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Model-based segmentation of sub-cortical nuclei for deep brain stimulation

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INTRODUCTION

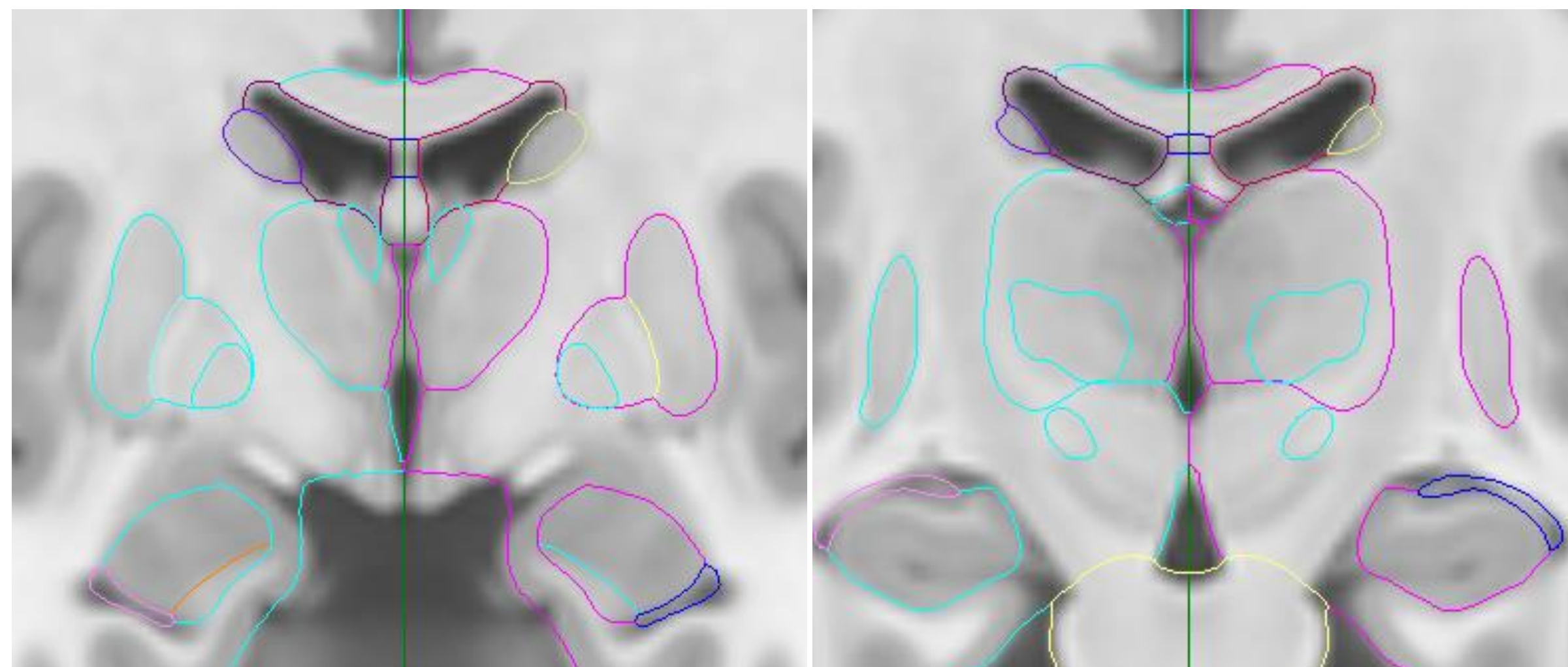
Deep Brain Stimulation (DBS) targets brain networks with abnormal neuronal firing in an attempt to synchronize brain activity and restore normal function. Clinically approved stimulation targets include the globus pallidus internus (GPI), the subthalamic nucleus (STN), the ventral intermedius nucleus (VIM), and the anterior nucleus of the thalamus (ANT).

AIM

DBS nuclei are identified either by using indirect targeting or patient-specific imaging data. Indirect targeting relies on atlas coordinates defined with respect to anatomical landmarks such as the anterior and posterior commissures. Patient-specific targeting employs multi-modal MRI for visualizing targets and identifying related functional networks. Although powerful, multi-modal imaging is time consuming, requires advanced post processing, and is still difficult to integrate in standard clinical workflows

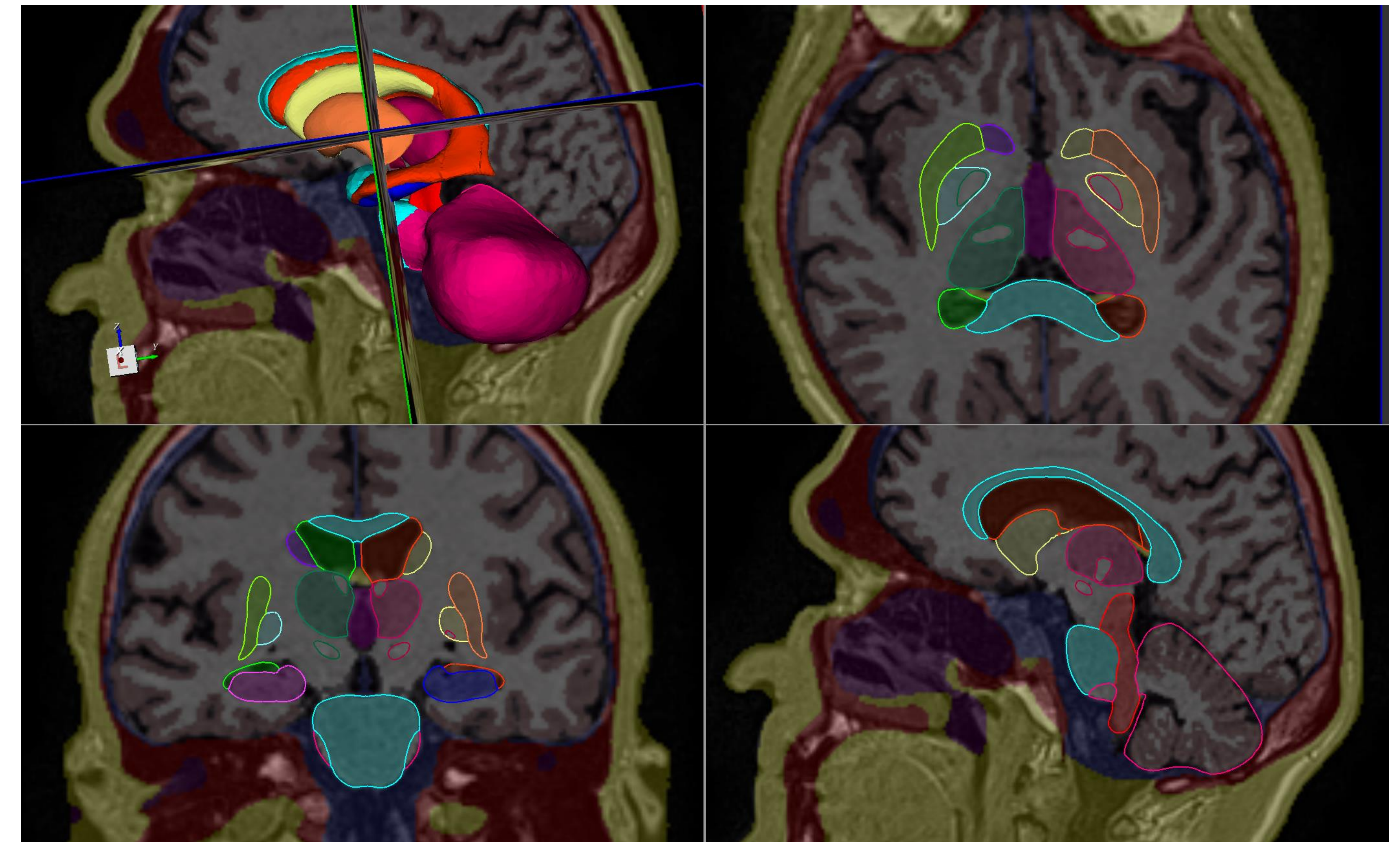
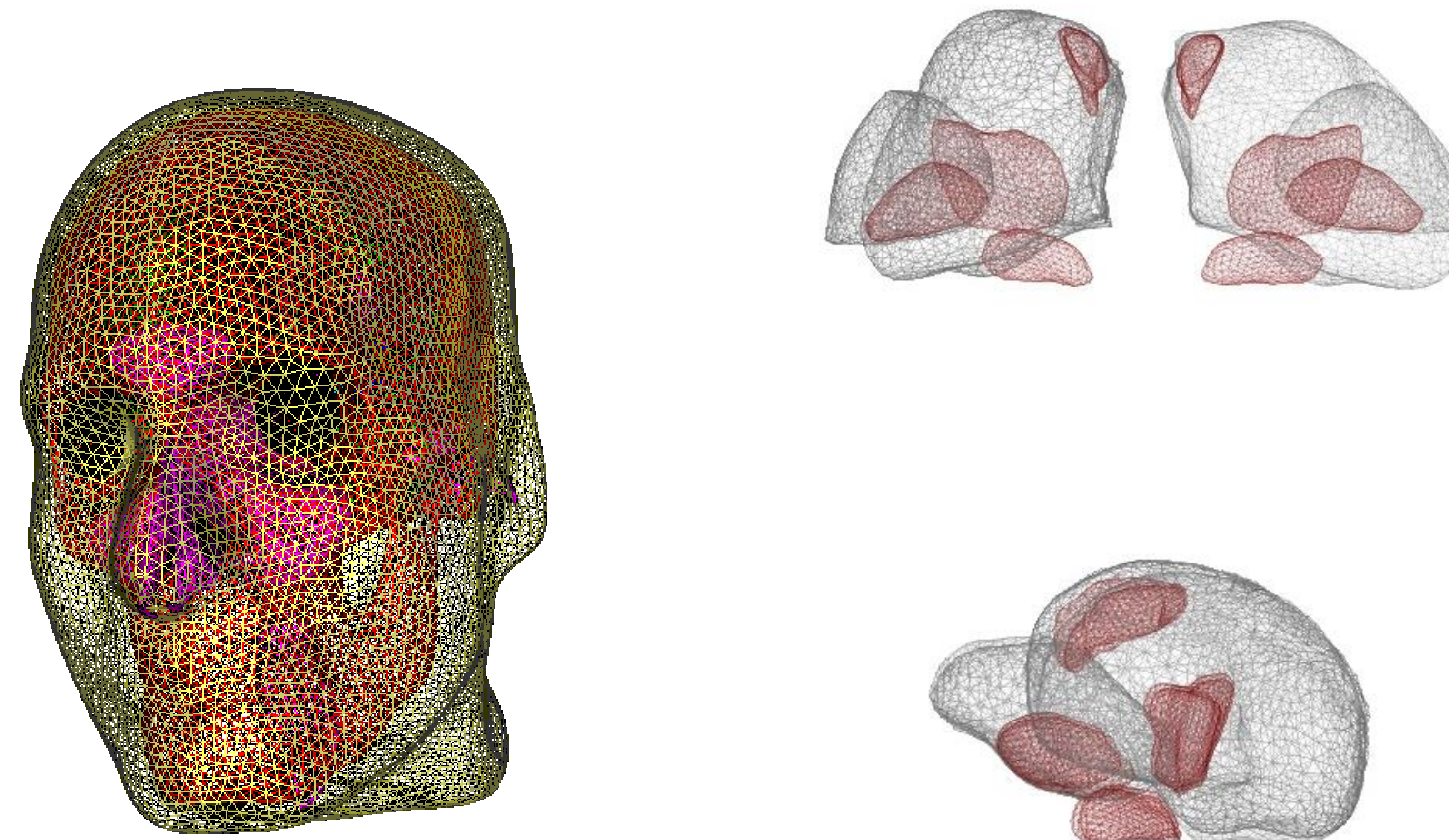
METHOD

This work presents a novel model-based approach to sub-cortical nuclei segmentation. The method needs only high resolution structural MRI to identify clinically approved DBS targets. The algorithm is based on a fully-automatic, shape-constrained deformable head model, where brain structures are represented as triangular meshes that are adapted to match local contrast at anatomical boundaries in the T1 data. The sub-cortical nuclei were added as sub-structures to the model, which adapts automatically to patient-specific MRI scans. The boundaries of the sub-cortical nuclei are represented as triangular surface meshes using their multi-modal definitions that have been adjusted to match the definitions in the DISTAL atlas.



RESULTS

The method was applied retrospectively to data acquired from minimally invasive DBS procedures performed with the ClearPoint® Neuro Navigation platform. 3-D visualization and quantitative comparison with targeted coordinates indicate the robustness of the new approach and show how it compares to target coordinates selected by neurosurgeons



CONCLUSIONS

This work demonstrates not only that shape-constrained segmentation of sub-cortical nuclei from structural T1 MRI is feasible, but also that it can benefit minimally invasive surgical interventions. In addition to providing accurate and reproducible sub-cortical nuclei segmentation, the new method greatly enhances clinical workflows.

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