Using Ontologies for the Visualization of Hierarchical Neuroanatomical Structures

Anja Kuß[1], Steffen Prohaska[1], Jürgen Rybak[2]

[1]Zuse Institute Berlin, Department of Visualization and Data Analysis

[2]Free University of Berlin, Department of Neurobiology

Motivation

Problem

Anatomical atlases combined with semantic information and visualization can support understanding of anatomy. Working with existing atlas browsing systems suffers from the following problems:

- Approaches using semantic information concentrate on retrieving information from knowledge bases;
- Atlas exploration often requires expert knowledge of knowledge representation concepts, such as relation types or specific query languages;
- Visualization approaches, so far, produce only basic results or require a lot of user interaction.

Approach

This work contributes an automatic method for creating intuitive visualizations of surface-based anatomy atlases. The visualizations facilitate the understanding of the hierarchical organization and the spatial and functional relations.

- We combine a spreading activation approach for computing focus+context in an ontology with a specific level-of-detail strategy for hierarchical structures;
- Expert knowledge is formalized in the ontology and in predefined queries which a user can choose from.

Ontology Creation

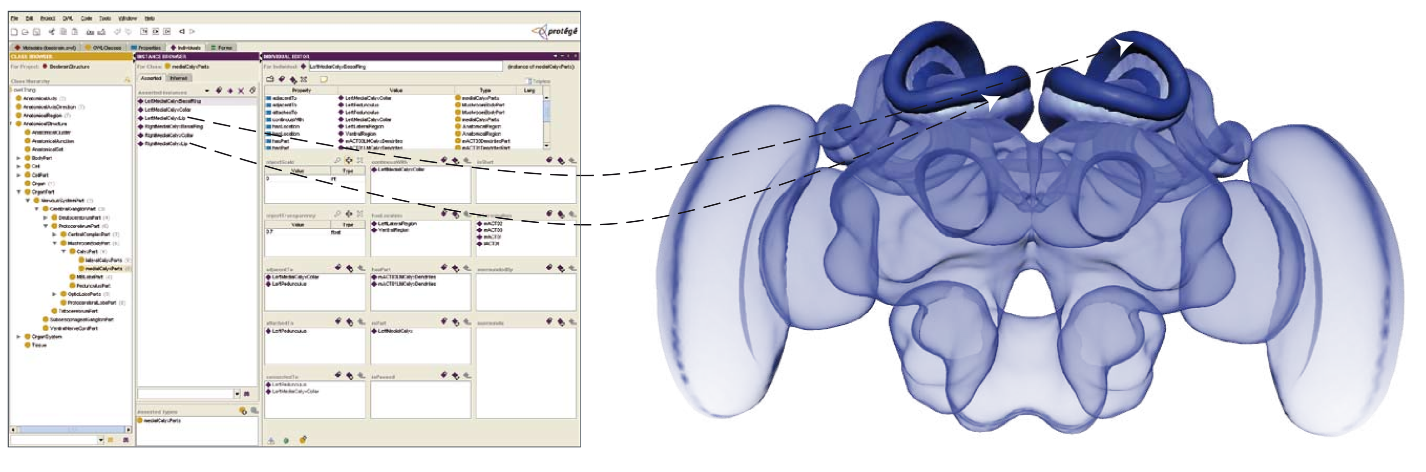
The ontology O can be described as a directed labeled graph (V, E) with a set of vertices V and a set of edges E. V and E can have edge or vertex types: $t(v)$ or $t(e)$. The instance graph I is the set of vertices $V_I = \{v | v \in V \wedge t(v) = instance\}$ and all their edges E_I. We define the class tree C as the set of vertices $V_C = \{v | v \in V \wedge t(v) = class\}$ and edges $E_C = \{e | e \in E \wedge t(e) = subClassOf\}$.

Hierarchic Structures: $v1\ hasPart\ v2 \wedge v2\ hasPart\ v3 \rightarrow v1\ hasPart\ v3$

$v1\ hasPart\ v2 \rightarrow v2\ isPart\ v1$

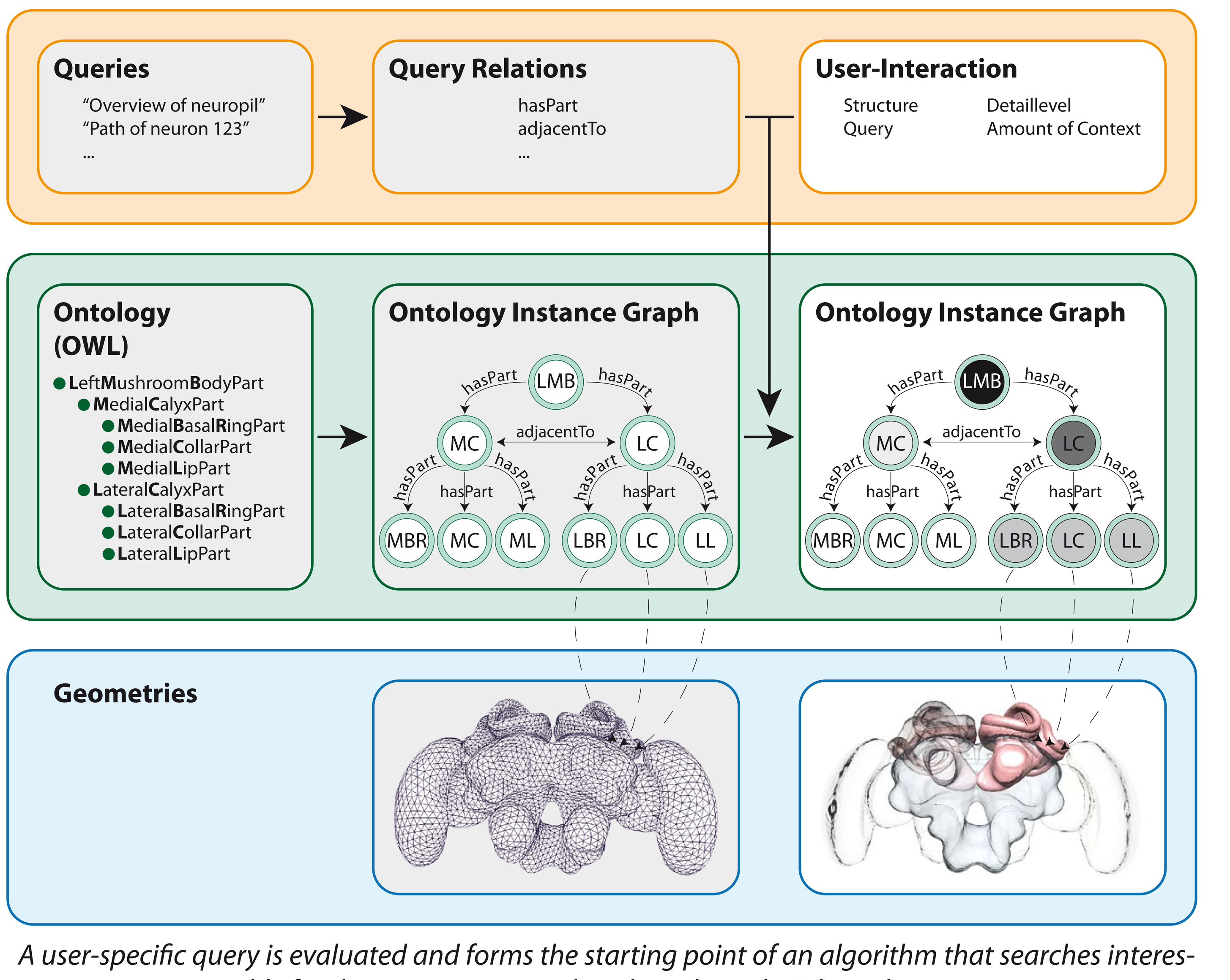
Scale Value: $\sigma : V_C \rightarrow N$

Visibility Value: $\varphi : V_I \rightarrow [0,1]$



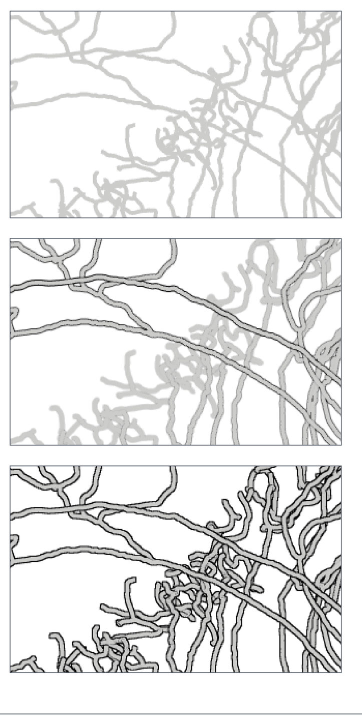
A basic ontology for structures of the honeybee brain storing semantic anatomical and functional information. It represents the hierarchical organization of structures and their relations.

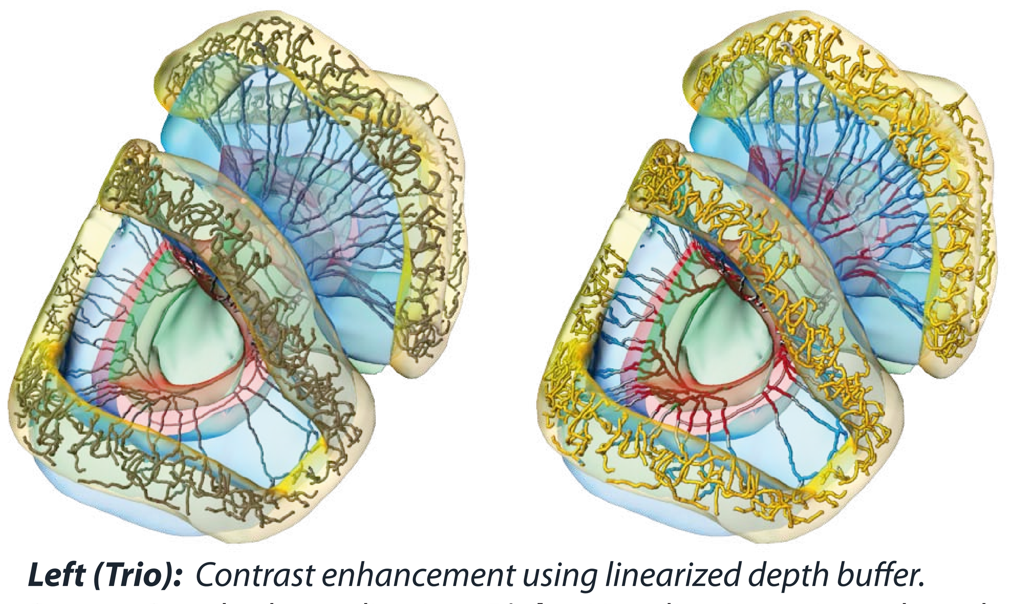
Ontology-based Creation of Visualizations



A user-specific query is evaluated and forms the starting point of an algorithm that searches interesting structures suitable for the query in an ontology based graph. Taking the user-input into account the final visualization is generated [2].

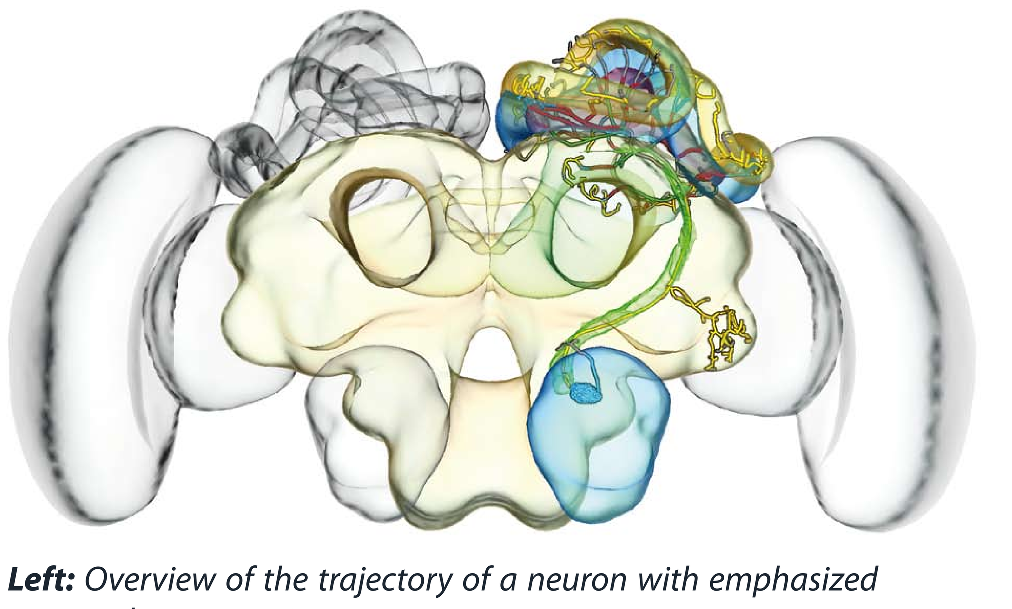
Effective Visualization Techniques

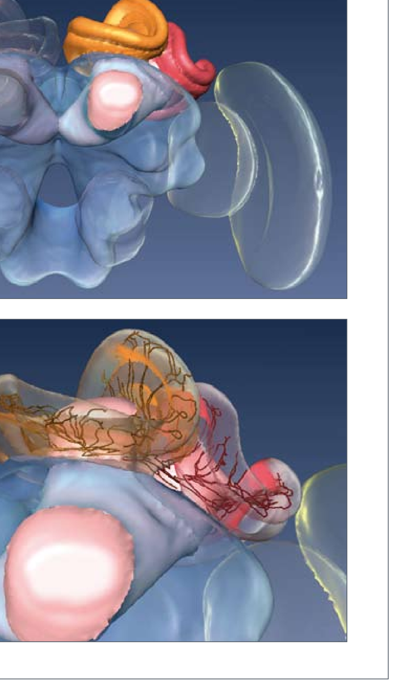




Left (Trio): *Contrast enhancement using linearized depth buffer.* ***Center:*** *Standard visualization.* ***Right:*** *Visualization using tube coloring, depth-dependent color modulation and contrast enhancement.*

Results

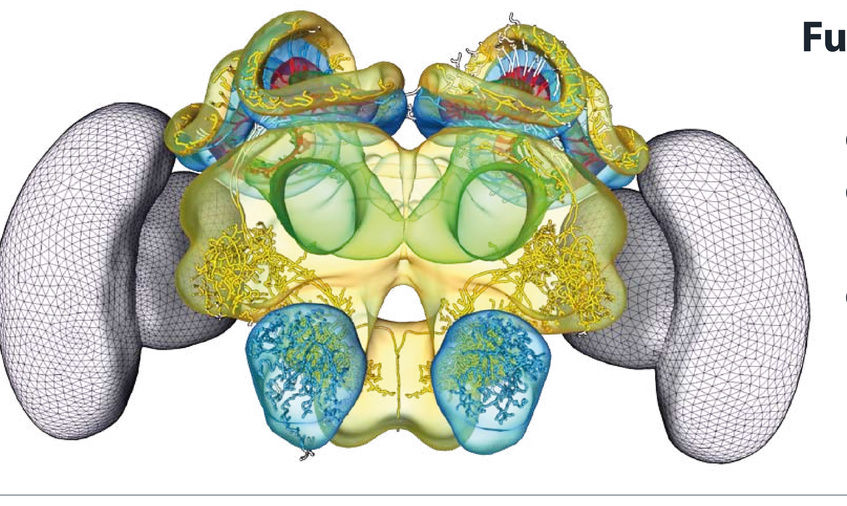




Left: *Overview of the trajectory of a neuron with emphasized input and output regions.*
Right: *Substructures of the mushroom body.*

Conclusion

We presented an approach to generate query-dependent visualizations of atlas data. Our method is based on the evaluation of semantic information from a specialized ontology. The determination of relevant context structures and visualization parameters takes different scales of biological data into account. This way we provide an intuitive and interaction reducing browsing tool for a structure's hierarchy.



Future Work

- Integration of geometrical level-of-details;
- Investigation of an intelligent algorithm to find important relations automatically;
- Extension to other application fields as for example the anatomy of the rat brain or the human heart.

[1] V. J. Dercksen, M. Gensel, A. Kuß, *Visual Accentuation of Spatial Relationships between Filamentous and Voluminous Surface Structures*, Conference Abstract: EuroVis 2009.

[2] A. Kuß, S. Prohaska, B. Meyer, J. Rybak , H.-C. Hege, *Ontology-Based Visualization of Hierarchical Neuroanatomical Structures*, Proceedings of the Eurographics Workshop on Visual Computing for Biomedicine VCBM 2008, C.P. Botha, G. Kindlmann, W.J. Niessen, B. Preim (eds.), pp. 177-184, October 2008.

[3] A. Kuß, H.-C. Hege, S. Krofczik and J. Börner, *Pipeline for the Creation of Surface-based Averaged Brain Atlases*, Proceedings of WSCG'2007, 15:17–24, 2007.

{kuss, prohaska}@zib.de

Zuse Institute Berlin