Interactive Visual Analysis of Animal Trajectories in a T-Maze

Rainer Splechtna, *Member, IEEE CS*, Fabrizia Bechtold, Christiana Winding,
Michael Balka, and Krešimir Matković, *Member, IEEE CS*

Abstract— A T-maze represents one of the standard experiments used in animal behavioral studies. After a sequence of runs is conducted the trajectories of individual animals are analyzed. In this paper we describe how we plan to deploy interactive visual analysis to analyze a whole ensemble of animal trajectories. We plan to extend our current solution used for open field studies by answering specific requirements in a T-maze setup. We present the first design of the Gate-O-Gon, a new view which will be superimposed on a T-Maze in order to show overall direction characteristics. We also describe directions of future work.

1 Introduction

Behavioral studies of animals provide a better understanding of neural mechanisms, underlying learning processes, various physiological processes, or the influence of drugs or medical interventions, for example [2]. Findings from such studies also lead to a better understanding of similar human processes, and eventually to better medical care.

One kind of study in behavioral science uses T-mazes. A T-maze is a simple maze consisting of T-shaped segments. It has been used since the early 20th century. The T-mazes are used to study rats' memory and spatial learning. Figure 1 illustrates the T-maze used in our experiments. A maze plan is depicted on the left, and a trajectory of one rat is superimposed in the right image. The animals are placed in the start field and they are tracked until they reach the end field (or until the time limit expires). There are 7 gates between the start and the end, each having a wrong (red lines in the figure) and a right (green lines in the figure) branch. A video tracking system is used to record the animals' trajectories. The current state of the art analysis methodology proposes to evaluate each trajectory separately, and then to analyze the results. In our previous work [6] we showed how interactive visual analysis can help in comprehending trajectory ensembles from an open field experiment with an object placement task. We focused on the whole ensemble, not on the results from evaluations of individual trajectories. A very positive feedback from domain experts motivated us to continue the research and to extend it to the T-maze data. This short paper describes the work in progress. We describe the basic idea and the first design ideas motivated by specific tasks in T-maze experiments.

Visual analytics [3] is "the science of analytical reasoning facilitated by visual interactive interfaces" [8]. Interactive visual analysis allows the user to interact with the data, receive immediate visual feedback, and, by doing so, to better understand the data. Coordinated multiple views (CMV) [7] represent one of the commonly deployed techniques in visual analysis. Linking and brushing – selecting a subset of items in one view and highlighting corresponding items in all other views – is a basic technique when deploying CMV. We use our CMV system ComVis [5] which supports composite iterative brushing, as well as an advanced data model. The data model allows, besides usual scalar items, time series and trajectories as basic items in a record. In our previous work [4] we described such a data model, the related interaction, and the analysis tasks identified; as well as views for depicting time series data. Andrienko et al. [1] describe visual analysis of movement data combining interactive visual displays, cognition, and reasoning with database operations and computational methods.

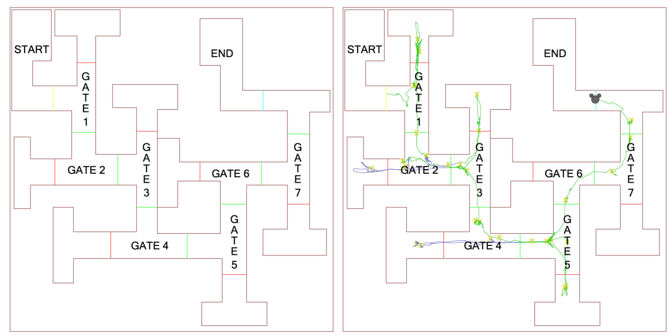

Fig. 1. **Left.** A T-Maze plan as used in our studies. Every gate has a right (green line) and a wrong direction (red line). At each gate the animal has an identical view to the right and to the left. **Right.** A trajectory of one run superimposed. The green trajectory corresponds to movement towards the end. Movement towards the start is depicted as purple trajectory. Small yellow crosses are drawn every 5 seconds and show the animal's speed.

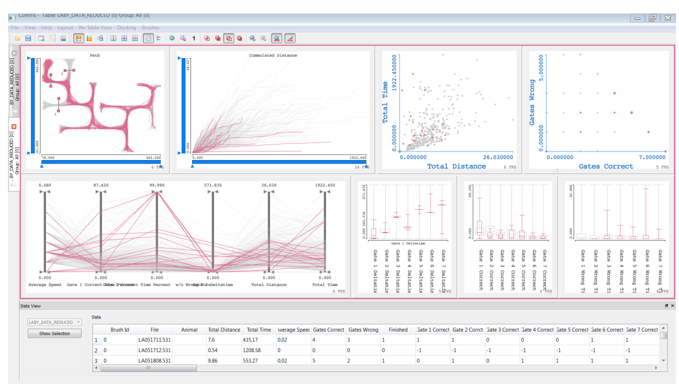

Fig. 2. A screenshot from an analysis session using currently available views. The top left view shows all trajectories (400 runs). The second view in the top row shows cumulated path length for each animal. Note that curves have different length, animals need different times to finish the task. The scatterplot views, parallel coordinate views and the box-plot views show different parameters.

- *Rainer Splechtna is with VRVis Research Center in Vienna, Austria. E-mail: Splechtna@VRVis.at.*
- *Fabrizia Bechtold is with VRVis Research Center in Vienna, Austria. E-mail: fabrizia.bechtold@hotmail.com.*
- *Christiana Winding is with University of Veterinary Medicine, Institute of Laboratory Animal Science, Vienna, Austria. E-mail: Christiana.Winding@vetmeduni.ac.at*
- *Michael Balka is with University of Veterinary Medicine, Institute of Pathophysiology, Vienna, Austria. E-mail: Michael.Balka@vetmeduni.ac.at*
- *Krešimir Matković is with VRVis Research Center in Vienna, Austria. E-mail: Matkovic@VRVis.at.*

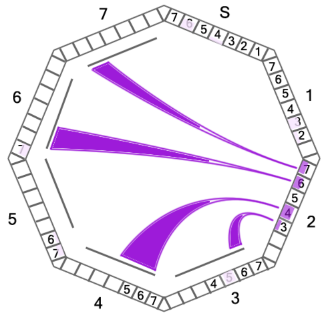

Fig. 3. A Gate-O-Gon for gate 2 showing how many animals heading in the wrong direction have already reached gates higher then 2. Distribution is shown as a histogram on the edge and as purple leaves. The length of each straight leaf edge corresponds to the number of trajectories. Distributions for other gates are shown as histograms only using a lighter color. Different configurations are allowed (not shown) which depict finer subdivisions of leaves.

2 T-Maze Ensemble Data and Analysis Tasks

Our study was conducted in a T-Maze which has an overall size of 1.4×1.4 meters. Each animal is placed in the maze from Monday to Friday for three runs each day. In the following week, the experiment is repeated on Friday only. The first week tests the short term memory, and the repetition in the following week tests the long term memory. Animals are tracked using a video camera in a infrared lit room. There is a reward (food) in the end section.

After the trajectories are collected, numerous parameters are computed for each run. Among others, the following values are computed: the times an animal spent in each gate, number of right and wrong decisions, total time and distance, etc. If an animal crosses the right gate first, the gate is considered to be passed correctly. Note that it is possible (and quite common) that animals turn back, and after passing one gate correctly, cross the wrong gate line. Still, such a gate is considered to be passed correctly as the first decision was right. Another interesting parameter is the time an animal spends in the overall wrong direction. If gate 5, for example, was already passed, all times the animal spends in gates 4, 3, 2, 1, and START are considered to be times in the overall wrong direction (Figure 1 purple parts of the trajectory). The times spent in each gate area are computed separately for each direction (towards end and towards start). Statistical evaluation of these times, and of all other parameters, can solve many questions. However, interactive visual analysis offers new possibilities and enables the exploration of the whole ensemble at once.

The data we are dealing with consists of one record for each run. We have about 400 runs resulting from one study. Each record contains scalar values, such as, animal ID, total time, total distance, number of gates passed correctly, number of gates not passed correctly, and many more scalar attributes, as well as the trajectory of the animal, and the distance traveled as a function of time. As analysis is done a posteriori we can easily compute all parameters and overall direction of an animal at any point in time.

3 Interactive Visual Analysis

Currently we can explore the data using the system used for the open field data [6]. Figure 2 shows a snapshot from an analysis session. Analysis possibilities are much better then using conventional approach only. Showing all trajectories and having the ability to select subsets using simple line brushes (as in Figure 2, where we excluded all trajectories which ever entered the wrong area in gates 1 and 2), offers analysis possibilities that were not available up to now. However, we would like to further improve the analysis. One of the key differences compared to the open field studies is the overall direction of an animal. We would like to show not only if the animal is heading in the wrong direction, but how far it already had gone. It is not the same if the animal passed the gate 6, e.g., and then returned to the starting area, or if it passed only gate 1 and returned immediately. For animals that are moving in the wrong direction we would like to show how many individual gates they have passed already.

In our case we have 6 gates and the start area where animals can run in the wrong direction. Note that experiment stops as soon as the animal enters the end area, so the animal can never be in the area of gate 7 while moving in the wrong direction. We define the gates as n_i, where $i \in 0, 1, 2, \ldots, 8$, and $i = 0$ and $i = 8$ for the start and the end area. We also define the already maximum reached gate as R, $R \in 1, 2, \ldots, 7$. For each gate n_i where an animal is moving in the wrong direction we can identify R. We are interested in the distribution of R for each gate. Note that we know that animals entered gate n_i from gate $n_i - 1$ or $n_i + 1$, but we want to know how far the animal already had gone.

We plan to depict the distribution per gate in the maze itself. We will place a new diagram showing distributions of R for each gate. We call the new digram the Gate-O-Gon. Figure 3 shows the current design. At gate 0 (starting area) the values of R can go from 1 to 7, at gate 1 the values can go from 2 to 7, and so on. At gate n_i the values of R can go from $i+1$ to 7. The polygon edges of the Gate-O-Gon will be connected depending on the number of available connections. Every gate will have its own Gate-O-Gon showing the connections of the gate. The Gate-O-Gon can also be depicted separately, as a view consisting of multiple small Gate-O-Gons or histograms can be used instead. A table with numerical values for the number of connections will also be provided. The Gate-O-Gon depicts the number of connections in a gate, or only in a correct or wrong area. It will be fully linked with other views, and as the user drills down, the Gate-O-Gon will show the current selection in focus and all others as context.

4 Conclusion

In this paper we describe a new idea how to improve the analysis of animal trajectories ensembles. In a close cooperation with domain experts we plan to introduce the Gate-O-Gon, a novel visualization which supports exploration and analysis of many trajectories. The important questions of animal direction in particular gates and the previously archived furthest point in case of the wrong direction will be easily answered. Our previous success of applying interactive visual analysis to the open field data indicates the usefulness of the newly proposed approach. We plan to finish the design of the Gate-O-Gon and to conduct a comprehensive evaluation with domain experts.

5 Acknowledgments

The authors thank prof. Hermann Bubna-Littitz from University of Veterinary Medicine in Vienna. Part of this work was done in the scope of the K1 program at the VRVis Research Center.

References

[1] G. L. Andrienko, N. V. Andrienko, P. Bak, D. A. Keim, and S. Wrobel. *Visual Analytics of Movement*. Springer, 2013.

[2] H. Bubna-Littitz and J. Jahn. Psychometric testing in rats during normal ageing. procedures and results. *J Neural Transm Suppl*, 44:97–109, 1994.

[3] J. Kohlhammer, D. A. Keim, G. Santucci, G. Andrienko, and M. Pohl. Solving problems with visual analytics. In *The European Future Technologies Conference and Exhibition 2011*. Procedia Computer Science, 2011.

[4] Z. Konyha, K. Matković, D. Gračanin, M. Jelović, and H. Hauser. Interactive visual analysis of families of function graphs. *IEEE Transactions on Visualization and Computer Graphics*, 12(6):1373–1385, 2006.

[5] K. Matkovic, W. Freiler, D. Gracanin, and H. Hauser. Comvis: a coordinated multiple views system for prototyping new visualization technology. In *Proceedings of the 12th International Conference Information Visualisation*, pages

[6] K. Matkovic, C. Winding, R. Splechtna, and M. Balka. Interactive Visual Analysis of Ethological Studies: Getting Insight from Large Ensembles of Animals' Paths. In *EuroVA 2012: International Workshop on Visual Analytics*, pages 85–89.

[7] J. C. Roberts. State of the Art: Coordinated & Multiple Views in Exploratory Visualization. In *Proc. of the 5th International Conference on Coordinated & Multiple Views in Exploratory Visualization*, 2007.

[8] J. J. Thomas and K. A. Cook. *Illuminating the path: The research and development agenda for visual analytics*, volume 54. IEEE, 2005.