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Anatomy-Driven Layouting for Brain Network Visualization

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What is this about?

Given its scale and complexity, neuroscience data is difficult to analyze. Visualizations make data more accessible and understandable and help to investigate cognition, memory, and diseases of the brain.
Typical **issues of network visualizations** are:

- Tools are usually tailored to visualize data of a single species.
- Spatial information should be retained.
- 3D is not possible in printed media

What do we contribute?

We provide a visualization **web-tool** that

- visualizes relevant **information at a glance in 2D**.
- is usable for brain networks of **multiple species and views**.
- draws **partial networks** with context for easier orientation and comparison.

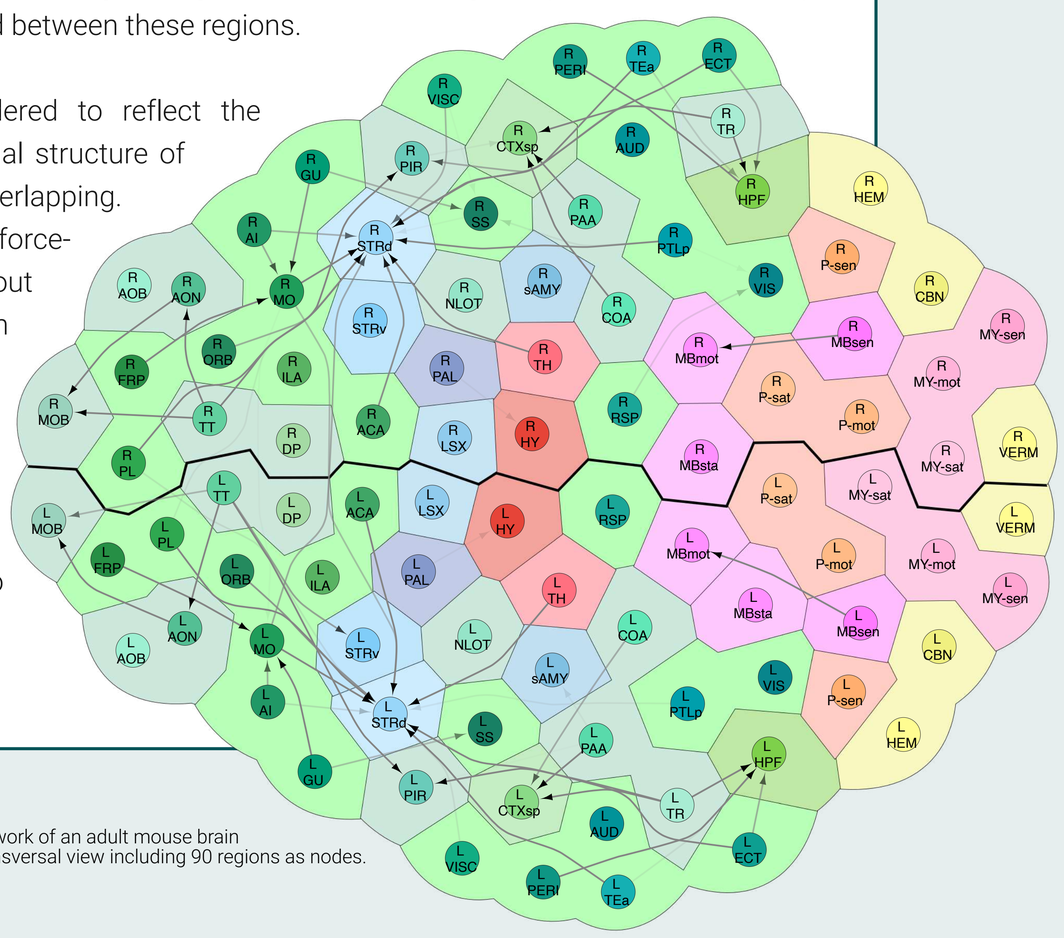
Addressing the Problem with the use of Graph Drawing and Algorithmic Geometry

The Brain as a Network

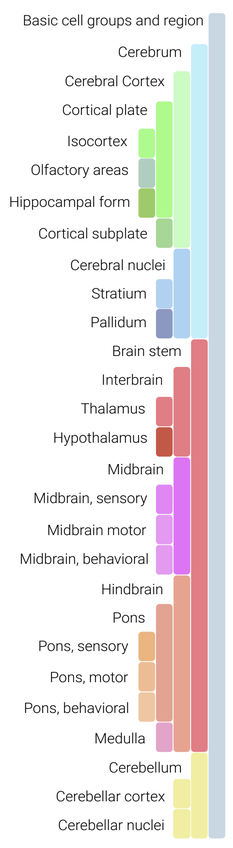
Stripped down to its roots, the brain is simply a **network**. Such networks consist typically of nodes representing the regions, whereas the edges express the relationships that can be measured between these regions.

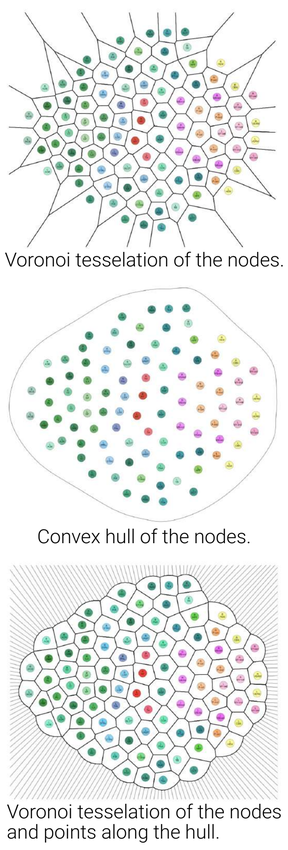
Nodes shall be ordered to reflect the anatomical and spatial structure of the brain without overlapping. The solution is a force-directed layout algorithm applied on edges representing the local closeness.

On the **edges** multiple layouts can be applied to enhance the visibility.

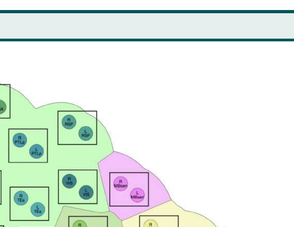


A network of an adult mouse brain
in transversal view including 90 regions as nodes.

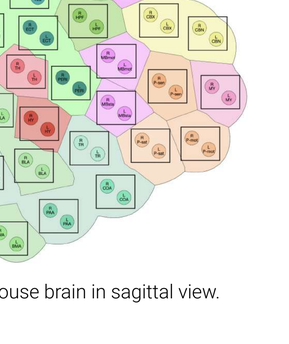




Voronoi tesselation of the nodes.



Convex hull of the nodes.



Voronoi tesselation of the nodes and points along the hull.

Parcellation

The hierarchical brain parcellation defines **closely connected regions**. It is visualized in the background. This highlights the relationship between nodes belonging to the same parcellation and allows the user an **easier orientation**. It is based on a Voronoi tesselation including the nodes of the regions and points along their convex hull.

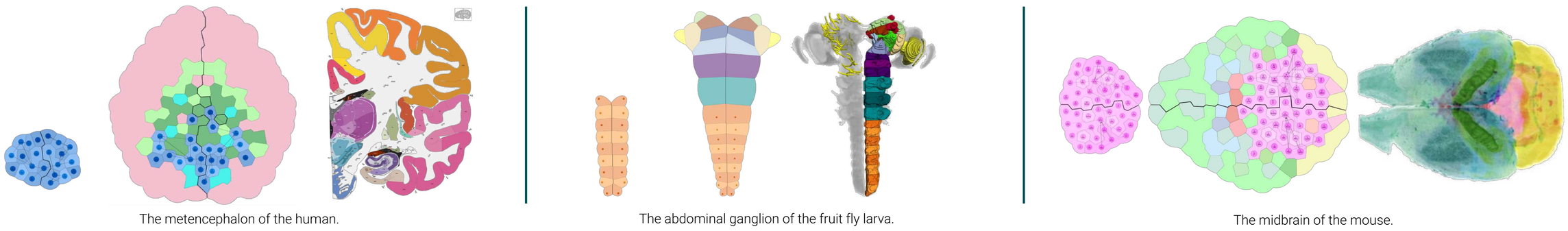
Partial Networks

The lack of connections to the whole brain makes it difficult to classify the spatial position and relationship of partial networks. The context integrated into the Parcellation Background **facilitates orientation** and **comparison** between partial networks without obscuring the view of the network.

A network of an adult mouse brain in sagittal view.

Views

We support a view along the **transversal** and the **sagittal** plane. For the sagittal view, compound nodes (black rectangles) preserve the spatial relation between corresponding regions of the two hemispheres.



The metencephalon of the human.

The abdominal ganglion of the fruit fly larva.

The midbrain of the mouse.

Each figure shows the partial network (left), the network including context (middle), and a reference image from the brain atlas (right).

User Study Results

Participants found our representations **intuitive** for perceiving arrangements of spatial relationships.
Experts were able to solve network-orientation tasks **faster** with the help of our layouts.
Visualization of sub-networks was considered very **useful**.
The generated images are suitable for **educational purposes**.

Accompanying Publication

Ganglberger, F., Wißmann, M., Wu, H. Y., Swoboda, N., Thum, A., Haubensak, W., & Bühler, K. Spatial-data-driven layouting for brain network visualization. Computers & Graphics, 105, 12-24, 2022.