The Effect of Using Large, High-Resolution Stereoscopic Displays for Flow Visualization (Sap_0583)

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Abstract

We report on a pilot experiment to explore the effects of display resolution, size, and viewing distance on three-dimensional flow visualizations. Participants performed three common flow visualization tasks using streamtubes, pathlines, and particle flurries on a rear-projected stereo display. Results show that participants favor high-resolution displays, although the display preference depends on the properties of the dataset. When interacting with the flow datasets, participants tend to place them at locations where they could see the whole dataset without losing context.

1 Introduction

With ongoing advances in display hardware and rendering algorithms, physically large high-resolution (pixels per inch or PPI) stereo displays have become more accessible in scientific visualization. Since visualization is not limited by the size and resolution of the display, it is of interest to determine how visualization tasks benefit from these high-resolution large stereo displays. Much previous work has found that large display size alone improves task performance and can generate better situational awareness and presence [1]. One reason is that larger sizes increase the *hardware field of view* (FOV, the angle subtended from the eye to the left and right edges of the display screen), freeing users from relying on navigation aids in 3D environments. This also theoretically applies to high-resolution displays, where more information per unit increases the *software FOV* (the angle of the viewing frustum). In addition, high resolutions beyond visual acuity are often needed on stereo displays [2].

By contrast, additional pixels can increase the amount of information to be displayed. Information-processing theory suggests that such displays may increase mental workload and reduce the amount of visual information human can understand. Most of these debates on screen resolution are based on intuition rather than an understanding of the tasks and applications from specific application requirements. In response to this lack of experimental evidence in three-dimensional (3D) stereo environments, we examine the effects of resolution and its associated parameters (size and viewing distances) for flow visualization.

2 Evaluation approach and results

In general, we wanted to learn how a high-resolution large display would affect users' task performance in 3D stereoscopic environments. As a secondary focus, we wanted to learn whether users would change their behavior while using different displays and whether the display characteristic imposed requirements to design new visualization methods.

The following independent variables were used: display size (small using 1 panel, large using 9 panels), resolution (low about 60 PPI, high about 120 PPI), viewing distance (close and far), and visualization methods (streamtubes, pathlines, and particle flurries). A 3x3 tiled stereoscopic display was used in this study. The highest screen resolution was 2400 x 1800 and set to a dot pitch of 0.331mm. The size of the 9-panel display was 184 cm x 132 cm. Three types of tasks were: (1) counting task (e.g., how many coincident points are there in the polylines?) (2) flow direction task (e.g., what is the direction of the flow?) (3) analysis task (e.g., can you tell if the pathlines and the stream tubes follow the same direction?). Two participants volunteered for this pilot experiment.

Results from the two participants were divided. They preferred the high-resolution displays and commented that stereo viewing helped in completing their tasks. One participant was a flow expert and preferred to view all visualizations using the small display, whilst the novice user preferred the large display. The expert participant liked the small display because information presented in the large format was overwhelming and required more visual scan efforts. On a small display with high resolution, everything was clearly showing in his vision, so accomplishing tasks became effortless. This could also be because participant's familiarity with the dataset did not require him to examine the data in fine details. Thereafter, accomplishing identification tasks was easy. In addition, the tasks only required understanding the global structures. Neither participant preferred the condition where visual information was displayed beyond the physical boundary of the display. They moved the data to a view where they could see the overall dataset and then performed the task.

Participants preferred a close viewing distance with the small display and a farther distance when using the large display, disregarding other factors. This is understandable because the image falling onto the retina remains the same even when the display sizes changed. The results also suggested that users might have difficulty locating known items or comprehending the data because of the loss of peripheral information and the simplicity of the tasks and datasets we used.

3 Conclusion

When screen resolution and size are no longer obstacles, it is important to understand that interpreting displays of huge information could well be beyond human cognitive and perceptual ability. This pilot experiment examined the parameter space for evaluating large high-resolution displays for flow visualization applications. The study suggested that resolution may be more prominent than size in terms of users' preference, perhaps because high-resolution displays allow more information to be displayed in the users' focused vision. The study may also suggest that a proper use of large displays is to show small multiples.

References:

[1] Tan, D.S., Gergle, D., Scupelli, P.G., and Pausch, R., "Physically large displays improve path integration in 3D virtual navigation tasks", *SIGCHI*, 439-446, 2004.
[2] Ware, C., Information visualization: perception for design, Morgan Kaufmann, 2000.

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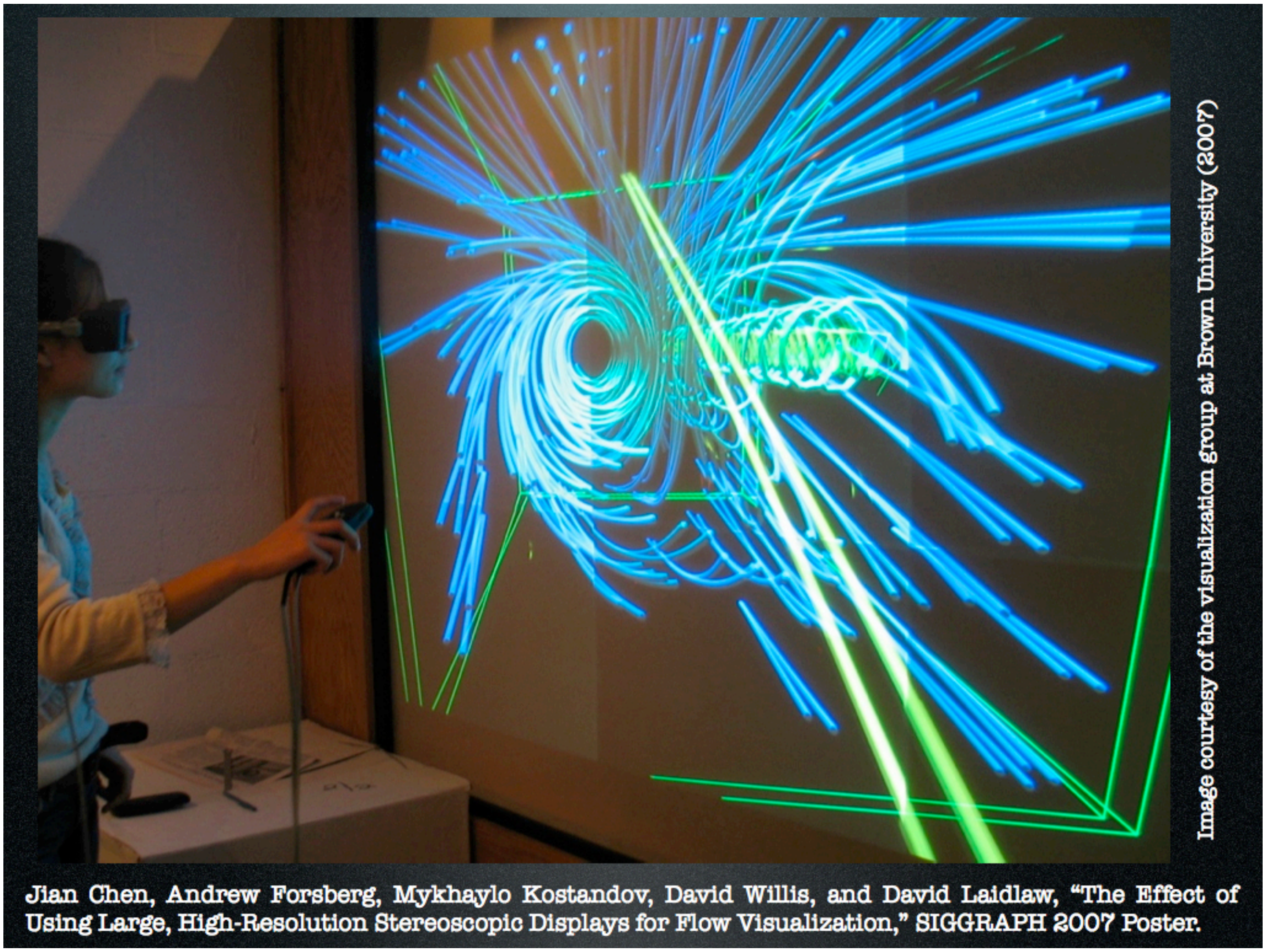

Figure 1. A user interacts with a high-resolution display to examine a flow structure