Explorative Analysis and Visualization of Large Information Spaces

Universität Konstanz

Analysing neurobiological image data

Martin Strauch

1 Background

The olfactory system of insects is a popular model for studies on signal perception, classification and memory formation. Using optical imaging techniques we measure combinatorial patterns of activity in neuronal units called glomeruli. These patterns are code-words which correspond to an odorant stimulus perceived by the insect. We present an image analysis pipeline [2] for the automatic extraction of these code-words from numerous datasets, enabling future research on the properties of this natural code.

2 Methods

- CCD camera data shows changes in intracellular calcium concentration and thus neuronal activity (Figure 1 left).
- Using ICA [1] we detect independent components (see inlay) that correspond to the visible objects. We then construct a map of the observed brain region (Figure 1 right).

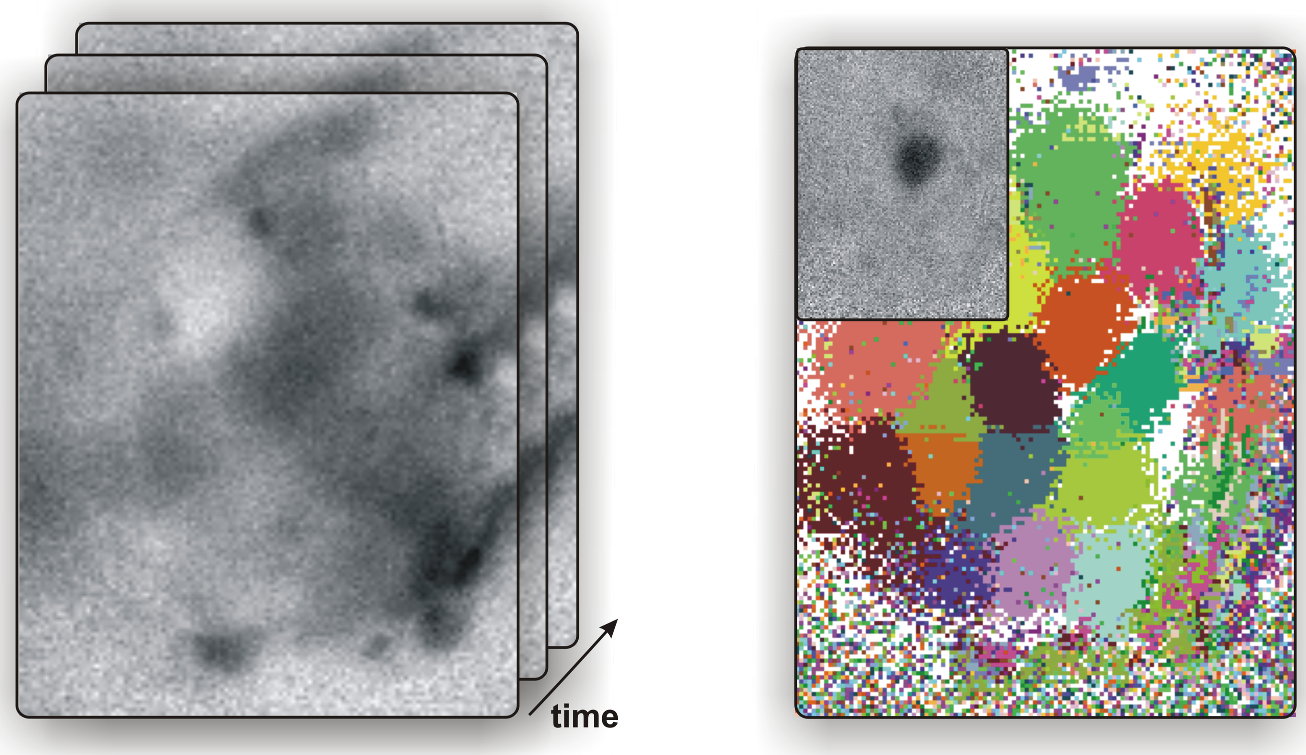

Figure 1: Constructing a map of the relvant brain region from noisy video data.

- We filter the map according to size and shape criteria, thus effectively reducing noise and discarding non-glomerulus objects.
- To identify the glomeruli we search for the best projection of the map onto an anatomical reference atlas. Atlas and map are transformed into topological graphs. We then aim at finding the best approximation to a subgraph isomorphism.

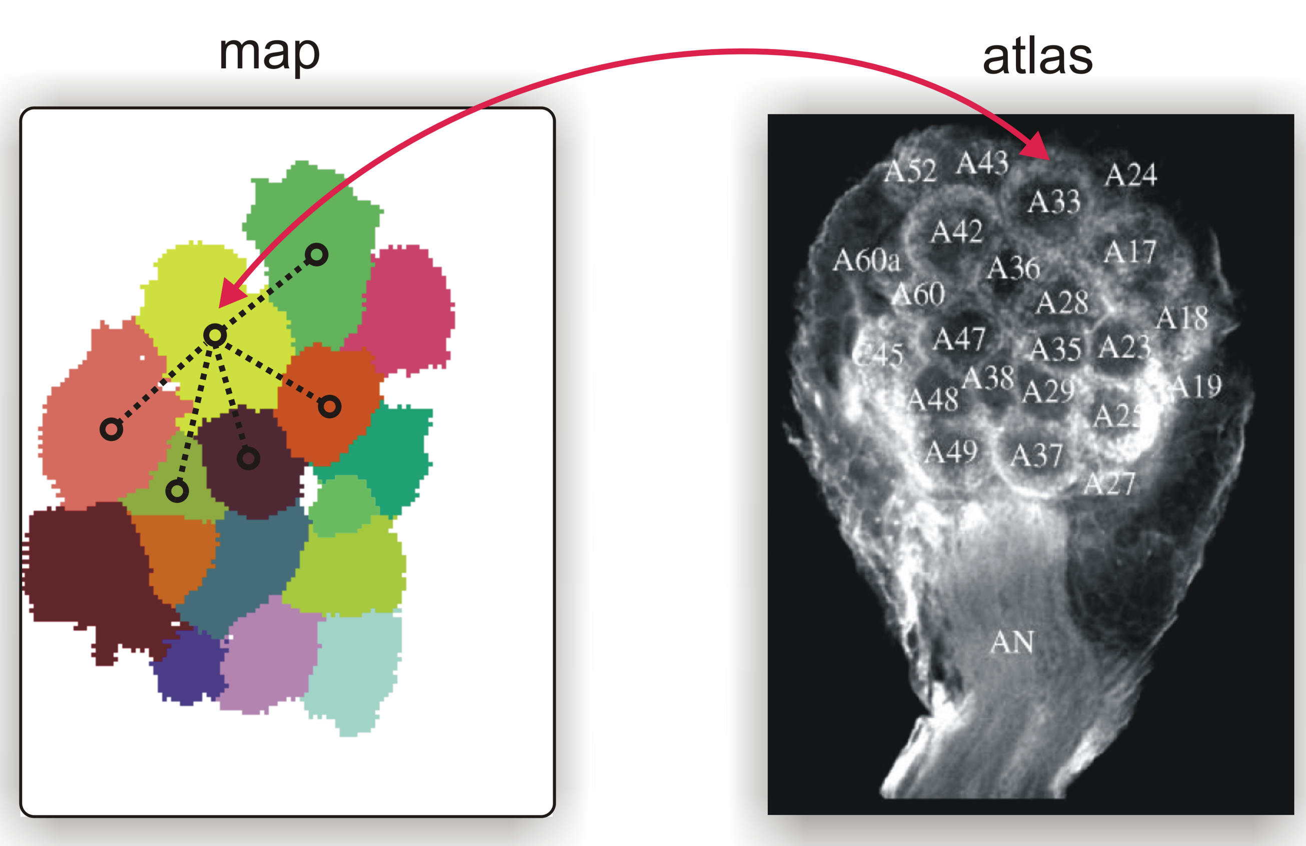

Figure 2: Projecting the map onto the atlas to identify glomeruli.

- A scoring matrix defines the biological parameters that reflect the probability of certain topological changes. Using an exact Branch&Bound approach we search for the lowest scoring projection of the map subgraph onto the atlas graph given the specified biological variability.

3 Results

- Evaluation against a human expert labelling shows that we achieve on average 79 percent correct labels. However, in some cases the best scoring projection is not the correct one.
- Topological variability is not equal for all glomeruli. Currently we are learning the natural amount of variability from training data to get a more realistic scoring matrix and thus to improve the results.

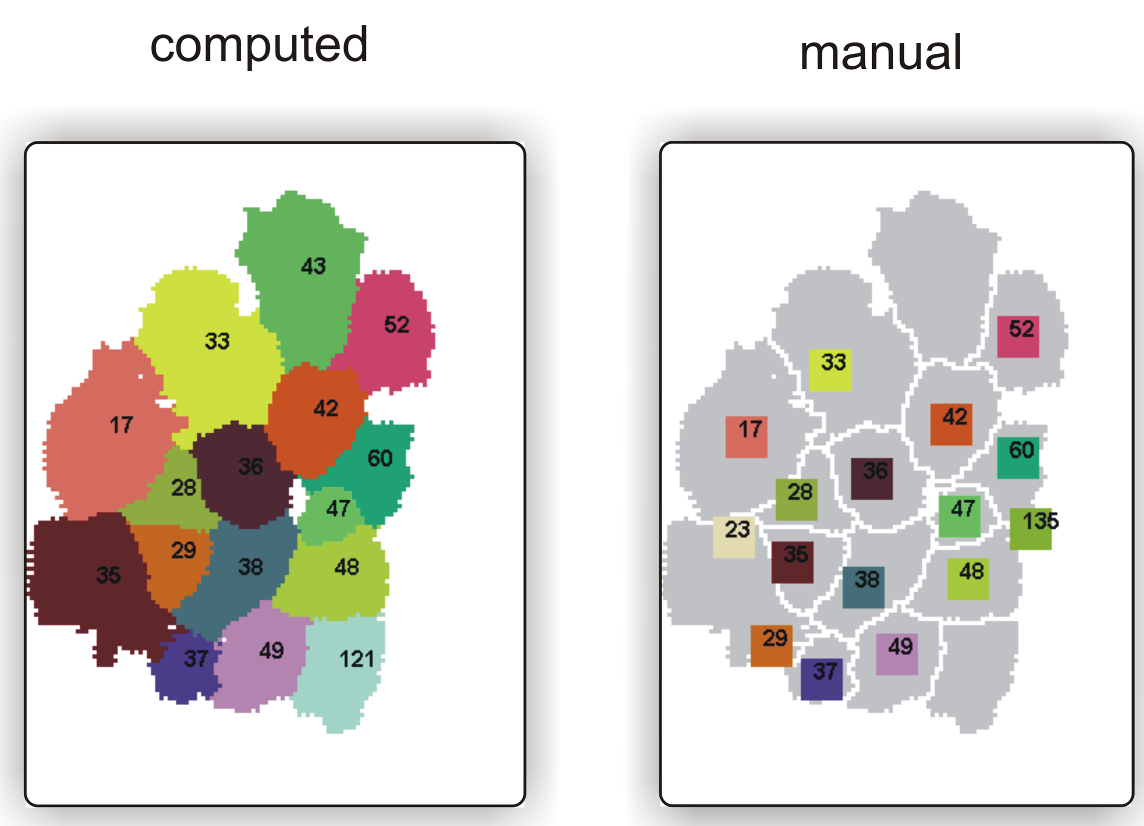

Figure 3: Comparing manual and computed solution for a typical case.

4 Applications

- After overlaying the computed map onto the false-color coded signal image (activity relative to pre-stimulus value) glomerulus activity patterns become visible.
- These patterns can be visualised e.g. with heatmaps. Our implementation makes use of the KNIME framework, through which we have access to e.g. classifiers from the WEKA library or further visualisation methods.

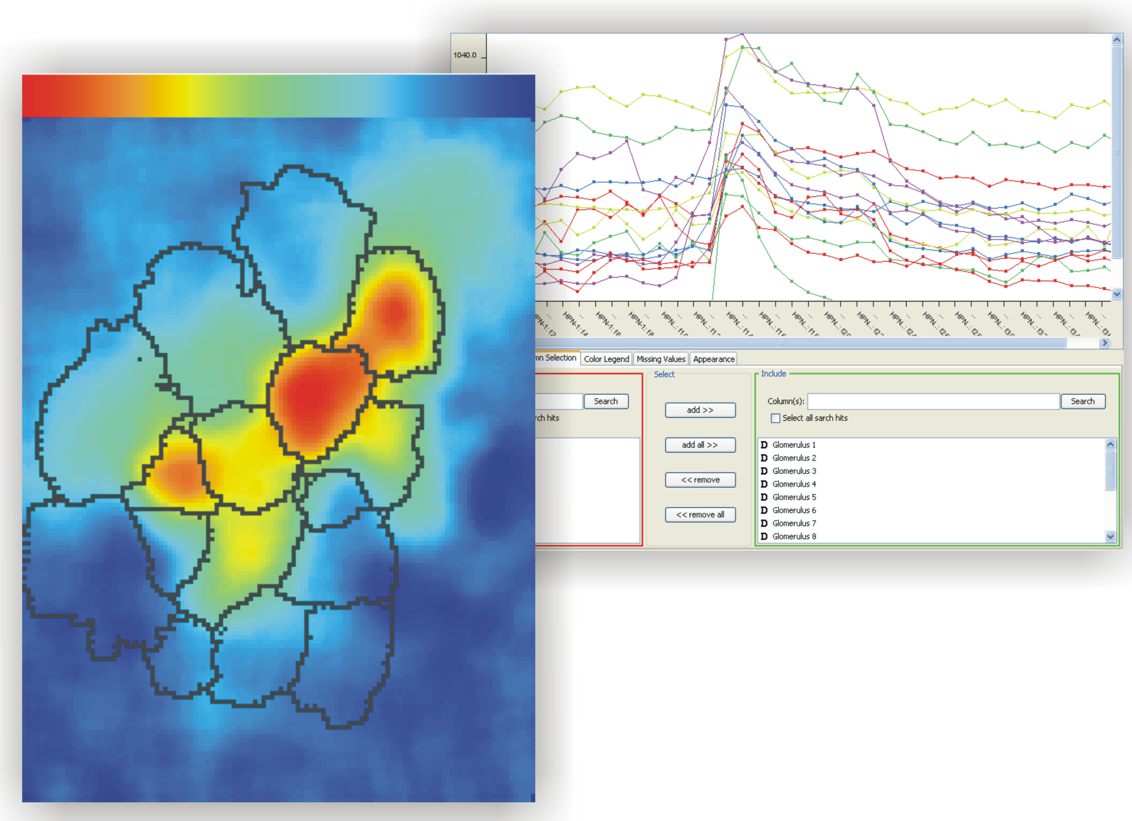

Figure 4: Glomerulus activity patterns: heatmap (left), time-series for each glomerulus (right)

- The method allows to integrate data from multiple sources, thus creating a data pool for future data mining approaches.

References

[1] A. Hyvärinen and E. Oja. Independent component analysis: algorithms and applications. *Neural Networks*, 13(4-5):411–430, 2000.

[2] M. Strauch and C.G. Galizia. Registration to a neuroanatomical reference atlas - identifying glomeruli in optical recordings of the honeybee brain. *submitted*.