Perifoveal Display: Combining Foveal with Peripheral Vision in one Visualization

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Figure 1: *A user is standing in front of the Perifoveal Display. Two depth cameras track the user's head direction. At the focal point more detailed information is shown. The data becomes increasingly abstracted the further away it is from the user's focus. In the periphery changes in brightness and movement indicate changes in the data and these can be perceived by the user.*

Abstract

The Perifoveal Display (cf. Figure 1) is a visualization display for complex, real-time, dynamic data such as stock market data or control room data. The system takes advantage of the unique properties of the human perceptive system which is capable of perceiving a high degree of detail in the foveal area, but is only perceptive to movement and black and white in the peripheral area. The Perifoveal Display varies how data is visualized based on the user's viewing direction. Data in the center of the user's focus are displayed in a lot of detail using color. Important changes in the data which fall into the periphery are highlighted by movement and change in brightness. As such the system is able to attract the user's focus towards data in the periphery that are in need of attention.

1 Introduction and Motivation

The human eye has a relative small focus area –the foveal vision– and a huge range of out of focus space –the peripheral vision. Within the line of sight –the focus– we can see complex shapes, sharp contours, colors, and we can read text. Images that fall into the periphery are blurry but we can detect sudden changes and fast movements. This helps us to react to much more information than we are focusing on and consciously aware of. The Perifoveal Display takes advantage of these human perception characteristics for visualizations of complex data such as stock markets, network traffic, and hospital. The motivation is to help users keep track of large amounts of data and help them react more efficiently to sensitive data changes. Previous work on attention in display design [Baudisch et al. 2003] predefines a detailed area on the display to which a user can drag content for more information. We combine this zooming capability with an ambient display such as the ambientROOM [Ishii et al. 1998] in which a user can keep track of information in her periphery through color, movement or sound.

2 Implementation and Conclusions

The Perifoveal Display system consists of four monitors that are arranged around the user and two consumer depth cameras. The system could easily be expanded to a larger number of displays such as a video wall. Each depth camera tracks the user's head and head direction in front of its two monitors. The space is calibrated so that the monitors are defined in relation to the camera. The head direction estimation is performed by the algorithm presented in [Fanelli et al. 2011]. This results in a head pose and direction estimation in the camera space. Ray-plane intersections lead to a pixel position on the monitors which is used as focal point.

In our prototype we visualize stock market data. The individual stocks are aligned in a grid on all four screens. In the focal area each individual stock is color-coded based on its current trend. Red meaning the stock falls, green meaning the stock goes up. Using a quad tree structure data points are summarized the more distant they are from the focal point. The color fades away until there is only grayscale information. If a data point changes in the periphery the corresponding rectangular area changes its brightness (white-the stock goes up, black-the stock goes down). Additionally, an animation of a circle moves around the changed data point to attract the user's attention.

We performed an informal user study in which we asked subjects to keep track of changes in the data and to assess their cognitive load using the Perifoveal Display as well as visualizations with less peripheral highlighting. The evaluation suggests that there is an advantage using the Perifoveal Display for tasks where a user has to keep track of a high amount of real-time data. Our results show that a user perceives a lot of stress when using the full detail everywhere display, whereas the Perifoveal Display guides the user to data changes which gives a safe and more relaxed feeling.

References

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