Analysis of Movements with Geospatial Visual Analytics Toolkit

Natalia Andrienko, Gennady Andrienko

Fraunhofer Institute IAIS (Intelligent Analysis and Information Systems), Sankt Augustin, Germany

ABSTRACT

The Geospatial Visual Analytics Toolkit intended for exploratory analysis of spatial and spatio-temporal data has been recently enriched with specific visual and computational techniques supporting analysis of data about movement. We applied these and other techniques to the data and tasks of Mini Challenge 4, where it was necessary to analyze tracks of moving people.

CR Categories and Subject Descriptors: H.1.2 [User/Machine Systems]: Human information processing – Visual Analytics; I.6.9 [Visualization]: information visualization.

Additional Keywords: Movement data, spatio-temporal data, aggregation, scalable visualization, geovisualization.

1 INTRODUCTION

The Geospatial Visual Analytics Toolkit includes a large number of tools for exploratory analysis of spatial and spatio-temporal data. It combines visual techniques (various methods for cartographic representation, scatterplot, histogram, parallel coordinates, time graph, time histogram, table view, etc.), interactive facilities (brushing, querying, filtering, classifying, manipulating visualization parameters), data transformation tools (computation of derived attributes, aggregation, summarization and others), and some methods of data mining. Recently we have developed a number of new techniques specifically oriented to movement data, i.e. sequences of recorded positions of discrete moving entities. We were very interested to test these new techniques by responding to Mini Challenge 4, where tracks of moving people needed to be analyzed.

2 OVERVIEW OF THE ANALYTICAL TOOLS

A map display with controlled animation and a space-time cube (STC) are traditionally used for visualization of movement data; see a review in [1]. They proved very useful in our exploration of the evacuation traces. The animation is done by means of an interactive time filter, which affects not only the map but all currently open views. We also applied traditional interactive techniques such as brushing, interactive grouping and classification, attribute-based filtering in Dynamic Query style, and spatial filtering by "spatial window", i.e. a selected rectangular area in space.

Besides these traditional tools, we used some of our new methods including spatial clustering of trajectories [2][3], dynamic aggregation of movement data by predefined areas (in particular, by grid cells), computation of derived attributes of trajectories (in particular, path lengths for selected time intervals), and automated detection of possible interactions between moving objects. The dynamic aggregation techniques are described in our regular paper in the VAST'08 proceedings.

http://geoanalytics.net/and

LEAVE 0.5 INCH SPACE AT BOTTOM OF LEFT COLUMN ON FIRST PAGE FOR COPYRIGHT BLOCK

3 ANALYTICAL PROCESS

We started with an overview of the temporal development of the situation by means of an animated map and STC. We found that all but a few people present in the building were staying in their rooms without movement till approximately moment 372. At this moment, a few more people started moving, and in the following moments the number of moving people continuously increased. It was hard to ascertain the exact moment of the evacuation start by means of only visual techniques. We used the function for computing path lengths by specified time intervals. The results were visualized by means of time graph and time histogram. We found that the first significant change of the number of moving people occurred in interval [372,373] (Figure 1). Hence, 372 could be taken as the moment of evacuation start; consequently, the explosion occurred before that, i.e. latest at moment 371.

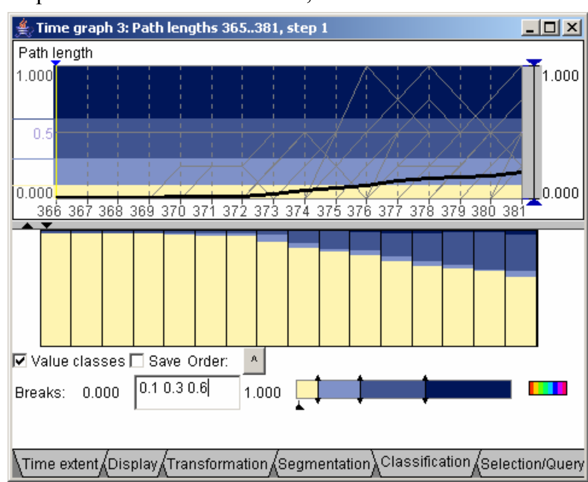

Figure 1. The time graph and time histogram visualize path lengths by 1-unit time intervals from [365,366] to [380,381].

Our search for the probable place of the explosion was based on the premise that it should be in the area where people were most seriously affected and could not move or stopped moving soon after the explosion. We set the time filter to the interval [372,837]. The approximate area was easily identifiable on the map (by containing very short tracks) and in the STC (as a base of a bunch of long vertical lines signifying constant positions of people).

To determine the position of the explosion more precisely, we set the time filter to the interval [1,371] and considered all movements that occurred before the explosion in the identified area. The map showed us that only Ramon Katalanow (N21) moved within this area and left it shortly before the explosion.

We considered and refuted the hypothesis that the bomb could be set off by one of the affected people (casualties). All but one casualty were able to move for a short time after the explosion, which means that the explosion could not happen exactly in the location of one of these people. The only person who did not move after the explosion (as well as before it) had an isolated position with respect to all other casualties. The explosion could not occur in this position as there was an unaffected person between it and the positions of the other casualties. Only one casualty moved before the explosion, but this was outside of the explosion-affected area and on its periphery whereas the bomb was, most probably, set off somewhere in the middle of the area.

The only remaining possibility was that N21 set the bomb and left the area; hence, the bomb was in one of the cells passed by N21. The most probable location should be close to the positions of the casualties who stopped moving earlier than others. These were N18 and N50, located in one room (they could not get out of this room after the explosion). N21 visited this room before the explosion, but it is not very probable that he put the bomb inside it because N18 and N50 could see this. He could rather put it in the corridor near the room. We used a suitable technique to compute the amounts of time N21 spent in each of the cells he passed. The computation is done for the subset of movement data currently selected by means of all active filters; the results are automatically updated when the selection changes (we call this technique "dynamic aggregation"). We visualized the computed variable "Max duration of stay" (Figure 2). Using the time filter and map interaction, we found that N21 spent 14 time units in the cell 67×31 in front of the door of the room of N18 and N50 before starting to move out of the area; in each of the following cells he spent only from 6 to 8 time units. We concluded that the cell 67×31 is the most probable location of the bomb.

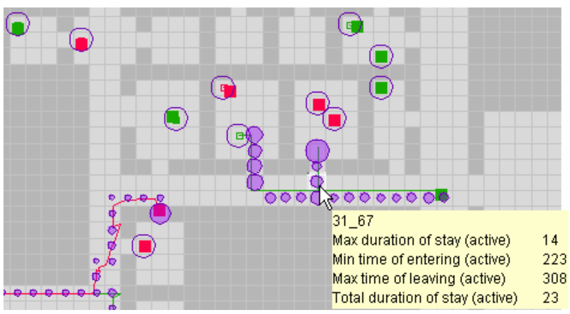

Figure 2. The graduated circles portray the computed maximum durations of staying in grid cells by people who passed them.

Then we analyzed the process of the evacuation. On the map, we found four major destination areas near the outer walls of the buildings, which we interpreted as exits or safe places. The traces of people who did not reach any of these areas were well detectable by the positions of the squares marking the ends of the traces. We detected a group of 5 people who stopped moving between moments 581 and 621 closely to each other. These could not be direct victims of the explosion that happened before moment 372: first, quite much time passed since that, second, many people successfully reached a safe place after moving through the area where these 5 persons stopped. Hence, it is very probable that some secondary incident happened in that area between moment 550, when the last "successful" person left it, and moment 581, when the first of the 5 persons stopped.

We were interested if there were contacts (interactions) between the survivors and the supposed victims of the secondary incident in the explored area. We used the computational technique that finds positions in different trajectories such that the spatial and temporal distances between them are within given thresholds. We took 1 as the spatial threshold and 0 as the temporal threshold. The STC in Figure 3 shows the movements and interactions that occurred in the area before and shortly after the possible time of the incident. The interactions are shown by gray lines connecting corresponding points from two trajectories. We see that some survivors interacted with one of the casualties (N60); moreover, in the course of one of the interactions N60 changed the direction of movement to the opposite. This was an interaction with N28, whose behavior after leaving the area was suspicious: N28 did not join the other survivors but moved to a separate place. We think that N28 might cause the secondary incident.

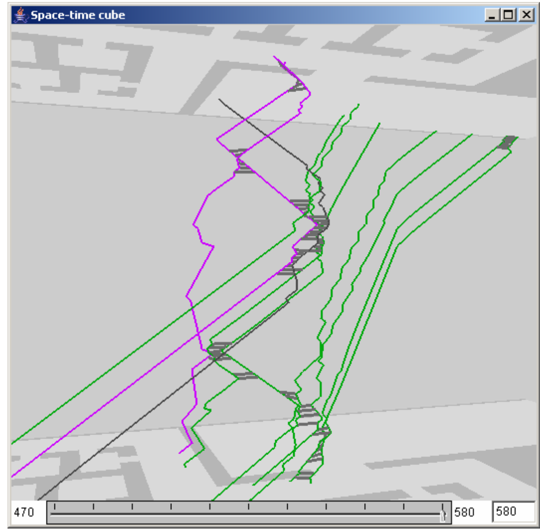

Figure 3. Tracks of supposed casualties (pink) and survivors (green and dark gray); gray horizontal lines signify interactions.

We also explored the fate of the other people who did not arrive to any of the main safe places and found plausible explanations.

4 Evaluation

The specific techniques we designed for visualization and analysis of movement data proved to be appropriate to the data and tasks of Mini Challenge 4. The possibility to use them together with more generic techniques available in our toolkit was beneficial.

We observed that the visual and interactive tools were first of all useful for getting overviews and generating hypotheses. The computations were often used for achieving higher precision e.g. in determining the moment of evacuation start, the moments when casualties stopped moving, or the cell in which the suspect spent more time than in the others. We also found that it would be very hard to detect and analyze possible interactions between moving objects without the use of computational extraction. Clustering, on the opposite, was not very expedient because the dataset was quite small and the clusters were easily identifiable visually.

Among the visual tools, the map display controlled (animated) through the time filter was used more intensively than STC. Most often we used STC for cross-validating patterns detected with the map. STC was generally more usable and useful when we looked at subsets of tracks resulting from filtering rather than the whole set. The only type of analysis where STC proved to be superior to the map was the analysis of interactions. We also found that STC is often superior to the map in presenting findings as it explicitly includes time, which is absent in a static snapshot from the map.

Acknowledgement: the work has been done within the ongoing EU-funded project GeoPKDD (http://www.geopkdd.eu).

References

[1] Andrienko, N., Andrienko, G., & Gatalsky, P.: Exploratory Spatio-Temporal Visualization: an Analytical Review. Journal of Visual Languages and Computing, 14 (6), 2003, 503-541

[2] Andrienko, G., Andrienko, N., & Wrobel, S.: Visual Analytics Tools for Analysis of Movement Data, A*CM SIGKDD Explorations*, 9(2), 2007, 38-46

[3] Rinzivillo, S., Pedreschi, D., Nanni, M., Giannotti, F., Andrienko, N., & Andrienko, G.: Visually–driven analysis of movement data by progressive clustering, Information Visualization, 7(3), 2008 (in press).