Scientific Visualization and Computer Graphics

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Focus

The research group Scientific Visualization and Computer Graphics carries out research in the areas of scientific visualization, information and software visualization, illustrative computer graphics, innovative interfaces using large displays, geometry modelling and processing, and vector graphics. We apply our research to fundamental and practical problems from the life sciences (functional brain imaging, bioinformatics), astronomy, and computer-aided design (CAD).

The group participates in the research school Behavioural and Cognitive Neuroscience (BCN) and the Neuroimaging Center (NIC) of the University of Groningen and the University Medical Center Groningen.

Scientific and Information Visualization

We investigate how to visualize medical and biological data. Methodologies such as functional MRI (fMRI), multichannel EEG, and diffusion tensor imaging (DTI) are used to extract functional brain networks and pathways. DNA microarray measurements allow us to visualize regulatory gene networks. We employ insights from perception science to improve current visualization techniques.

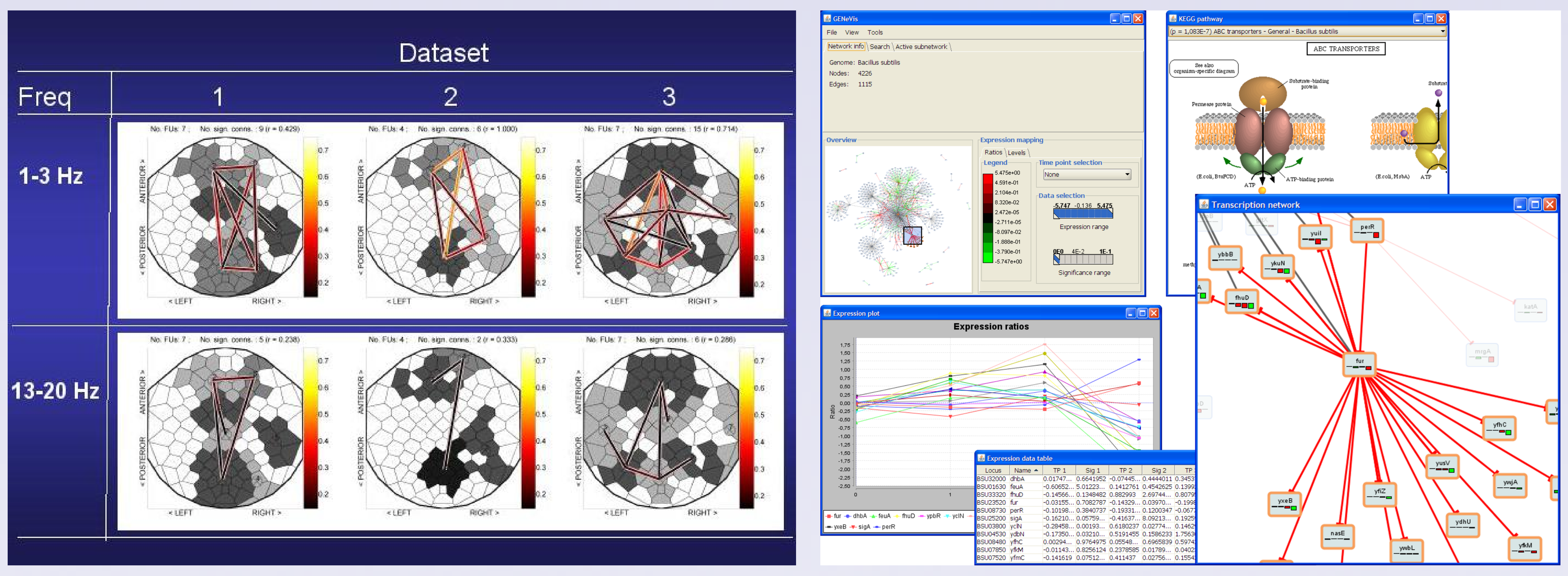

Figure 1: *Functional Unit maps for multichannel EEG coherence visualization (left) and visualization of genome expression and regulatory network dynamics in a genomic and metabolic context (right).*

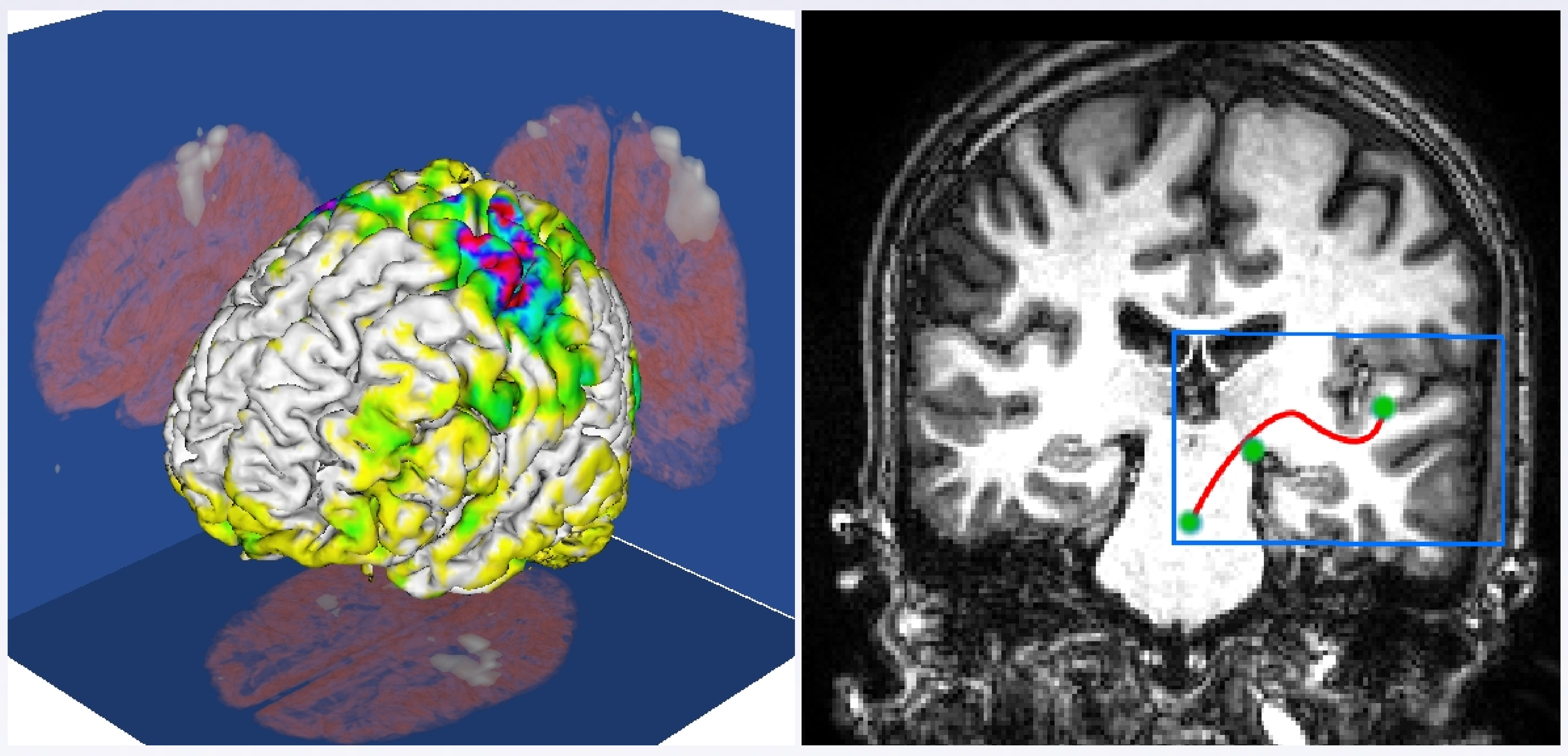

Figure 2: *Surface rendering of the human brain with fMRI data mapped onto the cortex (left) and statistical DTI analysis to show acoustic pathways (right).*

Shape Modelling and Processing

Shape representation and processing are key ingredients in many research areas and applications, such as Computer Aided Design (CAD), Computer Graphics, Computer Vision, but also Finite Elements (FEM) and Isogeometric Analysis (IgA). We focus on representations of (smooth) surfaces of arbitrary manifold topology, and on segmenting organic 3D shapes into their natural parts, such as the limbs of a (human) body based on their *curve and surface skeletons*.

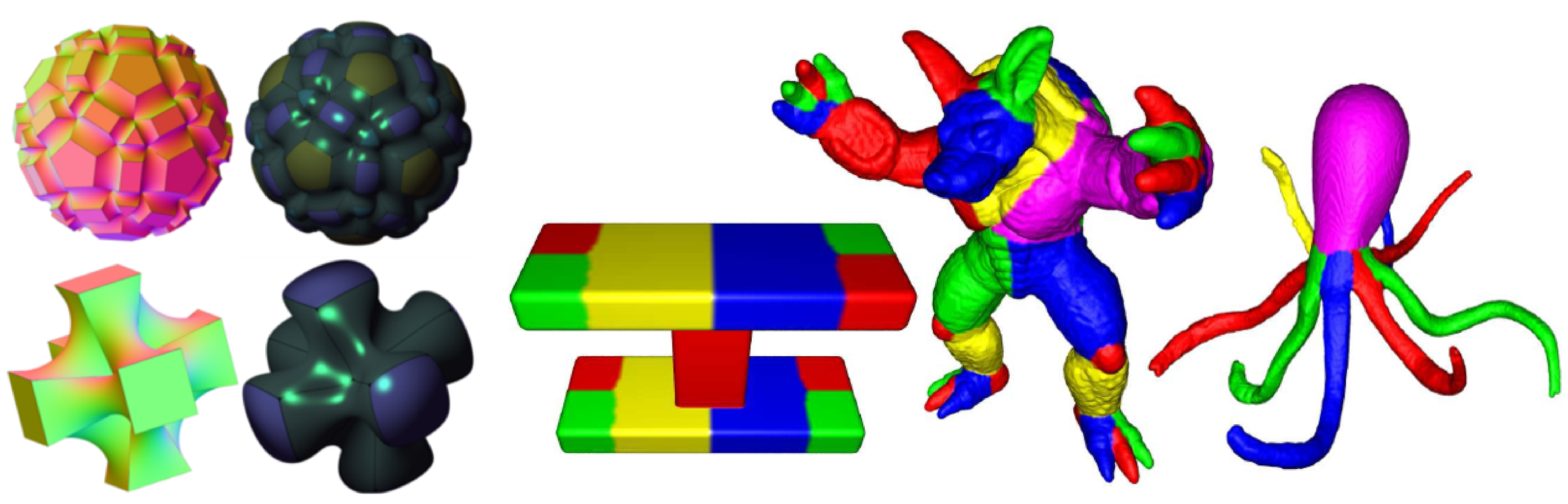

Figure 3: *Modelling of complex (and smooth) shapes of arbitrary topology (left), and using skeleton extraction to identify natural parts of CAD and natural shapes (three shapes on the right).*

Software Visualization

Modern software systems have an increasing size and structural complexity; also, they evolve in time. *Software visualization* methods address the challenge of understanding and maintaining large code bases by presenting the structure, attributes, and evolution of source code in scalable and intuitive ways. We develop methods that show the structural evolution of code at class, function, or statement level and that combine the visualization of software architecture diagrams with software metrics defined on groups of diagram elements. We implement our methods in tools that can be tested on real-world software systems.

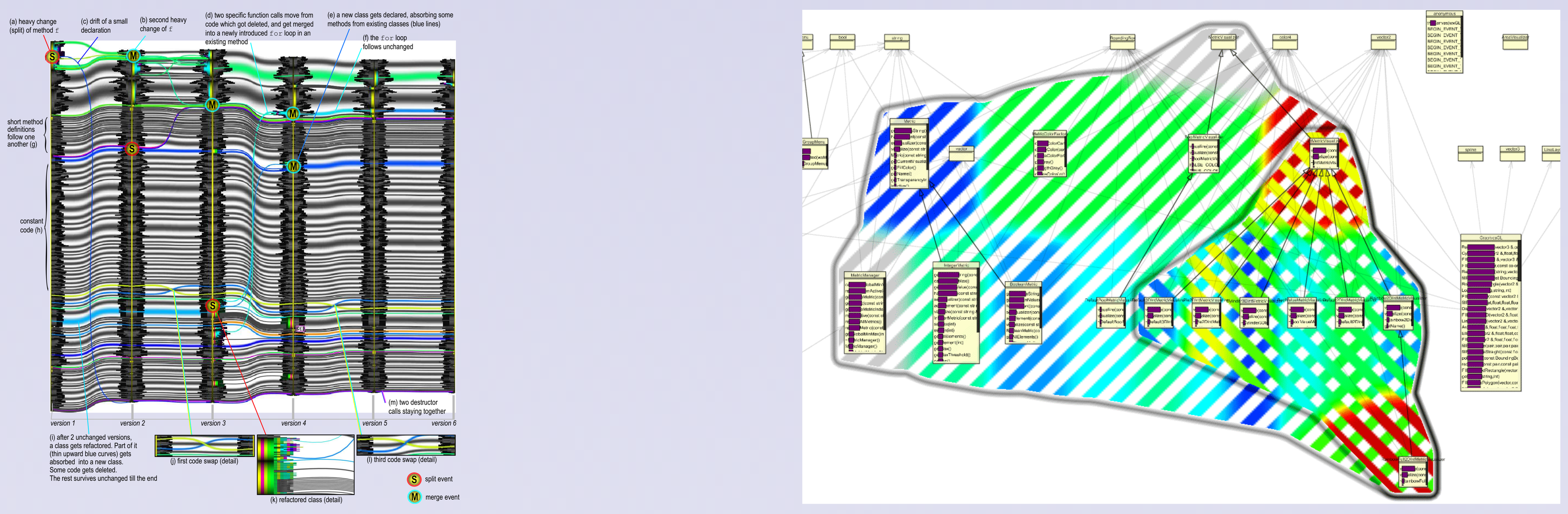

Figure 4: *Combining the visualization of software architecture diagrams with software metrics defined on groups of diagram elements.*

Visual Storytelling

Visual storytelling is an innovative approach for visual presentation and communication that is especially important in situations where the data analyst is not the same person as the decision-maker, and information needs to be exchanged in an intuitive and reproducible way. We focus on how to develop IT support for diagnostic and decision processes based on large and complex imaging data, with radiology being our primary use-case, relying on the concept of provenance graphs.

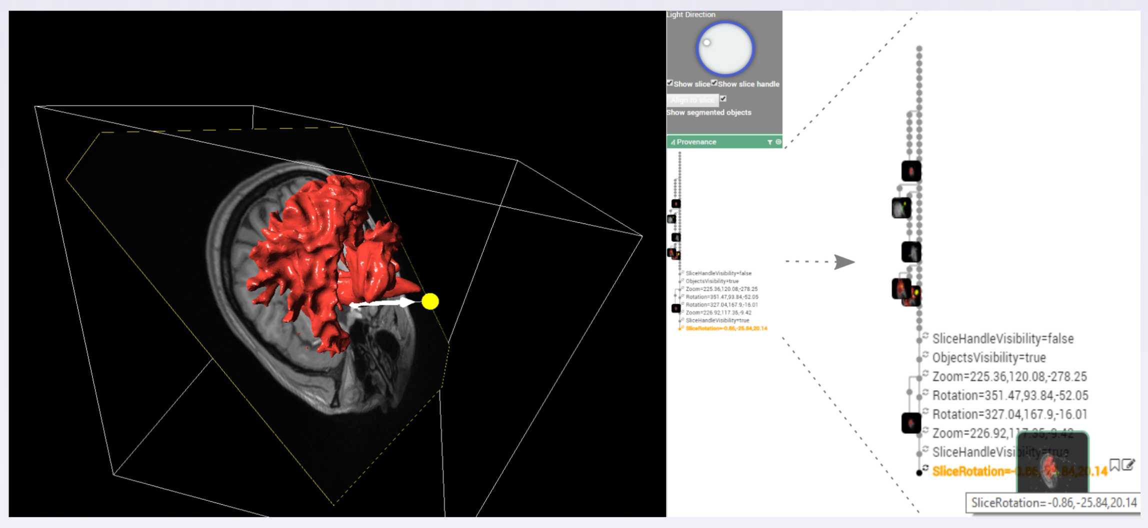

Figure 5: *Our visual storytelling tool with a main window for data exploration (left) and a widget for provenance graph interaction (right).*

Vector Graphics

Vector graphics, as opposed to raster graphics, represent digital images in a scalable and resolution independent manner, and are based on so-called primitive. These primitives range from simple ones such as lines, circles, disks, and rectangles, to more complicated ones like diffusion curves. We focus on the gradient mesh primitive, available e.g. in Adobe Illustrator and Inkscape, and its extensions, including (gradient) meshes of arbitrary manifold topology, sharp transitions, and local refinement.

Figure 6: *Husks of 'Chinese lantern' modelled using local refinement, branching, and sharp transitions using our extended gradient meshes.*

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