HAAG Weekly Report (Simplified) – Omar Moursy – 3D Modeling

Time-Log

What did you do this week?

- Created website for 3D Modeling project https://sites.gatech.edu/3dmodeling/
- Uploaded the Weekly reports and meeting recordings for Weeks 1, 2 & 3. Setup the website to mirror the Natural Florida History Museum project website https://sites.gatech.edu/nfhm/
- Had our first meeting with Dr. Porto on Tuesday 21st of January in which he shared his work and motivation for this project. This provided us with a very good starting point to do more research for the project.
- Read through Dr. Gatti's paper to compare his Neural Shape Model approach to Dr. Hirose's approach from last week.

What are you going to do next week

- Add the missing sections in the 3D Modeling website and upload any missing documents
- Setup the GitHub repo that Nikita has created on my desktop for collaboration.
- Read the articles and test out the 3D Modeling datasets shared by Dr. Porto
- Read through CPD paper and related works to explore how we can incorporate SSMs into the current algorithm used by Dr. Porto's ALPACA tool.

Blockers, things you want to flag, problems, etc.

- I believe most of us were not aware of the different deadlines and processes followed by the HAAG team and where to find them when we first started, this explains some of the missing deadlines in the first 2 weeks. I believe we are getting better at following these now, however earlier and more clear communication regarding these would also be appreciated.

Abstracts:

ShapeMed-Knee: A Dataset and Neural Shape Model Benchmark for Modeling 3D Femurs

https://pubmed.ncbi.nlm.nih.gov/38766040/

Abstract — Analyzing anatomic shapes of tissues and organs is pivotal for accurate disease diagnostics and clinical decision-making. One prominent disease that de- pends on anatomic shape analysis is osteoarthritis, which affects 30 million Americans. To advance osteoarthritis di- agnostics and prognostics, we introduce ShapeMed-Knee, a 3D shape dataset with 9,376 high-resolution, medical- imaging-based 3D shapes of both femur bone and cartilage. Besides data, ShapeMed-Knee includes two benchmarks for assessing reconstruction accuracy and five clinical prediction tasks that assess the utility of learned shape representations. Leveraging ShapeMed-Knee, we develop and evaluate a novel hybrid explicit-implicit neural shape model which achieves up to 40% better reconstruction accuracy than a statistical shape model and two implicit neural shape models. Our hybrid models achieve state- of-the-art performance for preserving cartilage biomarkers (root mean squared error → 0.05 vs. → 0.07, 0.10, and 0.14). Our models are also the first to successfully pre- dict localized structural features of osteoarthritis, outper- forming shape models and convolutional neural networks applied to raw magnetic resonance images and segmen- tations (e.g., osteophyte size and localization 63% accu- racy vs. 49-61%). The ShapeMed-Knee dataset provides medical evaluations to reconstruct multiple anatomic sur- faces and embed meaningful disease-specific information. ShapeMed-Knee reduces barriers to applying 3D modeling in medicine, and our benchmarks highlight that advance- ments in 3D modeling can enhance the diagnosis and risk stratification for complex diseases. The dataset, code, and benchmarks are freely accessible. (not necessary to read all articles read abstract and figures), or a paper whose content is relevant to your work.

Summary: The ShapeMed-Knee paper introduces a novel dataset containing 9,376 3D models of femur bones and cartilage derived from MRI scans, aimed at advancing osteoarthritis (OA) diagnostics and shape modeling in medicine. The authors propose a hybrid explicit-implicit neural shape model (NSM) that outperforms traditional statistical shape models (SSMs) and other implicit neural models in reconstructing both healthy and diseased joints. This model excels at capturing disease-specific features, such as cartilage thinning and osteophytes (bone spurs), which are critical in OA progression. The dataset supports seven evaluation benchmarks, including reconstruction accuracy, preserving cartilage biomarkers, and clinical prediction tasks like OA diagnosis, staging, and future disease progression. The hybrid NSM demonstrated superior performance in localizing and quantifying disease features and predicting clinical outcomes compared to SSMs and convolutional neural networks (CNNs). Additionally, the NSM's latent space enables interpretable manipulations, such as simulating disease progression and editing specific anatomical features, making it a versatile tool for both research and clinical applications.

What did you do and prove it

I mainly was catching up this week on some of the missing tasks such as project website creation and uploading the weekly reports and meeting recordings here https://sites.gatech.edu/3dmodeling/

I also read the paper by Dr. Gatti explained above. I went over a survey paper on non rigid transformation to get a better idea on related works and advances in this field of 3D modeling predictions.

Links to the papers:

https://pubmed.ncbi.nlm.nih.gov/38766040/

https://arxiv.org/pdf/2103.02690