High-Resolution Displays Facilitating Greater Insight in a Dynamic Environment

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ABSTRACT

This paper discusses the outcome of an experiment that tracked the navigation and performance of participants as they played a popular strategy game on one, four, and nine monitors. The results show that having only one monitor was a clear disadvantage in both performance and the percent of time participants navigated. Participants performed significantly better on the four and nine monitors than the one monitor due to increased awareness and insight into the game. Also, the larger the display, the less participants navigated. There was also found to be a *positive* transfer from the smaller to larger screens, but no transfer (positive or negative) from the larger to smaller screens.

Keywords: high-resolution, insight, awareness

1 INTRODUCTION

This paper attempts to show how large, high-resolution screens help people gain greater insight into a dynamic geospatial environment. In order to simulate such an environment we used a real-time strategy game. The game we used is Wargus, an open source game based on WarCraft®II. WarCraft®II was a popular strategy game in the mid to late '90's developed by Blizzard Entertainment. WarCraft®II is a game based on gathering resources, building up forces, and attacking and destroying enemy forces. Participants were told that they were playing on WarCraft®II and could not tell a difference between the real game and Wargus. Figure 1 shows an example of Wargus being played on the nine monitor configuration.

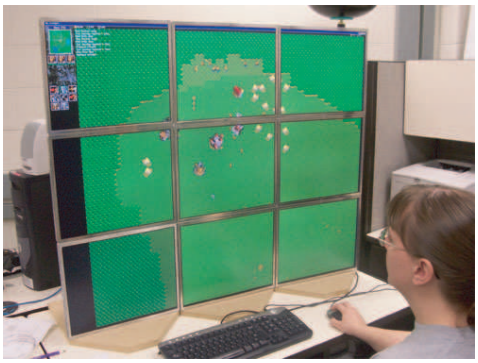

Figure 1: Example of Wargus being played on nine screens at a resolution of 2400x1800.

We held 12 tournaments with three participants at each tournament for a total of 36 participants. Each participant played three games on each of three different monitor configurations: one monitor, four monitors, and nine monitors. We performed a full factorial design where all monitor orderings were completed six times. In other words, each participant played at each monitor once and after six participants we completed a full factorial of monitor orderings.

By modifying the open source game engine that was designed to play Wargus, we were able to add code that tracked user navigation and performance as well as modify the source to allow larger resolution sizes.

The purpose of our study was to evaluate the usefulness of high-resolution displays when dealing with a dynamic environment in a geospatial setting. Based on the results from [2] [5] and [3] our hypothesis was that the score would be highest on the nine monitor configuration. We anticipated that navigation would be the most on the one monitor configuration and the least on the nine monitor configurations due to increased awareness and insight. Based on [1] and [4] we anticipated that participants would prefer the larger configurations.

For the experiment we used three computers. The first computer had one monitor (see figure 2.a). The second computer had four monitors that were tiled together in a 2x2 matrix on a stand (see figure 2.b). The third computer had nine monitors that were tiled together in a 3x3 matrix on another stand (see figure 2.c).

Figure 2: a) One monitor configuration - 640x480 resolution (games's native resolution). b) Four monitor configuration - 1600x1200. c) Nine monitor configuration - 2400x1800.

Figure 3 shows approximately the difference in resolution of the one monitor configuration to the nine monitor configuration.

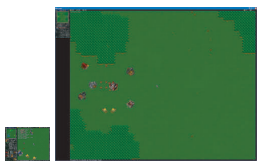

Figure 3: a) One monitor screen shot at a resolution of 640x480 (game's native resolution). b) Nine monitor screen shot at a resolution of 2400x1800. The screen shots are place beside each other at approximately the right size ratio.

2 Navigation and Score

There appears to be a correlation of score to display size. With a statistical significance of $p < 0.01$, we found that score statistically varied by display size. The average score on the one monitor was 2207, 2659 for the four monitor configuration, and 2790 for the nine monitor configuration.

This improvement of performance due only to a larger viewport size is important in that it has implications for not only the information visualization community, but for normal life as well. For geospatial dynamic environments, these results could be used. For example, surveillance and tracking of people or aircraft, traffic control, military usage, etc.

We also found that the amount of time spent navigating differed among the different sized resolutions. With a statistical significance of $p < 0.0001$ we found that participants navigated less the larger the resolution. Figure 4 shows a summary of percent of time navigating in the game based on monitor size.

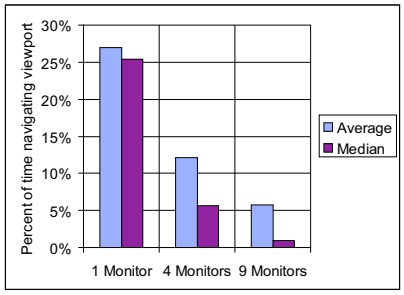

Figure 4: This graph shows approximately what percent of the time participants spent navigating the viewport of the map.

3 Positive and Negative Transfer

We also found that there was a *positive* transfer when participants went from a smaller monitor configuration to a larger monitor configuration and a no positive or negative transfer when participants went from the larger monitor configuration to a smaller monitor configuration. For example, if a participant went from a smaller monitor configuration to a larger then on average his score would increase by 508 points. However, going from a larger monitor configuration to a smaller monitor configuration had little to no effect as participants would generally increase their score by only 2 points.

4 Insight

As can be seen from figures 2 and 3 the larger the display, the more data can be seen. On the display each graphic represents some piece of data. The green trees represent how much more wood is available to be used. Each building showed the capacity to build a special unit. Each unit represented how much force, or might, could be employed to attack another base and so on.

Each graphic represents to the players some piece of information that they needed to quickly analyze and then use to attack their opponents. As mentioned, the larger the display used the less navigation occurred as more of the battlefield could be seen at once. Looking at figure 5 one can seen two overview shots of the same battlefield. The left figure shows how much of the battlefield is viewable by the one monitor as indicated by the outlined rectangle. For reference, the rectangle is at the top left corner of the overview. In comparison, the figure on the right shows how much of the battlefield is viewable by the nine monitor display.

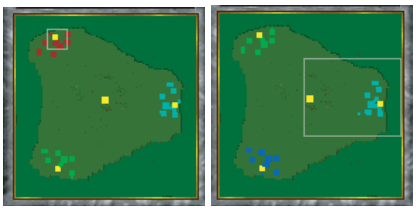

Figure 5: a) One monitor overview b) Nine monitor overview. The outlined rectangles in the overview shows how much of the map the user can see. The one monitor configuration sees only 5% of what the user on the nine monitor configuration sees.

By spending less of their time on navigating and more of their time on actually understanding the battlefield and gaining insight into the current situation, participants on the nine monitor display were able to outperform the one and four monitor displays.

In fact, 90% of participants agreed that the nine monitor configuration helped them become more aware of the overall battlefield. The larger configuration gave participants greater insight into the entire map and were able to create better strategies that helped them receive a higher game score.

For example, participants on the four and nine monitor configurations would defend their base against enemy units advancing towards them. However, participants on the one monitor configuration would generally be more reactive in that they would not defend their base until enemy units had already attacked them as they would not see enemy units until they were very close to the base.

Participants on the larger displays were able to plan global attack strategies that involved attacking enemy bases on several sides, planning better resource harvesting strategies, and being able to better estimate the force of any defending or attacking enemy. These strategies were only possible due to the increased view of their data allowing the participants more time to actively analyze their data and create better strategies.

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