

# 3D-Brain Model Software

## A New Interactive Real-Time Graphics Visualization for Rat Brain

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**Abstract.** The project's main goal is the development of an interactive 3D atlas, that allows detailed exploration of the rat brain as well as illustration of interactions and information flows between various brain structures. Compared to other software on the market, this tool will focus more on the specific needs of scientists and students. Simplicity of use is one of its keys features. Students and scientists should be able to easily manipulate and view data that the system provides. Especially scientists should be able to import or add results and compare or illustrate them within a unified framework. The software will run on normal consumer hardware and not require expensive workstations, so that students can use it for learning purposes at home, as well as scientists being able to add data from their regular work PCs. Despite not having high hardware requirements, it will make use of various visualization effects.

## 1 Introduction

Brain atlas research was originally based on accurate localization of specific structures and regions and supply the research with static profile. 3D atlas have a potential to provide virtual model, better visualization and interpretations. Such information is highly valuable for neuroanatomists and surgical procedures [1]. 3D reconstruction of structures and cells has remained largely manual despite the rapid development of computer technology. Current techniques for mapping are too slow to support a adequate quantitative analysis of brain morphology at cellular and tissue level.

To date very limited amount of detailed 3D data from brain to single cell populations is available in electronic form to supply sufficient scientific information. With some exceptions like works of "Rutgers University" [2], which developing a major brain regions (reference brain) and containing outlines. Works on a 3D atlas of spinal cord of rat done by Prof. Paxinos and Dr. Koutcherov [3] proved how important can be a detailed information. At ultrastructural level "Synapse Web" ([www.synapses.bu.edu](http://www.synapses.bu.edu)), developing a powerful tools for reconstructions

and visualization of fine structures of CNS which we take in account for our own model. We are developing a tool to help improve data collection, preparing and visualization of quantitative results. Structural presentation as 3D coordinate space is in use in many brain imaging researches. We creating a tool which can be adapted to cover large field of anatomy and teaching activities.

## 2 State of the art and new contribution

Compared to similar 3D viewing programs from the past, today's consumer graphics hardware is powerful widely available and not limited to workstations. Various visualization effects will make viewing our 3d atlas more exciting and present the models more vividly. When targeting students with our software (Fig. 1, 2), it should not have the "sterile" look of aged software, which simply didn't have the power to do further effects, but present the data in a form that is appealing to the current and coming generation of neuroscientists. The effects will not be used for the effects sake but to illustrate information flows, selections and objects . To make use of hardware accelerated viewing, OpenGL is used for rendering. It also allows portability of the application to various platforms, although for the beginning only Microsoft Windows-based systems are intended.

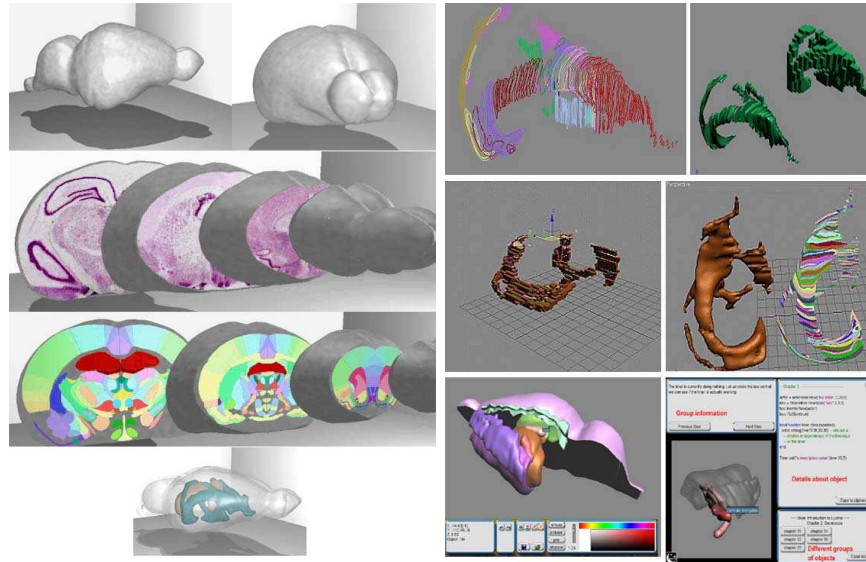
Most of today's top medical visualization software is very advanced and allows high-level application, however its functionality is not always easily accessible, and the software might be too expensive to be used for students as learning software at home. Once 3D atlas is created entirely it can be used for many purposes and can be associated with database. It make sense to develop the work further for localizations of expression of certain receptors of cellular proteins [4, 1].

## 3 Methods

For the development of the 3D rat brain we use "luxinia", a scriptable 3D engine, written by two students of the Otto-von-Guericke University of Magdeburg. The application code is written in LUA script, developed by Pontifical Catholic University of Rio de Janeiro, Brazil. Scripting languages, allow faster and easier development of software, due to them being high-level, compared to the low-level languages such as C or C++. However as low-level languages allow greater performance, the engine itself was written in C. The users of the rat brain viewer will also benefit from the use of a high-level language, as they can extend the software on their own, and do not need to write low-level code. Compared to similar 3D engines, luxinia's hardware requirements are still fairly low, but allow various effects even on older graphics hardware. There is also support for sound and physics and it is free for non-commercial use.

At first we were constructing the surface models of the brain structures. To achieve this, we uses a series of photographs taken from Nissl stained brain sections of Sprague Dawley rats, which have been traced and vectorized to spline data. Every structure is made of a series of spline layers, where each layer has

**Fig. 1.** 3D model surface presentation and 2D-3D atlas sectioning (left); Snapshots from user modus (right)



thickness of 0,75 mm. Surface creation from the spline layers is done in Autodesk 3dsmax. A tool written in maxscript and C++ generates a polygon mesh from the input data. Maxscript is the proprietary scripting language of 3dsmax and allows object creation, as well as workflow enhancement and many other tasks, as it often allows direct access to 3dsmax's objects. The aim is the ease of use, especially when it comes to creation of graphical user interfaces, which makes creation of artist friendly tools easier. On startup the user can define the location of the input files and set distance between layers, as well as starting layer location. After the import each layer is turned into a 2D polygon and rasterized using a C++ plugin. As result of the rasterization, a voxel representation of the model is being created. These voxels are then turned into a polygon hull mesh, with customizable resolution. Various modifiers of 3dsmax can be applied to the hull mesh. Such as the generation of a relaxed surface, which is smooth and does not have the typical voxelized hard-edged look. While a certain precision loss compared to the original volume data comes with the use of triangle meshes and using voxels as base, the advantage is performance for the interactive 3d viewer. Triangle meshes are easily accelerated on most of today's graphics hardware, which is necessary for the software having low hardware requirements. However precision can also be raised with finer ray-shooting. 3dsmax also comes with various LOD methods to further lower the triangle count of the mesh, for improved interactive framerates. A high-resolution mesh could still be used as reference for advanced real-time rendering methods, such as local-space normal mapping. Another benefit from creating the data within 3dsmax also means it

can be exported to various other file formats, or can be used for illustrative renderings and animations. Another method, creating the surface model from connecting the splines, did not yield good meshes, and was not so well suited for automatic use, as the voxel method is. As mentioned before the final meshes can be used for offline rendering of images and animations, however for this project the data will be exported to the 3D engine's format as indexed triangle meshes.

Real-time glow effects are used to enhance selection and illustration processes. Per-pixel Gooch-shading allows better perception of curvature. To illustrate volume data within the brain's substructures, a form of billboard rendering was chosen, which also allows shading on the normally flat billboards. Another method, which might be implemented additionally, is the use of 3D textures and view-aligned planes.

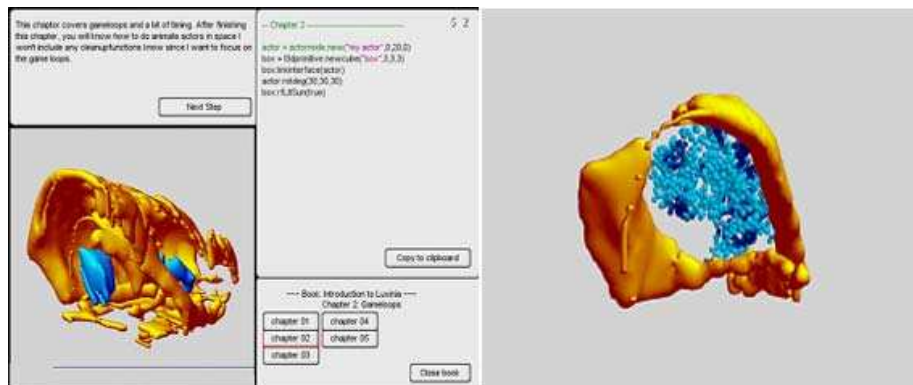
## 4 Results

Our 3D tool should not feel like a CAD application, but more like a virtual space. The classic three-views and wire frame depiction of the models, is less suited for transporting the spatial information of the "bigger picture" easily and fast, hence focus will be on perspective viewing. Light and environment effects, such as fog, should help giving the viewer enough depth cues to get familiar with the dimensions of the structure. Mouse interaction and a graphical user interface with proper icons should be sufficient. Students could be asked to click certain regions themselves, as a test. Furthermore the viewer must give easy access to detailed information about each structure, not just their names and functions, but also interaction between them. Structures should be categorize able and hide able. It would be needed to color-code them based on their influence towards certain effects. Particle systems, or other effects such as animated surface textures, glows and alike will be used to represent this data. Each 3D model can carry different calibrations depending on the age of animals. We are planing to incorporate a tool to view and use also a 2D atlas (Fig. 1) for fast orientation and moving. Once cell populations and connectivity been reconstructed they can be placed into virtual environment to visualize the dense neuronal forests and morphology [5]. A real-time rotating and zooming view will represent a cell population distribution using a voxel rendering technique. Our tool representing brain regions which are unique fill color coded and can divergent depending on cell (sub region) specification (Fig. 2).

## 5 Discussion

The tool which we are developing is a step along the way to improve data access and 3D visualization instead of static view. While students would rather consume this data, scientists would feed the data into the system. Scientists especially need to be able to create data sets of influence and flow values within the model's substructures. It must be easy for them to enter text or automatically add values based on external data, e.g. Excel data files and alike. That way they

**Fig. 2.** Snapshots from 3D detail analysis (neuronal population presented in blue)



could use the benefits of a unified viewer of their results, and also compare results against each other. For teaching purposes used in a similar way by the group of Sundstein [6], the system allow packing information in chapters. Each chapter can give information about a substructure or its interaction with others. Animated sequences could further illustrate effects. The advantage of being able to interact with the scene must be made use of, compared to the classic use of static images / pre-rendered animations. We presenting a tool simplified the way of data presentation and deriving a quantitative information. We creating a tool which presenting a anatomical and functional data, to manipulate and detect patterns in resulting image database. Thus will reflect in better understanding brain functions and support the scientists.

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