Leveraging Machine Learning for Intuitive 3D Visualization in Skullbase Neurosurgery Training

Neurosurgical training in complex neuroanatomy may be enriched by leveraging recent advances in computer vision to create & share high-resolution, low-latency 3D models for VR

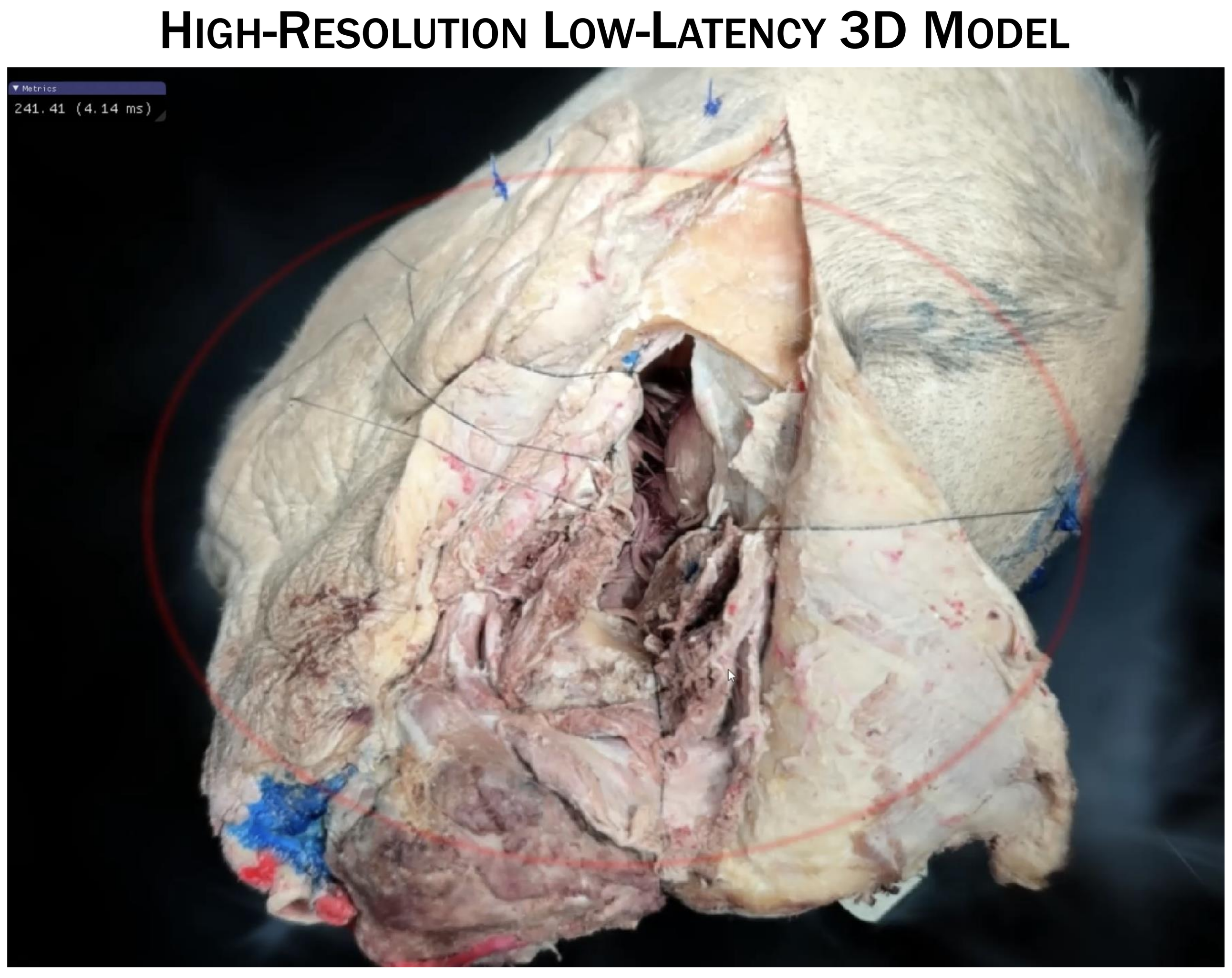
INTRODUCTION

- Skullbase neurosurgery requires a trainee to develop an intimate familiarity with 3-dimensional anatomy of the target region as well as the approach corridor.
- This begins with careful study of 2-dimensional representations including stylized drawings, exemplar dissections, and intraoperative videos.
- The transition from 2 to 3-dimensional understanding of this anatomy is challenging, often accomplished through painstaking cadaveric practice.

OBJECTIVES

Our objective was to translate the 2-dimensional teaching manuals of skullbase neurosurgery to an intuitive 3-dimesional format that directly mimics the surgeon's vantage and mobility.

High-Resolution Low-Latency 3D Model



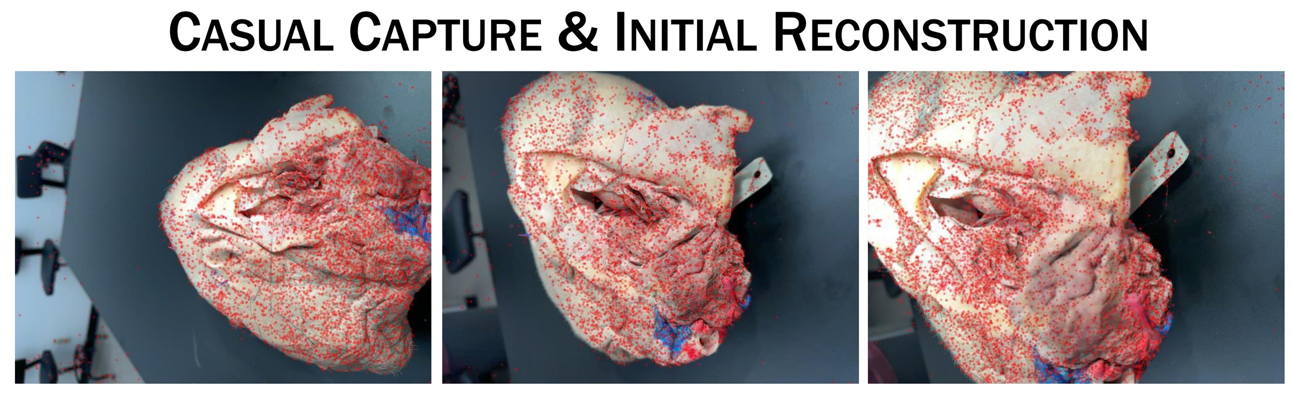
RESULTS

- With cadaveric specimens, we completed 10 classic neurosurgical approaches and captured models at 3 points in each dissection: pre-incision, dural exposure, and final intracranial view.
- The real-time rasterization of gaussian splatting enabled direct rendering of these models in Virtual Reality with a Meta Quest 3 headset.
- The casual capture and low computational costs allowed trainees to archive their own dissections for later review.
- The trainee could move freely around the dissection table and directly manipulate the view with controllers.
- This also facilitated faculty review of trainee's dissections in detail without being physically present in the lab.

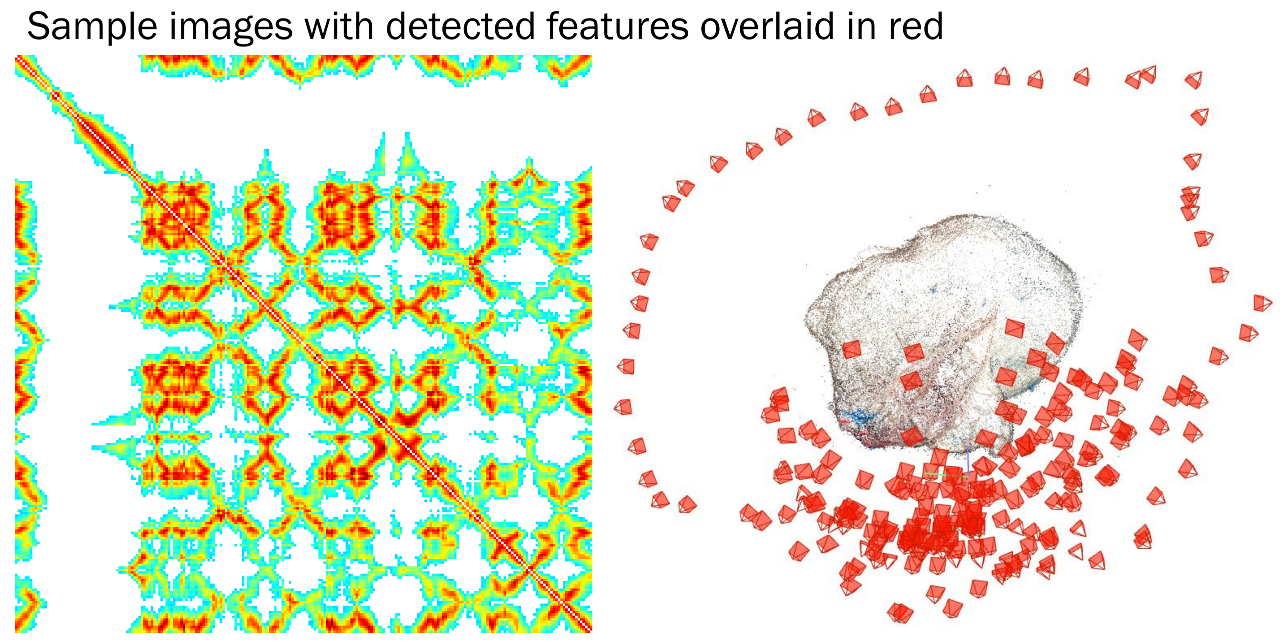
CONCLUSIONS

Neurosurgical residency training in complex neuroanatomy may be accelerated and enriched by leveraging recent advances in computer vision to create an interactive 3D manual of skullbase dissection

Casual Capture & Initial Reconstruction



Sample images with detected features overlaid in red



Matched feature density between images (left)
Sparse 3D point cloud with estimated camera positions (right)

METHODS

- Pictures of cadaveric dissections were collected using an iPhone, GoPro, endoscope, or microscope.
- 200 images were sufficient for high-quality models.
- These were spatially registered with structure-from-motion, estimating camera pose & intrinsic parameters.
- 3D gaussian splats were trained which enabled novel-view synthesis by optimizing volumetric representation using gaussian primitives defined by position, opacity, and anisotropic covariance.
- Models were trained & rendered on a NVIDIA RTX 4070.

Interacting with Models in Virtual Reality

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