 'strongly (dis)agree') for a better comparability.

Analysis of subjective data revealed that 11 out of the 12 subjects rated the basic visualization concept as understandable. Additionally, 9 subjects affirmed that *P+D* gave them the feeling of constantly having all information in view. All participants affirmed that the 3D domes in *P+D* were helpful to them in keeping their orientation on the network plan. This also became evident during the test itself, in which 9 subjects pointed out the positive effects of the domes without being asked. The information on the HUD appeared to be particularly helpful: 10 subjects affirmed that the miniature map overview had assisted them in keeping their orientation on the network plan. Furthermore, the mechanism for selection using the HUD was rated 'understandable' by 11 subjects. Another observation was that subjects found it easy to identify the shortest route to the next target point if that point lay within the perspective extension. This observation was confirmed both by subjects' statements and by analysis of the interaction paths recorded during task completion. Another aim of the case study was to obtain the subjects' assessments of basic aspects concerning the realization of the concept on the curved display. 11 out of the 12 participants rated touch interaction as useful for this kind of application. Related work reports touch interaction on vertical surfaces as being significantly more exhausting than it is on horizontal ones [9]. We have accordingly designed a short and selective interaction concept on the vertical part of the display. Consequently, we could not identify any major differences in arm fatigue after our study, which took between 60 and 90 minutes. Only five participants rated touch interaction on the vertical plane as slightly more laborious than on the horizontal area, whereas 11 subjects stated that touch interaction on vertical and horizontal displays at the same time is acceptable. The dragging gesture to open detail views of a specific station was performed without difficulty by 10 out of the 12 participants, according to their self-assessment.

6. CONCLUSION AND FUTURE WORK

In this paper we presented *perspective+detail* – an enhanced overview+detail visualization which seamlessly adds a perspective extension using a vertically curved display. This extension, in combination with a virtual and partly transparent head-up display, eases the assimilation of large information spaces. We described the basic concept of *P+D* and reported initial findings made in a preliminary case study. Particularly the HUD, as the logical link between the two main display areas, turned out to be an important aid to orientation within the information space. Not only did the use of 3D domes mitigate perceptional difficulties due to perspective distortion in the extended overview; the color coding of the domes and the textual detail lists actually also made it easier to detect potentially severe problems. Moreover, the logged navigation paths gave evidence of improved user orientation: users shortened their paths while following rail tracks if the next turns in the track were visible within the perspective extension of the overview.

One problem of *P+D* is that a natural feeling of perspective can only be attained when the user is sitting in a central position in front of the display. A seating position at the outer edges of the display results in severe perspective problems across the entire display. An automatic reconfiguration of the underlying 3D model (see Figure 3) along the X (horizontal) and Y (vertical) axes based on head/position tracking data collected from the user could mitigate this problem. Such integration of an optical tracking system would need very precise calibration to avoid unintentional reconfiguration while also achieving a very fast response time. Though this solves the problem for one user our current P+D implementation is not suitable for a co-located multi-user workspace.

Building on this initial investigation, a further study involving a two-dimensional implementation as control condition could provide more statistical insights. It may show how strong the positive effects of the perspective extension are compared to a common system. Another interesting aspect for a future user study is the general evaluation of the 3D domes and their impact on interaction and task processing time using *P+D* and three-dimensional information spaces in general.

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