# Poster: Collaborative Data Exploration Using Two Navigation Strategies


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## Abstract

Virtual collaborative systems are vital tools for accessing and sharing scientific data visualizations. This paper shows how two different modes of collaboration can affect user performance in a specific exploration task. Experiments with groups of users that are working in pairs showed that the lack of mobility can affect the ability to achieve specific exploration goals in a virtual environment. Our analysis reveals that the task was completed more efficiently when users were allowed to move freely and independently instead of working with limited mobility. In these systems, users adapted their own abilities and minimized the effect of mobility restrictions.



**Keywords:**, HCI, usability, evaluation, scientific visualization.

**Index Terms:** H.5.3 [Group and Organization Interfaces] : Computer-supported cooperative work; H.5.2 [User Interfaces] Evaluation/methodology


## 1 Introduction

For years scientists have used scientific visualization techniques to gain insight into complex datasets and models. Scientists can infer and find relationships among phenomena relying on the human visual system rather than computerized analytical techniques. These systems have helped to build better drugs, to find global economic trends, or to predict the weather. But modern discoveries are no more made by single individuals because complex scientific projects often demand the collaboration of several specialists.

This paper explores scientific visualization and its relation to virtual collaborative systems. Virtual collaboration is necessary for visualization analysis for many reasons:

- Complex systems require the skills of several experts in different knowledge areas.
- It is not uncommon to use supercomputers or other specialized hardware to run simulations that produce large amounts of data for visualization. It is thus better to make the visualization close to these resources or at the very least closer to the data from which it comes from.
- Reliance on experts in the same geographical area is often difficult, and it is thus more practical to provide mechanisms for remote data exploration.

For these reasons, the discipline of Computer-Supported Cooperative Work (CSCW) has emerged [1]. Visualization systems of the type this paper is dealing with have adopted different ways of enabling collaborative work. These ways lead to different architectures that allow users to collaborate in different modes. It is our belief that a good understanding of these modes of collaboration are of great importance when choosing which architecture to deploy in a distributed environment.

For this study, a minimal visualization system was built that allowed to recreate an environment used by scientists working in fluid mechanics. A series of tests were performed on two collaborative models, and we investigated which mode of collaboration was more efficient for an exploration tasks.

## 2 Experiment Description

The architecture of the collaborative system is a client-server one. Clients send control commands to handle (start/end) the session and interactive commands (virtual camera views and tracker movements) to the server. The server receives the commands, takes care of session life cycle, and forwards commands to the session members.

The interaction takes place on the client side. Users are allowed to move the virtual camera, not only the position but also the view direction. A pointing mechanism is also provided. If users find something that deem important, they can use an electromagnetic tracking device to move an arrow close to the area of interest, making it easy for others members of the collaborative session to see it.

Figure 1. User interacting with the system

Users interact with both hands. One hand is used to move the virtual camera using the keyboard, the other is used to move the tracker (see Fig. 1). The Skype video-conference system is used for oral communication during a collaborative session. In a collaborative session, different colors serve to distinguish other the arrows of different members, and a long vertical line, pointing to the sky, is drawn to help users find their partners from a distance.

A visualization of a dataset obtained from a simulation created by the Mechanical Engineering Department at EAFIT University


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was used to create the virtual world that users explored and shared. The visualization shows the direction and magnitude of the wind over the Aburrá Valley (the valley where EAFIT University is located). The terrain of the valley is presented and attributed with small cones glyphs representing the direction and magnitude of the wind. Cones with different colors made it easy to identify places of low (blue) and high (red) wind velocity.

### 2.1 Task Description

Users worked in pairs to find places of high wind velocity. A region was considered found when the arrow "touched" it, indicating that the avatar was close enough to the target position. An audio signal and a semitransparent sphere, that enclosed the cone position, provided feedback to the users and helped them track the cones that had not yet been visited. Each team completed two tasks, using one of two different modes of collaboration:

1. Master-slave (MS): In this mode of collaboration, one user played the "master" role, and the other the one the "slave" role. Both users could use the tracker to point, but only the master could move the virtual camera. Both users thus shared the same point of view, and the slave was limited to exploring the virtual world through master's eyes.
2. Free: In this mode, both users were free to move independently through the virtual space.

A warm-up session at the beginning of the experiment allowed users to become familiar with the system. To compensate for learning effects, two datasets (A and B), with goals (red cones) positioned in different places, were used for each experiment.

A task was considered complete, when all goals had been reached. Each goal reached by a member was added to the total score, so it was not necessary for each member to find every goal.

### 2.2 Evaluaion Criteria

Two metrics were used to capture performance:

1. Task Completion Time (TCT): This is the time spent from the beginning of the task until all goals have been achieved.
2. Trajectory Length (Length): This is the sum of each user's traveled distance from the starting point in the virtual world until the task is completed.

## 3 Results and Discussion

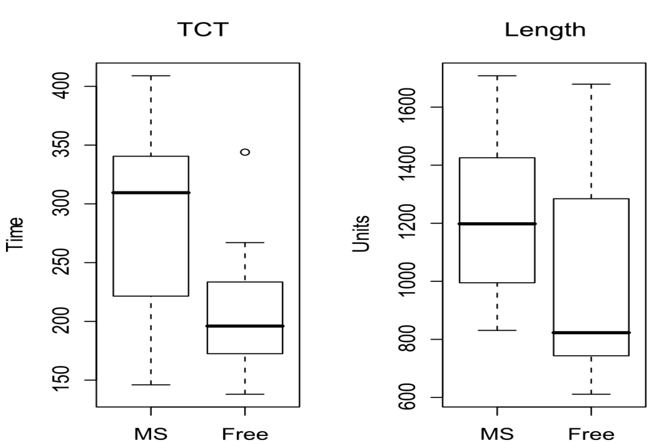


Figure 2. Boxplots for Tct (left) and Length (right) comparing groups MS and Free.

Twenty-four people, working in twelve pairs, were chosen among students and assistants of the faculty. This sample size is comparable to similar experiments described in [2,3].

The boxplot in Figure 2(left) summarizes the observed TCT values for both collaborative modalities, MS and Free. A paired t-test yielded a significant difference between groups MS and Free, $t(11)=3.0$, $p<0.05$. The boxplot in Figure 2(right) summarizes the observed Length for both collaborative modalities. A paired t-test yielded only a marginally significant difference between groups MS and Free, $t(11)=2.0$, $p=0.076$.

An analysis of subjects' behavior in the Free condition revealed that they tended to ignore goals (red cones) when goals visibility was poor (e.g. when they were displayed in a corner of the screen or were partially occluded by other cones). These attentional difficulties can be blamed for the fact that subjects had to put a lot of effort into handling the interface with both hands. This was not an issue in the MS condition, where one member of the team did not have to move the camera, and because both members were exploring the same area at the same time. Ignoring goals made subjects go round in circles and forced them spend more time and space to find the goals. In contrast, the dynamics of MS condition was more predictable (despite being less efficient). The old turtle and rabbit fable provides a metaphor for the two conditions, the Master-Slave mode is slow but steady like the turtle, whereas the Free mode is fast and unpredictable like the rabbit.

## 4 Conclusions and Future Work

We have explored how different collaboration schemes affect the performance of users in virtual collaborative visualization systems. The experiments support the hypothesis that, when working in group of two, it is more efficient to explore and find regions of interest, when each user is free to move and look around independently (Free mode), than when only one of the members of the team steers the task.

Nevertheless, some observations revealed that users did not care much about limitations imposed by the collaboration modes, and found a way to achieve the objectives.

Large differences between Free and Master-Slave conditions were observed when both members of the team were skilled with the keyboard and the tracker, but this difference began to disappear as the skills of the members improved. In this case, the Master-Slave mode allowed users to specialize their work according to their abilities. One of them could move rapidly using the keyboard, and the other could find regions of interest and select cones with the tracker. In an ideal situation, the Master-Slave mode can be considered to be a more efficient mode.

This "gray area", in which the Master-Slave collaboration mode can be more efficient for exploration than the Free mode deserves further study. In Master-Slave mode, clients have the same point-of-view, and the implementation of a collaborative system can thus benefit from video streaming, rather than transmitting datasets or geometry. This could save substantial bandwidth, improving the possibilities for real-time Virtual Collaborative Environment applications.

## References

[1] Brodlie, K.W., Duce, D.A., Gallop, J.R., Walton, J.P.R.B., Wood, J.D.: *Distributed and Collaborative Visualization*. *Computer Graphics Forum*. 23, 223-251 (2004)

[2] Casera, S, Nageli, H.-H., Kropf, P: Collaboration in Scientific Visualization. In: *The 12th International Conference on Computer Supported Cooperative Work in Design CSCWD 2008*. Xian, China (2008)

[3] Gutwin, C., M. Roseman, and S. Greenberg: A usability study of awareness widgets in a shared workspace groupware system. In *Proceedings of ACM CSCW'96*, p. 258-267, Boston (1996.)