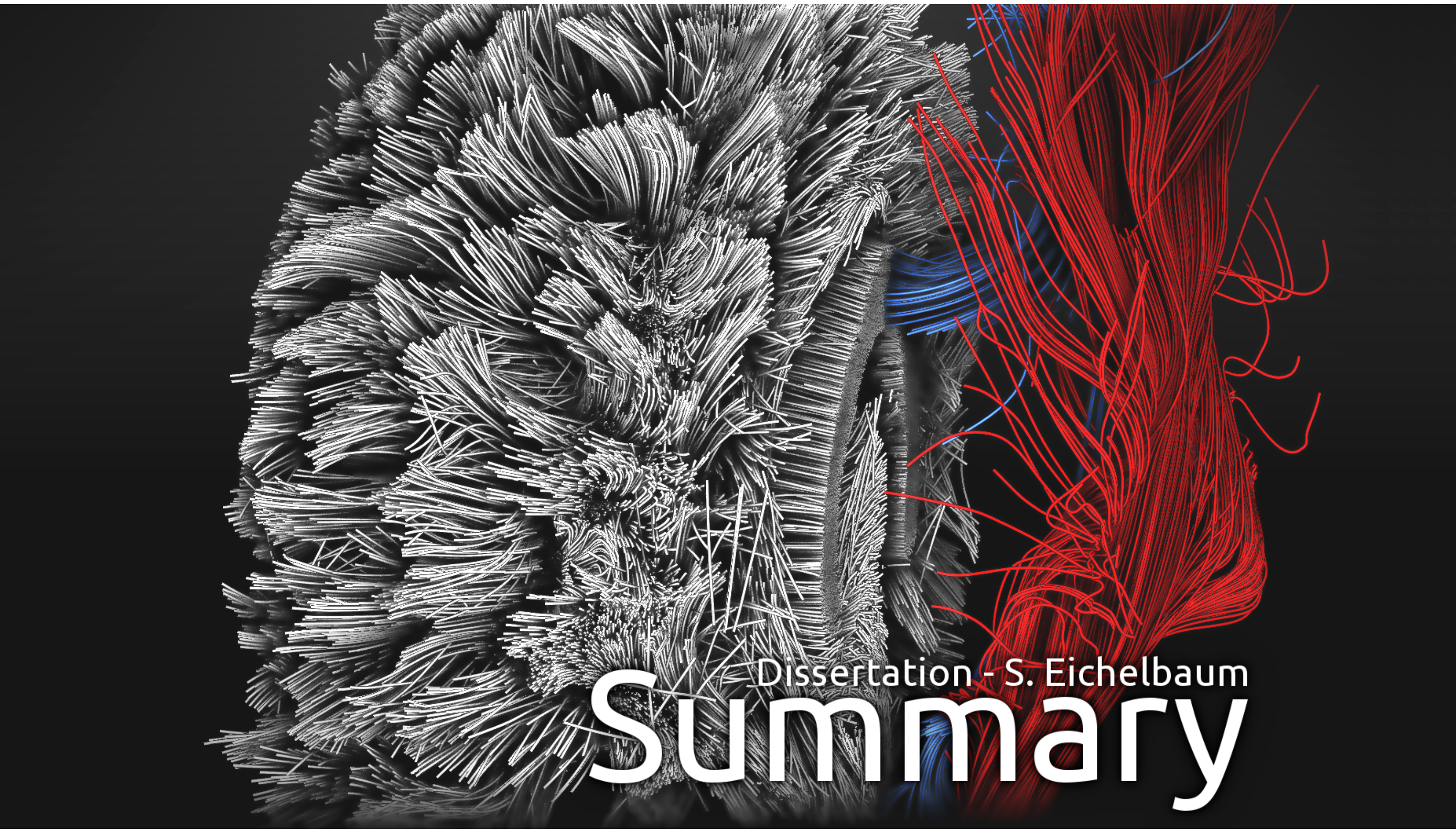

Applied Visualization in the Neurosciences and the Enhancement of Visualization through Computer Graphics.

Part I In the first part of my work, I address the visualization in the neurosciences. Neuroscience is an incredibly complex interdisciplinary science, reaching from chemistry, over medicine to computer science and engineering. The shared goal of all involved disciplines is the final understanding of the brain's function, beginning at its smallest parts, the neurons up to its global infrastructure. To achieve this ambitious goal, the neuroscience uses a combination of data from a myriad of source. To handle and analyze the diversity of different data types and sources, the neuroscience needs specialized and well evaluated visualization techniques.

During my research work, me and my collogues intensively collaborated with neuroscientists, who were working in the areas of neuroimaging, cognitive neuroscience, and computational neuroscience. Unfortunately, modern visualization is not actively used. Instead, colormaps on slices and statistical assessment are the defacto standard for analysing complex simulations and measured data, even though there is a huge interest in visualization. We identified three major reasons for the restraint to use advanced visualization techniques: Visualization methods are (a) mostly unevaluated, (b) too complex and parameter dependent, (c) not accessible in terms of software and applicability to a given kind of data.

In my dissertation, I introduce our contributions to alleviate this set of problems. As a start, I show an extensive software called "OpenWalnut". It forms the common base for developing and using visualization techniques with our neuroscientific collaborators. Using OpenWalnut, standard and novel visualization approaches are available to the neuroscientific researchers too. Afterwards, I am introducing a very specialized method to illustrate the causal relation of brain areas, which was, prior to that, only representable via abstract graph models. I finalize the first part of my work with an evaluation of several standard visualization techniques in the context of simulated electrical fields in the brain. The goal of this evaluation was to clarify the advantages and disadvantages of the used visualization techniques to the neuroscientific community. I exemplify these, using clinically relevant scenarios.

Part II The visualization pipeline is usually depicted by three major steps: filtering, mapping, and rendering. Besides the data processing steps, which play a tremendous role in visualization, the final graphical representation (rendering) of the data is essential for understanding structures and features in the data. The graphical representation of data can be seen as the interface between the data and the human mind. The second part of my work is focused on the improvement of structural and spatial perception of visualization – the improvement of the interface.

Unfortunately, visual improvements using computer graphics methods, originally invented of and for the computer game industry, is often seen sceptically. In the second part, I show that such methods can be applied to existing visualization techniques with ease to improve spatiality and to emphasize structural details in the data. So, advanced computer graphics in visualization is not only about beautiful pictures, but provides a tremendous benefit, when it comes to understanding the shown data and structures.

Part two starts with an introduction to the modern graphics pipeline and the screen space rendering paradigm, as this is the basis for the shown methods. The background chapter is directly followed by the first two methods that improve the perception of mesh-like structures on arbitrary surfaces. Those mesh structures represent second-order tensors and are generated by a method named "TensorMesh". Afterwards, I show a novel approach to optimally shade line and point data renderings. With this technique it is possible for the first time to emphasize local details and global, spatial relations in dense line and point data.