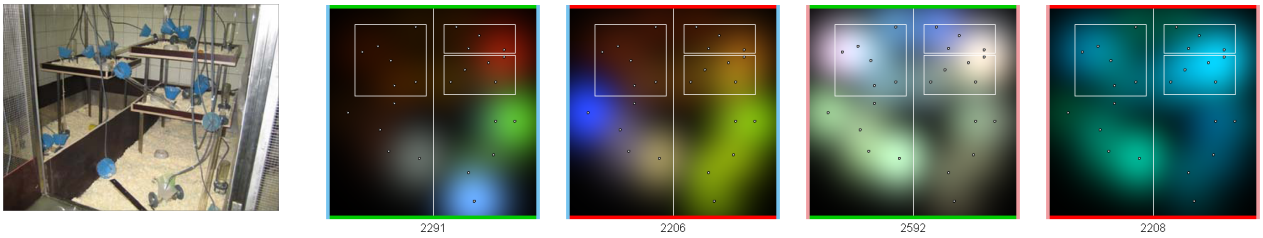
Northern Lights Maps: Spatiotemporal Exploration of Mice Movement

Halldor Janetzko Florian Mansmann Peter Bak Daniel A. Keim



1 Introduction

Alzheimer's disease is known to alter the behavior and memory capacities. In order to get a better understanding of behavioral changes biologists conducted an experiment with 22 Alzheimer-transgenic and 61 healthy mice using RFID sensors to track their movement in a cage (see picture above) over a time period of several months. The principal research question is, whether there are significant differences between the movement patterns of healthy and Alzheimer-transgenic mice. The photo on top shows the multi-level cage used in the experiment. It is equipped with 27 strategically placed RFID receptors that log mice activity when they come closer than 3 centimeters to the receptors. Since this kind of logging only results in discontinuous event data, we need to compute lower bound properties of the travel distances of each mouse rather than analyzing a complete path of its movement.

In general, spatiotemporal visualization is a challenging research field. While traditional two-dimensional maps are familiar to most users, extending their representation to more than three dimensions (position x & y, color) becomes a real challenge. Recent research proposed to use the third spatial dimension to represent time, but thereby introduce new usage challenges, such as the ambiguous position of a point in a 3D representation when viewed on an ordinary computer screen.

This paper proposes a technique called *Northern Lights Maps*, which visualizes both, temporal and geospatial aspects of the data. We show a two-dimensional top view of the cage and use the RGB - channels to visualize the temporal information of sensor events. The user has therefore a visualization of the whole life span of a mouse at a glance and can, for instance, see territorial behavior.

2 Our Approach

The spatial location of the sensors was mapped to a two-dimensional schematic representation, keeping their relative location at their approximate position. The temporal aspect of movement was extracted by knowing relative age of the mouse at the time of the movement. For a fair comparison, we used the first three months of movement data from each mouse. Each of these three months was mapped to colors using the three channels of the RGB-color system. The red color channel was used to reflect movements in the first, green in the second, and blue in the third month. The intensity of movements at a sensor was measured by the number of times a sensor was triggered. This information was mapped on top of the RGB-coloring by combining it with a gray-scale reaching from black (rare movements) to white (frequent movements), resulting in the color mapping model in Figure 1. Two examples of combining RGB colors to express the temporal occurrence of movements are shown on the right in the same figure.

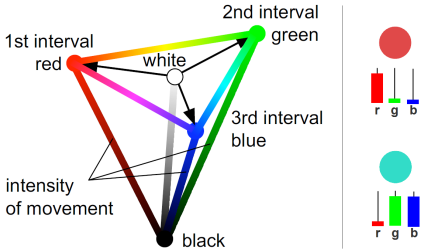


Figure 1: *Channels of the RGB-color scale are used to map temporal properties of mice movement. The resulting colors, when frequent movement occurs mostly in the first interval (upper), and when moves are mainly during the second and third intervals (lower), are shown on the right.*

However, since only one single colored pixel at the screen coordinates of each of the 27 sensor nodes would be drawn, a a low pass filter – in this case an Gaussian filter with a large filter kernel – was applied to enhance visibility and comparability of the maps.

The next step of the analysis is trying to determine territorial behavior as a function of gender and the healthy/transgenic category. For analyzing this kind of parameters, each mouse is represented in a separate Northern Lights Map. We found significant gender differences and some indication for behavioral differences between healthy and transgenic mice. Male mice show more intense colors. It is seemingly hard to distinguish between healthy (e.g. mouse 2291 on top of this page) and transgenic male mice (2206) because both display intense colors. Additionally, mouse 2291 has a interesting movement pattern: its life began at the top right side in the cage and it moved clockwise to the bottom right as seen by red, green and blue colored areas of the cage. Female healthy mice (2592) show no clear concentration of movements in one location, but rather movements all over the cage at all the life-intervals, which is shown by mixed colors (white) at all locations. As opposed to female healthy mice, female transgenic mice (2208) have a tendency to move intensively within one particular life-interval, which is indicated by the appearance of one intense color throughout several sensor nodes.

Overall, insightful analyses are made possible, when interpreting the representations in detail. Also, recognizing individual preferences and behavior patterns open new analysis possibilities and unveils novel research questions.

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