Diplomarbeitspräsentation der Fakultät für Informatik

neuroMap - Interactive Graph-Visualization of the Fruit Fly's Neural Circuit

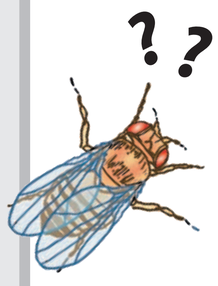
Masterstudium:
Visual Computing

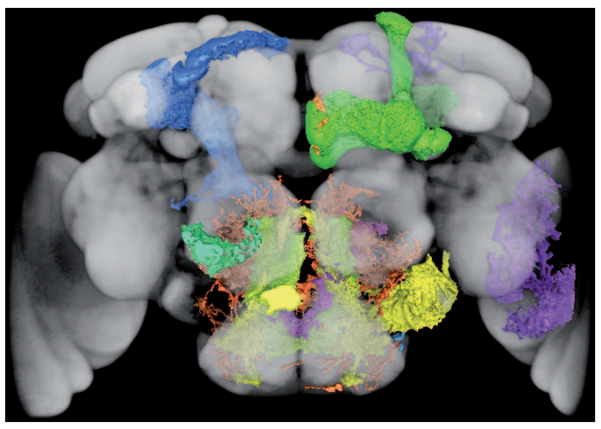
Johannes Sorger

Technische Universität Wien
Institut für Computergraphik und Algorithmen
Arbeitsbereich: Computergraphik
Betreuer: Ao.Univ.Prof. Dipl.-Ing. Dr.techn. Eduard Gröller
Mitwirkung: Dipl.-Math. Dr.techn. Katja Bühler

Problem Statement

- A major goal in circuit neuroscience:
  discovering how behavior is mediated
  through information processing in the neural circuits of the brain.
- **Knowledge about neuron connectivity is essential**
  for understanding how this information is processed and transmitted.
- Connections between neurons can only occur, if the respective terminal branchings of **nerve fibers (arborizations) overlap.**
- **Hypothesis formation** about neural connectivity based on arborization overlaps **using three dimensional visualization** is difficult when multiple neurons are involved, since the displayed objects oclude each other.

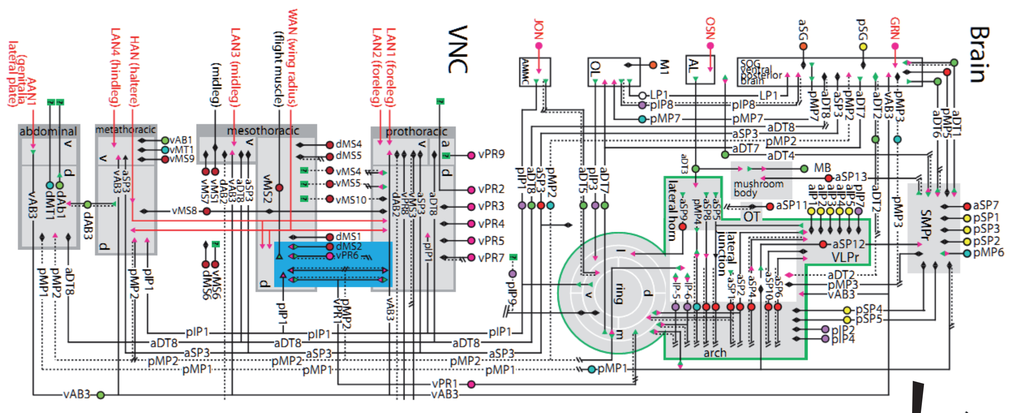




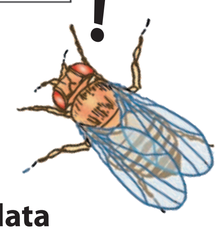
Volume rendering of 10 arborizations and the template of Drosophila's brain.

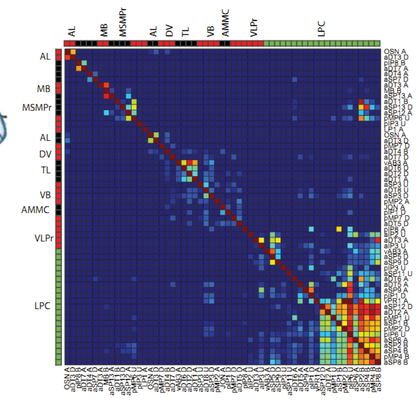
Motivation

A new form of connectivity representation was desired. This led Yu to the creation of a two dimensional diagram of neural projections.



The graph was created manually in a graphics editor and depicts,
which neurons are potentially connected to each other in which brain region (neuropil).
The actual overlap of the neurons' arborizations (and therefore necessary condition for a connection) is depicted in a separate heatmap where the amount of overlap percentage is encoded by color (bottom).





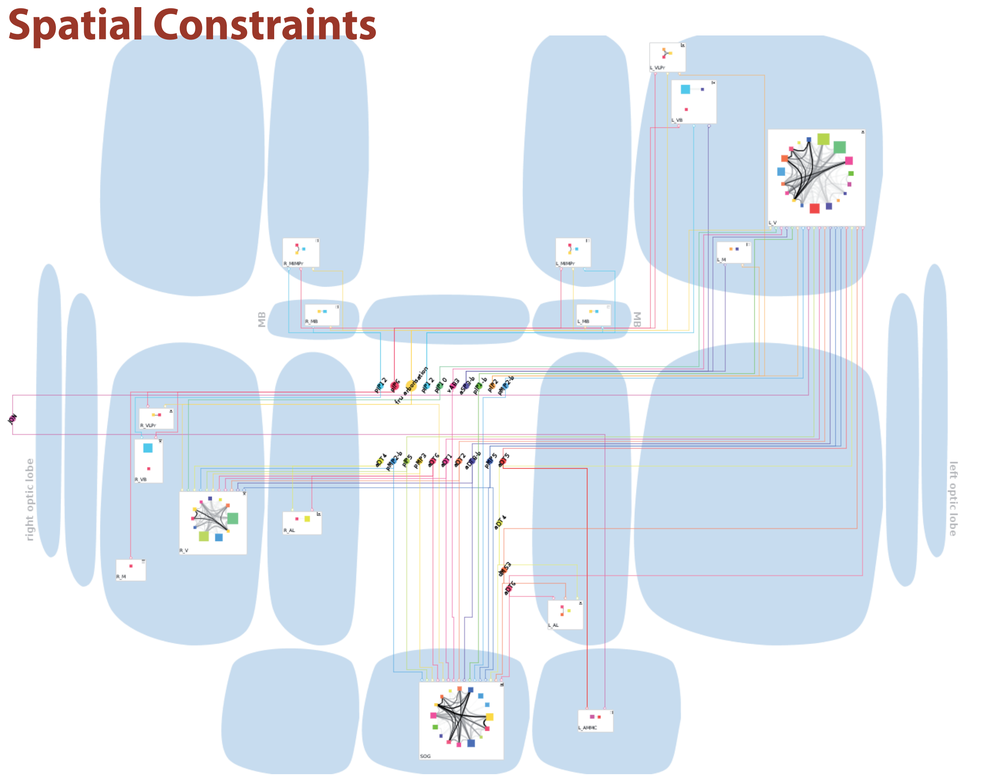
Goal of the Thesis

- **Replicate** the features of **Yu's diagram in an automatically generated interactive graph**
- **Provide** a new and **intuitive way of exploring neuron data**
- Provide means for **easier connectivity hypothesis formation**
- Enable fast and automatic **generation of connectivity diagrams for presentation purposes**

Limitations in Other Systems

- Exploration of hierarchical networks
- Visualization of mulltiple attributes
- Visualization of flows and paths
- Incorporation of spatial constraints

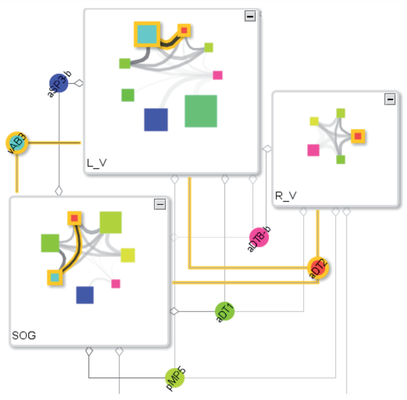
Spatial Constraints



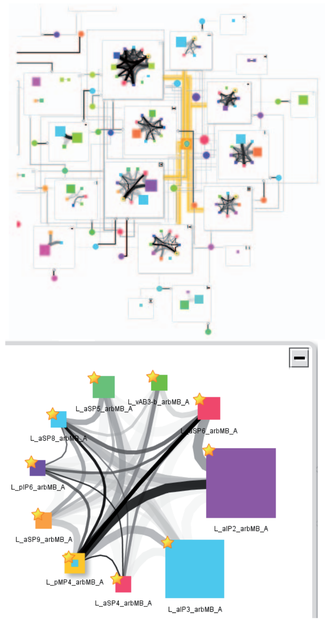
neuroMap's **anatomical layout** assigns neuropils to 19 compartments that represent actual brain regions. The regions are arranged to comply with the **scientists' mental model of Drosophila's brain**. This supports the intuitive understanding of the graph structure and the contained signal flows.

Visualization of Flows and Paths

Highlighting
reacts differently for each type of element.
Highlighting an overlap shows all associated overlaps and elements in the graph.

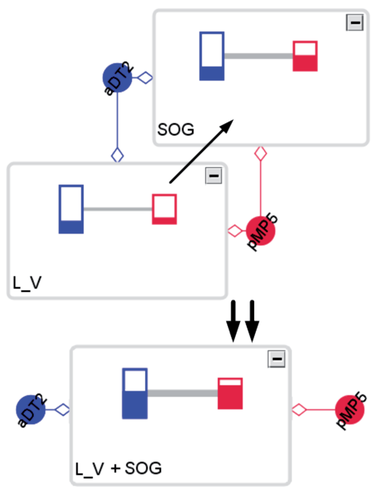


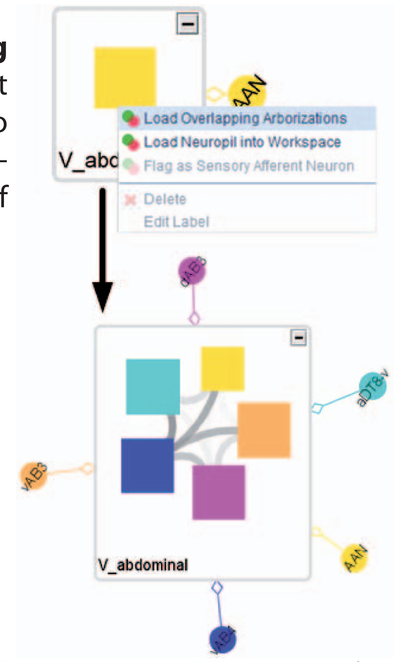
Exploration



Level of Detail (LoD) zooming adapts the displayed information to the available screenspace.

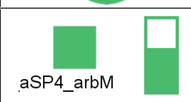
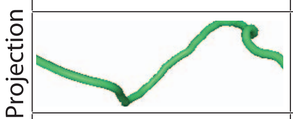
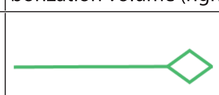
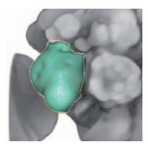
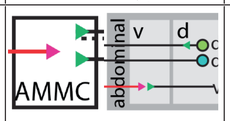
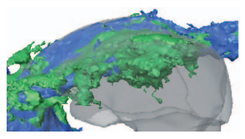
Interactive neuropil **merging** enables the scientists to adapt the structure of the graph to comply to their current research focus. Attributes of merged elements are aggregated.





Context sensitive **queries** enable the extension of the graph structure with potentially connected neurons directly from within neuroMap.

Visual Encoding

	Anatomical	Yu's Diagram	neuroMap
Cell body			
Arborization		n/a	 aSP4_arbM Overlap with neuropil (left) as well as total arborization volume (right).
Projection		 The arrow tip encodes the terminal type.	
Neuropil		 Terminals are displayed within neuropils.	 Can be closed to regulate the amount of displayed information.
Arborization Overlap	 It is hard to judge, how much the blue and green arborizations overlap within the gray volume (neuropil).	 Overlap between arborizations encoded by the color of single cell.	 Overlap encoded in the saturation and line-width of the edge between two connected arborizations.

Conclusion

- Created and evaluated in collaborations with a group of neuroscientists at the Institute of Molecular Pathology (IMP).
- Features of Yu's drawing successfully replicated and extended.
- Providing an abstract overview of complex neuroanatomical data.
- Already actively deployed by our collaborators.

Kontakt: sorger@vrvis.at, buehler@vrvis.at

Want to take a look at the whole thesis? →