Analysis of Evacuation Traces

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ABSTRACT

We describe the tools and techniques used in our analysis of the VAST 2008 Challenge regarding the evacuation traces based on the data from RFID tags [1]. We applied visual analytics to explore and describe the evacuation caused by an explosive device. That included identifying casualties, witnesses and suspects. We used ComVis tool and its multiple linked view capabilities, including PathView visualization, to show positions and paths of all persons in one view. CommVis facilitated better collaboration among team members due to its ability to capture the context and state of visual analysis (views, brushes) for a given data set.

Index Terms: I.3.0 [Computer Graphics]: General—; I.3.6 [Computer Graphics]: Methodology and Techniques—(Interaction techniques);

1 INTRODUCTION

In this paper we describe analysis of the traces dataset provided for the VAST 2008 mini challenge. The dataset consists of positions of people in a hospital, just before and shortly after an explosion. All people were tracked, and for each person, the position as two dimensional coordinates on a cell map is given for each time step. In total, there are 836 time steps and 82 people in the dataset. A map of the hospital is also given in a bitmap format. We have analyzed the dataset using a coordinated multiple view tool and identified suspects and injured persons. We have also detected some interesting facts about the evacuation and spotted a problematic area in the hospital.

2 DATA AND TOOLS

We have mapped the given data to a data model which contains families of mappings as described in [1]. For each person we have computed the path as a series of cells over time. Furthermore we have computed the cumulative path length for each person as a function of time and speed in each time step as function of time as well. This gave us a data table which has 82 rows (one for each person) and four columns: Person ID (scalar value), path, cumulated path length, and delta way (all three are time series, position, path, and step as function of time). In order to analyze such a dataset we have used ComVis, a coordinated multiple view system developed at VRVis. ComVis supports conventional views for scalar values, and few special views for families of function graphs. We have used path view and curve view extensively. All views are linked and the user can brush in one view and corresponding items will be highlighted in all other views. Besides single brushing, ComVis supports composite brushes using boolean operation in an iterative manner. Brushing in the curve view is realized by a simple line which selects all curves that cross it.

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[1] http://www.cs.umd.edu/hcil/VASTchallenge08/

The path view supports a background map and arbitrary paths of various lengths. In order to analyze our data set we have extended the path view slightly. We have added an animated mode so we can watch the persons' movements. We display the path as a poly-line with a small circle at the end. There is an option to display just a limited number of the last steps. In this way a trailing line is drawn behind the spot. The length of the trailing line indicates the speed – the longer a trailing line is, the faster a person is walking. This is visible on static images as well. Figure 1 (left view) shows a path view showing the complete paths. Only the last 10 steps are shown in the middle view) and the curve view on the right depicts cumulative path lengths over the time.

While ComVis is (still) a single-user application, it has the ability to capture the state of the visual analysis session (brushes, views, etc.) and store it (together with the data being analyzed) in a single file (`.cvv` file). Such files can be exchanged among collaborators to provide the common context and framework for visual analysis. ComVis made it possible for our team members located in Vienna (Austria), Zagreb (Croatia), and Blacksburg (USA) to better leverage regular communication channels (audio/video conferences, workshops) using the common visual analysis context captured in a `.cvv` files.

3 INTERACTIVE VISUAL ANALYSIS

We have analyzed the data using ComVis. The animation feature of the path view has proven to be extremely helpful. Cumulative path lengths depicted in the curve view show some interesting patterns on the first sight (Figure 2. We can clearly see some curves which are increasing from the early time steps. These curves represent persons which were moving around at this time. Persons which are staying in the same cell have a zero value for this period of time. Interestingly some of the persons which are walking in the beginning continue to move to the very end (constantly increasing path). Two persons were moving in the beginning and stopped after some time. A large group of people starting to move around time step 375 indicates a sudden event which caused almost everyone to move. The bomb went off at this moment and alarm was issued. It triggered the movement. There are persons who managed to find the exit faster, and some which continue walking to the end. There is also a small group of people which started to move and then stopped, and persons with IDs 18 and 36 who hardly moved at all. Simple brushing in the curve view allows us to see corresponding paths. Of course, we can brush the paths in path view and see corresponding curves in curve view, as well.

3.1 Suspects and Casualties

We have brushed interesting groups of curves as described above and developed some hypotheses. Although the person moving most (ID 29) exhibits unusual behavior, we do not think she/he is a suspect but rather a medical employee working in the hospital and she/he just had to walk around. We have then selected a group of people which moved very little. Some of them did not move at all, and some stopped the movement shortly after explosion. We have used animated path view to further examine this cases.

It seems the device was set off at position 66,32 because many people near this spot stop moving shortly after the incident. We assume that these people are dead or at least unconscious. Shortly before the incident, a person walks into this room, waits from time

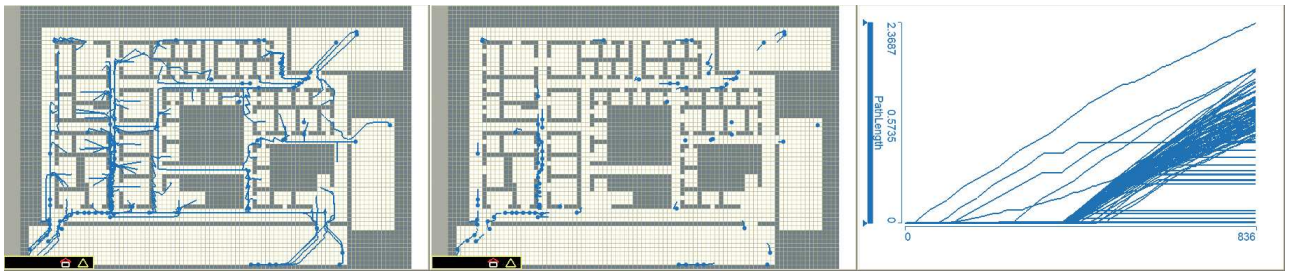

Figure 1: A combination of PathView and curve views. The first PathView (left view) shows the complete paths, the second PathView (middle view) shows the last ten steps of the paths while the curve view (right view) shows cumulative path lengths over time

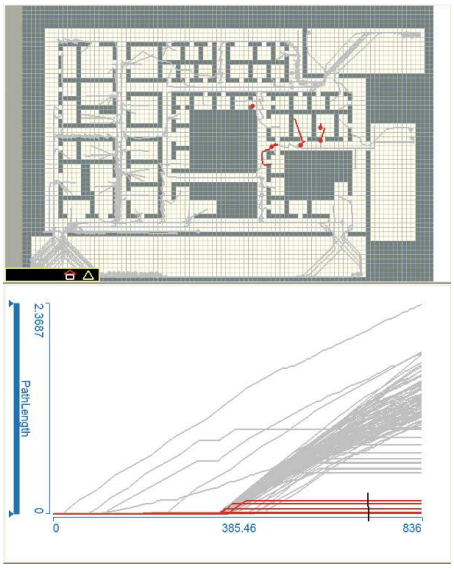

Figure 2: Pathview (upper view) shows traces near the explosive device, including the current position—timestep 487 (red dots) and last ten steps (trailing lines). Curve view (bottom view) shows a time-series visualization of the path lengths of all people. Horizontal lines represent people that do not move. The traces with very short path lengths, all of them are near the bomb site indicate casualties.

Figure 3: Situation during the evacuation (timestep 588). The suspect (orange) has already escaped. The traces with no movements near the explosive device indicate casualties. Some people (light green) manage to escape, but from one moment on, people (red) turn around, and stop moving soon (due to fire, debris) and since they do not move we can assume that they die too. People far away from the explosive device survive but since the half of the hallway seems to be blocked (dark green). Some even turn around and try to find another way out (purple).

step 243 to 280, and walks out again. The grid cell where this person paused could be the place of the bomb. Furthermore this person also does not leave the building immediately, but waits for person 1 to leave first, because being the first one outside may be suspicious. Unless this was a suicide attack, we think that this person – person 21 has placed the bomb. Interestingly our suspect walks much slower than all others and walks a very straight path.

By broadening the brush a little bit, we can include some additional people with short paths, leading us to further conclusions. Most casualties occur near the bomb, and only our suspect is able to escape the building. Person 36 does only move one step from time step 243 to 244. This person either died or lost his or her RFID Tag. Person 59 moves back into the building, probably he or she forgot something important and tried to fetch it. From time step 693 on the person does not move any further, so he or she probably died.

3.2 Evacuation

We have examined overall evacuation as well Figure 3). The evacuation was quite civilized, with the exception of the lower left corner. These persons were not really endangered by the explosion, but this area was very crowded, and some part of the hallway seems to be blocked. Therefore some people changed their mind and chose another route on the far left some people even changed their mind twice. This is also the area where two people that were already near the exit turn around and go back.

Another interesting behavior can be observed in upper right corner. We suppose there is a group of seriously injured people here or, if not, some unusual behavior is present. Persons with ID 3, 20, 37, and 65 were in the same room. Two of them started evacuation a little bit earlier. Interestingly, one of them, ID 65, stopped moving earlier and did not manage to leave the hospital. He was close to the door and returned. Similar behavior at the same spot (coming close to the door and going back, and then stopping) was observed for several more ID (23, 65, 78, 69,) Since some people leave the building there, some others turn around and run into the opposite direction we suspect fire or a collapsed wall has blocked the exit.

4 Conclusion

We have organized the data in such a way to allow the use of multiple coordinated views, the PathView and curve view. The combination of the PathView and curve view proved to be the key technique to successfully analyze the data. Brushing in the curve view (cumulative path lengths) clearly identified different categories of traces.

References

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