3D rendering

Visualizing and comprehending 3D neuroanatomy is challenging. Cadaver dissection is limited by low availability, high cost, and the need for specialized facilities. New technologies, including the 3D rendering of neuroimaging, 3D pictures, and 3D videos, are filling this gap and facilitating learning, but they also have limitations.

A proof-of-concept study explored the feasibility of combining the spatial accuracy of 3D reconstructed neuroimaging data with realistic texture and fine anatomical details from 3D photogrammetry to create high-fidelity cadaveric neurosurgical simulations.

Methods: Four fixed and injected cadaver heads underwent neuroimaging. To create 3D virtual models, surfaces were rendered using magnetic resonance imaging (MRI) and computed tomography (CT) scans, and segmented anatomical structures were created. A stepwise pterional craniotomy procedure was performed with synchronous neuronavigation and photogrammetry data collection. All points acquired in 3D navigational space were imported and registered in a 3D virtual model space. A novel machine learning-assisted monocular-depth estimation tool was used to create 3D reconstructions of 2-dimensional (2D) photographs. Depth maps were converted into 3D mesh geometry, which was merged with the 3D virtual model's brain surface anatomy to test its accuracy. Quantitative measurements were used to validate the spatial accuracy of 3D reconstructions of different techniques.

Results: Successful multilayered 3D virtual models were created using volumetric neuroimaging data. The monocular-depth estimation technique created qualitatively accurate 3D representations of photographs. When 2 models were merged, 63% of surface maps were perfectly matched (mean [SD] deviation 0.7 ± 1.9 mm; range -7 to 7 mm). Maximal distortions were observed at the epicenter and toward the edges of the imaged surfaces. Virtual 3D models provided accurate virtual measurements (margin of error <1.5 mm) as validated by cross-measurements performed in a real-world setting.

Conclusion: The novel technique of co-registering neuroimaging and photogrammetry-based 3D models can (1) substantially supplement anatomical knowledge by adding detail and texture to 3D virtual models, (2) meaningfully improve the spatial accuracy of 3D photogrammetry, (3) allow for accurate quantitative measurements without the need for actual dissection, (4) digitalize the complete surface anatomy of a cadaver, and (5) be used in realistic surgical simulations to improve neurosurgical education [1].

1)

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