15th International Congress for Stereology and Image Analysis
Aarhus University, 27–30 May, 2019

Abstract

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Possibilities of virtual reality approach for measurement and 3D visualization of tubular microstructures

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3D visualization and measurement of structural characteristics of different types of tubular microstructures are of interest in many biological studies – visualization is important for qualitative examination and formulation of hypotheses on structural changes under different conditions, while quantitative measurements can be used for testing the hypotheses. However, it can be difficult for the observer to perceive the exact organization of complex structures rendered 3D and measurements of structural characteristics by stereological and other interactive methods are often tedious and time-consuming. In our study, we tested possibilities of virtual reality (VR) as a tool that could enhance exploration and interaction within 3D microscopic images of tubular structures. We developed a custom-made VR image analysis software, capable of rendering a very high resolution VR image of microstructures to high-end enterprise head mounted display (developed by VRgineers). Goggles were tracked using absolute position tracking system developed by DTrack. The application rendered images to the virtual space around the user, enabling him/her to move and interact using his/her own hands or specialized controllers with rendered 3D reconstruction of acquired microscopic images. Acquired microscopic images of microstructures were converted into a volumetric object, which was then rendered to each eye using ray casting technique. User was able to walk through the rendered structure and to mark up, draw and thus measure parts of the tissue. Application was developed in .Net framework and DirectX 11 considering optimized algorithms for fluent visual perception. We tested VR approach on two types of tubular structures, acquired by confocal or STED microscopy techniques:

1. Microtubules (MT), i.e. cylindrical cytoskeletal polymers indispensable for many vital cellular activities, representing a dense and complex network of fibers inside cells. The individual fibers could be poorly separated, due

to low resolution of microscopic images. Virtual reality approach enabled to enhance perception of organization of MT in human osteosarcoma cell U2OS acquired by STED microscopy.

2. Blood capillaries, important tubular structures, supplying living tissues with nutrients and oxygen while simultaneously removing metabolic waste products. Capillaries, acquired by confocal microscopy, represent a complex net of well-separated tubes. Virtual reality approach was applied for clear visualization, as well as for capillary length measurement. The results of measurement of the length of rat brain capillaries obtained by VR approach were in accordance with results obtained by more tedious approaches ([1]) using stereological methods based on a computer generation of isotropic uniform random virtual test probes in 3D, or interactive "tracer" method based on a manual delineation in 3D stacks of images.

This work was supported by the Grant Agency of the Czech Republic (17-11898S), MEYS (LM2015062 Czech-BioImaging and CZ.02.1.01/0.0/0.0/16_013/0001775 funded by OP RDE).

References

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