Background Reading Presentation: Virtual Reality for Synergistic Surgical Training and Data Generation

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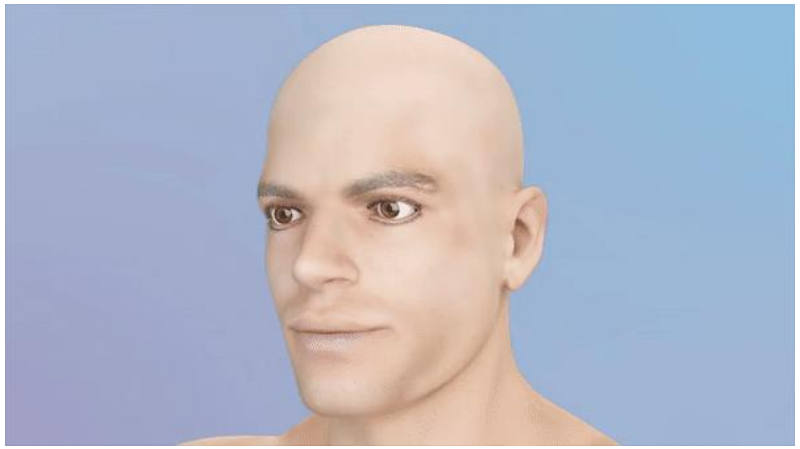
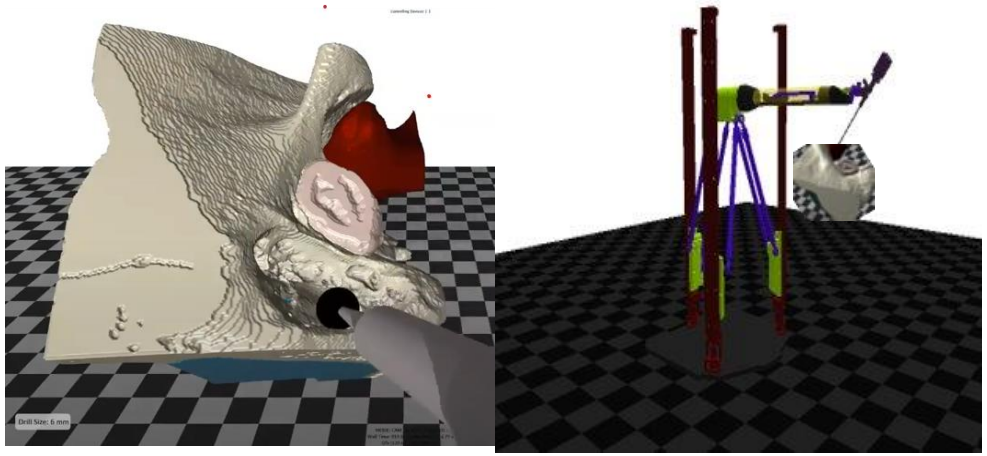
Introduction: Project Summary



Context Situation Awareness



Actual Surgical State

Simulated Surgical State

Video credit:
[1] https://www.youtube.com/watch?v=jnonLwxW2Cg

[2] Munawar, A., Li, Z., Kunjam, P., Nagururu, N., Ding, A.S., Kazanzides, P., Looi, T., Creighton, F.X., Taylor, R.H. and Unberath, M., 2021. Virtual reality for synergistic surgical training and data generation.

Introduction: Background Reading Paper

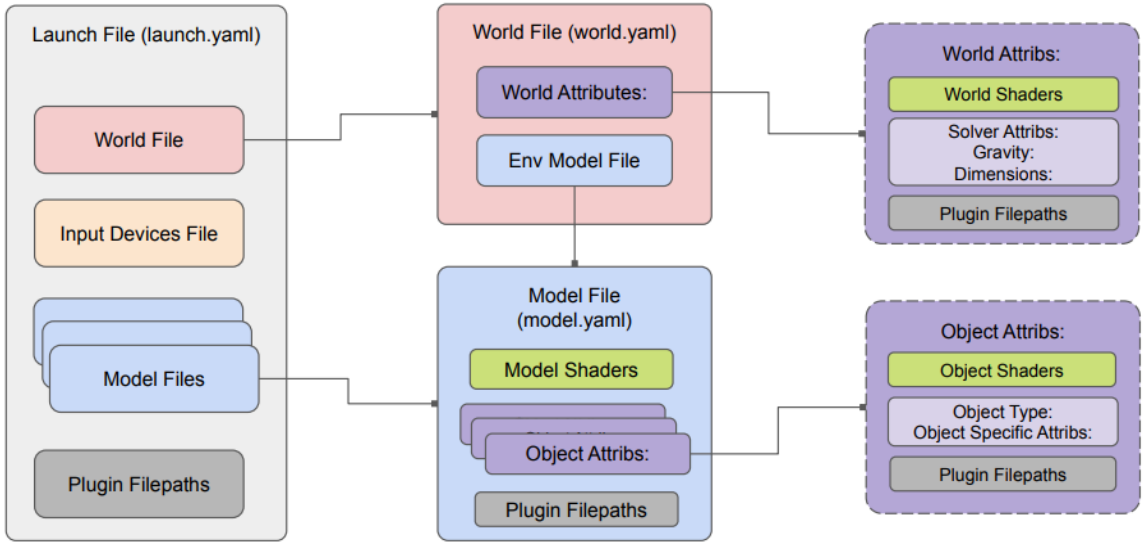
- Topic: Surgical Skill Training, Synergistic Data Generation
  - Not offered together
- Proposed by the paper:
  - Asynchronous Multibody Framework Plus (AMBF+) as solution
    - VR/haptics device enabled immersive surgical simulator for Mastoidectomy surgical skill training
    - Data generation of various kinds

Relevance to Our Project

- Framework
  - Asynchronous Multi-Body Framework (AMBF)
- Surgical Procedure
  - Mastoidectomy/Skull based surgeries
- Technical Methods
  - Volumetric drilling algorithm
  - Framework plug-ins
  - VR/Haptics supports
  - Logistics

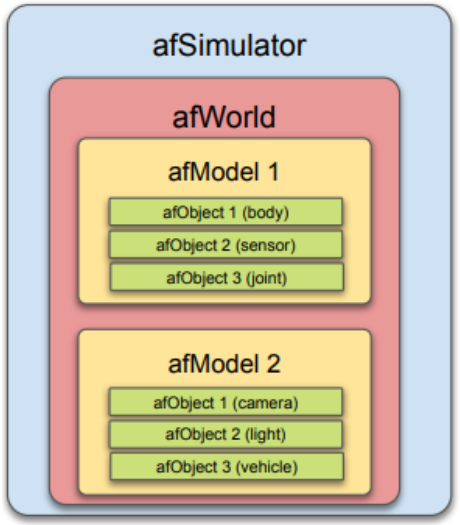
Key Components

1. AMBF Framework

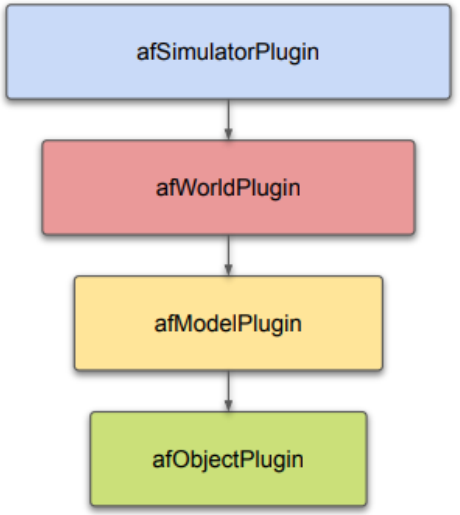


Key Components

- 2. AMBF+ Plugins



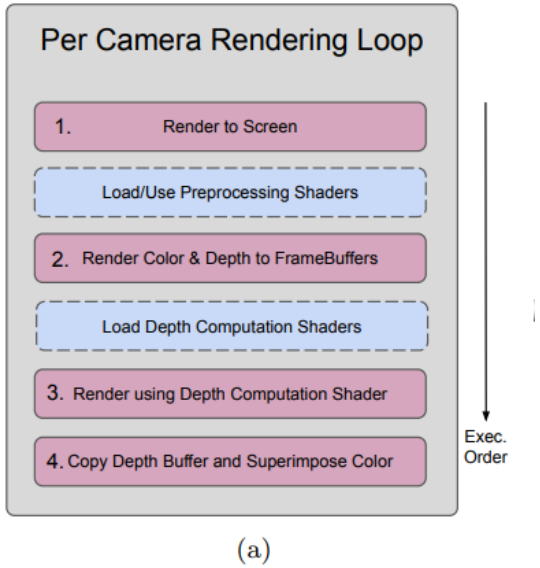
(a)



(b)

Key Components

- 3. Rendering Pipeline

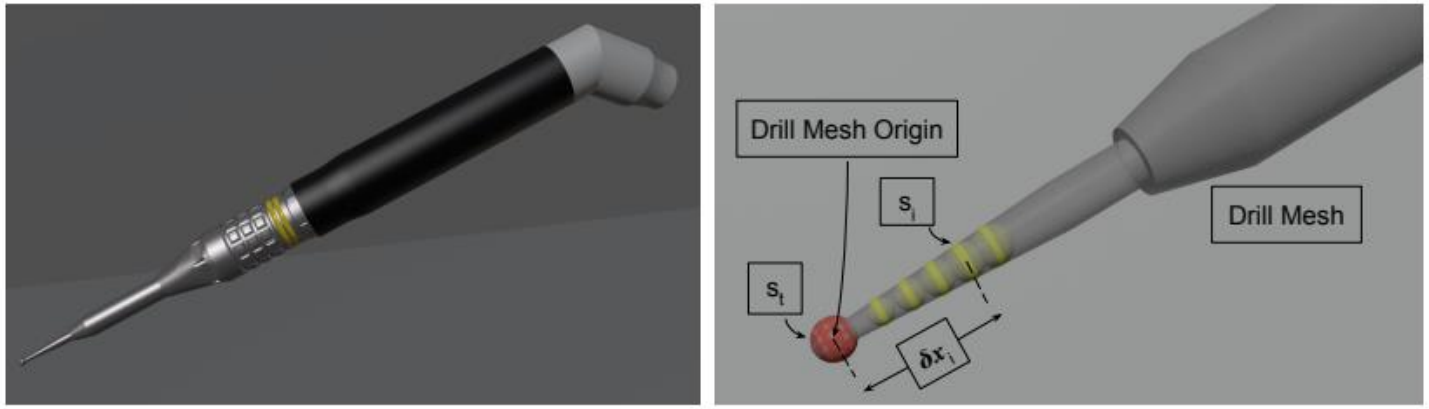


(a)

- 4. Data Streaming and Recording

Key Components

- Simulation Setup and Haptic Feedback



(a) (b)

Experimental Evaluation

- Patient Anatomy Tracking

- Depth Estimation using Transformer Networks

Results: Pose Tracking

- Moving Camera has significantly greater error than moving drill, which can be problematic in a clinical setting.
- Data was easily generated and processed by moving a camera and drill in simulated space

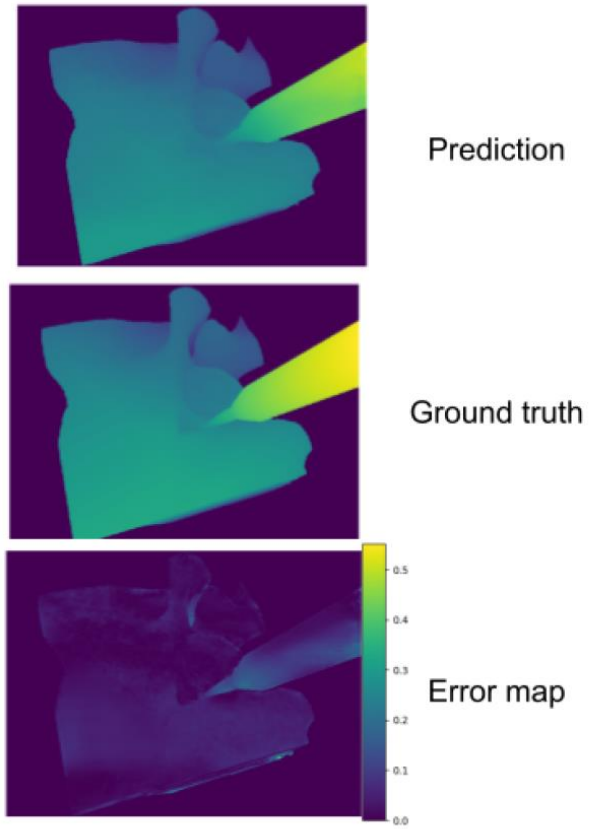
Table 1. Quantitative result (mean and standard deviation of L1 error) of ORB SLAM V3 applied on the synthetic stereo microscopic data generated by the drilling simulator.

	Translation Error (mm)	**Rotation Error (deg)**
Moving camera	40.97 ± 22.40	8.44 ± 3.07
Moving drill	8.1E-1 ± 9.1E-1	3.2E-3 ± 3.6E-3

[1]

Results: Stereo Depth Estimation

- Prediction has low deviation from the ground truth
- Predictions tested on deformed scene, while network was trained on undeformed data
  - Validates STTR network
  - Showcases simulator framework as a simple and cost-effective alternative for gathering data



(b)

Figure 8. b.) Visualization of depth prediction from STTR [1]

Critical Review

- Strengths
  - Strong overview of novel simulation framework AMBF+
  - Specific use-case provided
- Weaknesses
  - Did not fully showcase some key features of simulator such as:
    - Surgical Training
    - Improving patient surgical outcome
    - Ability to seamlessly handle parallel robot
- Key Takeaways
  - Our project sets up the groundwork necessary to conduct studies to prove the ability of the joint system in answering some of these questions, i.e. improving patient surgical outcomes

References

- [1] Adnan Munawar, Zhaoshuo Li, Punit Kunjam, Nimesh Nagururu, Andy S. Ding, Peter Kazanzides, Thomas Looi, Francis X. Creighton, Russell H. Taylor & Mathias Unberath (2021) Virtual reality for synergistic surgical training and data generation, Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization, DOI: 10.1080/21681163.2021.1999331

QUESTIONS?