AUGMENTED REALITY IN HEALTHCARE

Team 8

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ABSTRACT

Medical imaging technologies such as X-rays, MRI, and CT scans have revolutionized diagnostics by offering detailed internal views to detect conditions like fractures, deformities, and organ abnormalities. However, these images are predominantly displayed in 2D formats, posing challenges in visualizing and comprehending complex 3D anatomical structures. Clinicians must often mentally reconstruct these relationships from multiple 2D slices, increasing the likelihood of spatial perception errors. Our project addresses this limitation by developing a solution that converts 2D medical imaging data into highly detailed 3D models and further integrates them into Web-based Augmented Reality (WebAR). This approach enables real-time, interactive visualization of anatomical structures, enhancing disease analysis, surgical planning, and patient education. By leveraging WebAR to offload computational tasks to the cloud, our project overcomes device limitations, providing an accessible and intuitive platform for medical professionals and patients alike, ultimately improving diagnostic accuracy and clinical outcomes.

INTRODUCTION

- **Medical Imaging:** Technologies like X-rays, MRI, and CT scans provide detailed internal views, but are often limited to 2D images.
- **Challenges with 2D:** Visualizing complex 3D structures from 2D images is difficult, especially for analyzing bone fractures and deformities.
- **Augmented Reality (AR):** AR offers an innovative way to convert 2D imaging data, such as X-rays, into 3D models for improved understanding and analysis.
- **Project Focus:** Developing an AR tool that emphasizes 2D-to-3D conversion for medical images, enabling real-time visualization of structures using ARCore/ARKit.
- **Applications:** The AR tool will support diagnostics, surgical planning, and medical education by simplifying the analysis of skeletal anatomy.

LITERATURE SURVEY

No.	Year	Author	Title	Summary	Key Findings	Drawbacks
1	2021	Pak-Hei Yeung	Learning to Map 2D Ultrasound Images into 3D Space with Minimal Human Annotation	Uses CNN to map 2D ultrasound images into 3D space, with self-supervised learning to generate 3D predictions. Benchmarks on real and synthetic fetal brain ultrasound scans showed performance gains.	Pairwise comparison of images, attention mechanism improves prediction. Generalizes well to freehand ultrasound sequences. Outperforms baseline models by 23%.	Poor performance in outer brain regions, dependency on input image count for accuracy, complexity in training and data generation, occasional misalignment with real-world scans.
2	2020	Satya P. Singh	3D Deep Learning on Medical Images: A Review	Comprehensive review on 3D deep learning applications in medical imaging, including segmentation, classification, detection, and localization for modalities like MRI, CT, PET. Covers architectures like U-Net for organ and lesion segmentation, and CNNs with LSTM for disease classification.	3D CNNs provide superior performance in organ segmentation, lesion detection, and disease classification. Integration with LSTMs improves neuroimaging classification.	High computational cost, small datasets lead to overfitting, and class imbalance for rare conditions like tumor detection.
3	2021	Ryoya Shiode	2D–3D Reconstruction of Distal Forearm Bone from Actual X-ray Images Using CNNs	Proposes a CNN and GAN-based method for reconstructing 3D models of the forearm bones (radius and ulna) from 2D X-rays, using DRR-like images to augment small datasets.	High reconstruction accuracy of 1.05mm for the radius and 1.45mm for the ulna, with promising results for replacing CT scans in orthopedics.	Lower accuracy for ulna reconstructions, limited dataset of healthy bones reduces generalizability, single-direction X-rays lead to lower accuracy compared to multi-directional imaging.
8	2019	Nicole Wake	Creating Patient-Specific Anatomical Models for 3D Printing and AR/VR	A step-by-step guide on creating 3D printable and AR/VR-compatible anatomical models from medical imaging data for cranio-maxillofacial, orthopedic, and renal cancer cases.	Enables patient-specific anatomical models for surgical planning and education using DICOM data. Courses on the technique offered at medical conferences.	Complex multi-step process, high technical requirements, and the potential for the technique to become outdated due to rapid technological changes.
11	2022	Yong-Qin Wang	AR and Fracture Mapping Model for Femoral Neck Fractures: A Proof-of-Concept	Explores the use of AR for visualizing femoral neck fractures, revealing fracture patterns and suggesting AI integration for procedure planning and improved outcomes.	AR visualizations of fracture patterns offer potential for enhanced surgical planning with AI integration.	Limited exploration of real-time benefits, user experience not addressed, and no technical validation for AR accuracy and usability in clinical settings.

LITERATURE SURVEY

1. Technological Advancements in 3D Reconstruction:

- CNNs and GANs are extensively used for reconstructing 3D models from 2D medical images (e.g., ultrasound, X-ray, CT scans).

2. Use Cases and Applications:

- Applications range from fetal brain ultrasound imaging to orthopedic bone reconstructions and AR/VR-based fracture mapping.
- Patient-specific anatomical models are being used for surgical planning, education, and even 3D printing.

3. Strengths of Existing Techniques:

- Improved diagnostic accuracy through high-resolution 3D reconstructions.

4. Challenges and Drawbacks:

- Computational complexity and high resource requirements limit scalability.

5. Future Potential:

- Integration of AI and AR for better visualization and fracture pattern mapping.

RESEARCH GAP

EXISTING	PROPOSED
CNNs for 2D-to-3D reconstruction face challenges like image misalignment and quality issues.	Integrate AI algorithms to improve alignment and model quality, requiring minimal data input.
3D CNNs like U-Net suffer from high computational costs and class imbalances in segmentation tasks.	Use cloud-based WebAR systems to offload computational tasks, enabling lightweight and efficient processing.
AR tools for medical education and surgery planning are hardware-dependent and limited in real-time use.	Develop a WebAR solution to eliminate expensive hardware dependencies and enable real-time, accessible interaction with 3D medical models.
AR solutions in diagnostic imaging and orthopedics lack validation and real-time interaction capabilities.	Rigorous validation and optimization for real-time, interactive 3D models tailored to clinical and educational use cases.
Converting DICOM files to AR-compatible models is complex and inaccessible to non-experts.	Streamline the conversion process to create user-friendly tools for non-expert adoption, enhancing usability in clinical and educational settings.

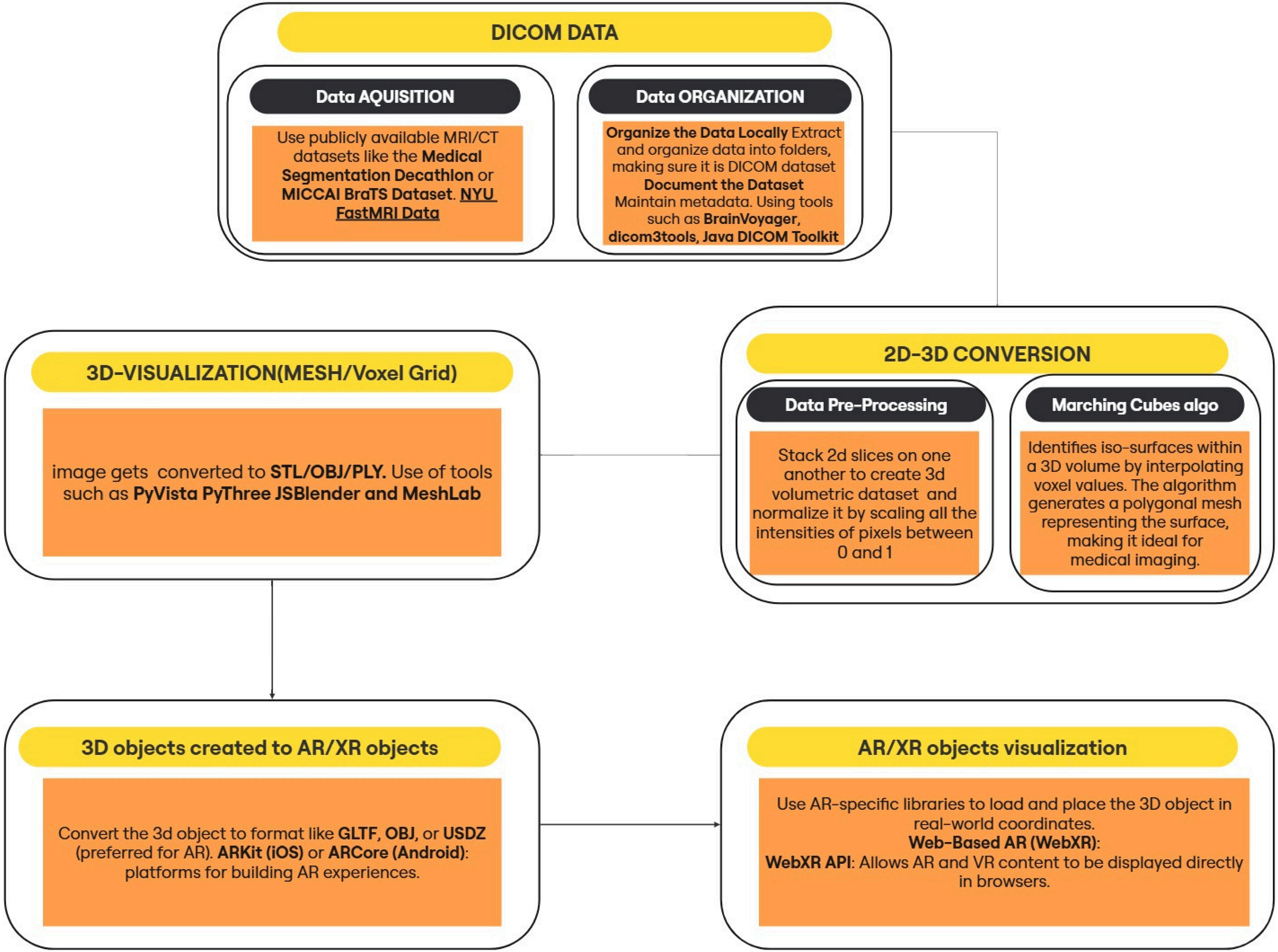
PROBLEMS

- **Limited Spatial Understanding:** X-ray images and other 2D medical imaging formats lack full 3D visualization, which can lead to errors in diagnosis and treatment planning.
- **Current AR Solutions:** Existing AR tools often require expensive hardware like HoloLens and are not optimized for X-ray data or real-time interaction.
- **Need for an Accessible AR Tool:** There is a need for a cost-effective AR application that allows accurate and real-time interaction with 3D bone models, enhancing clinical workflows while being accessible via mobile devices.

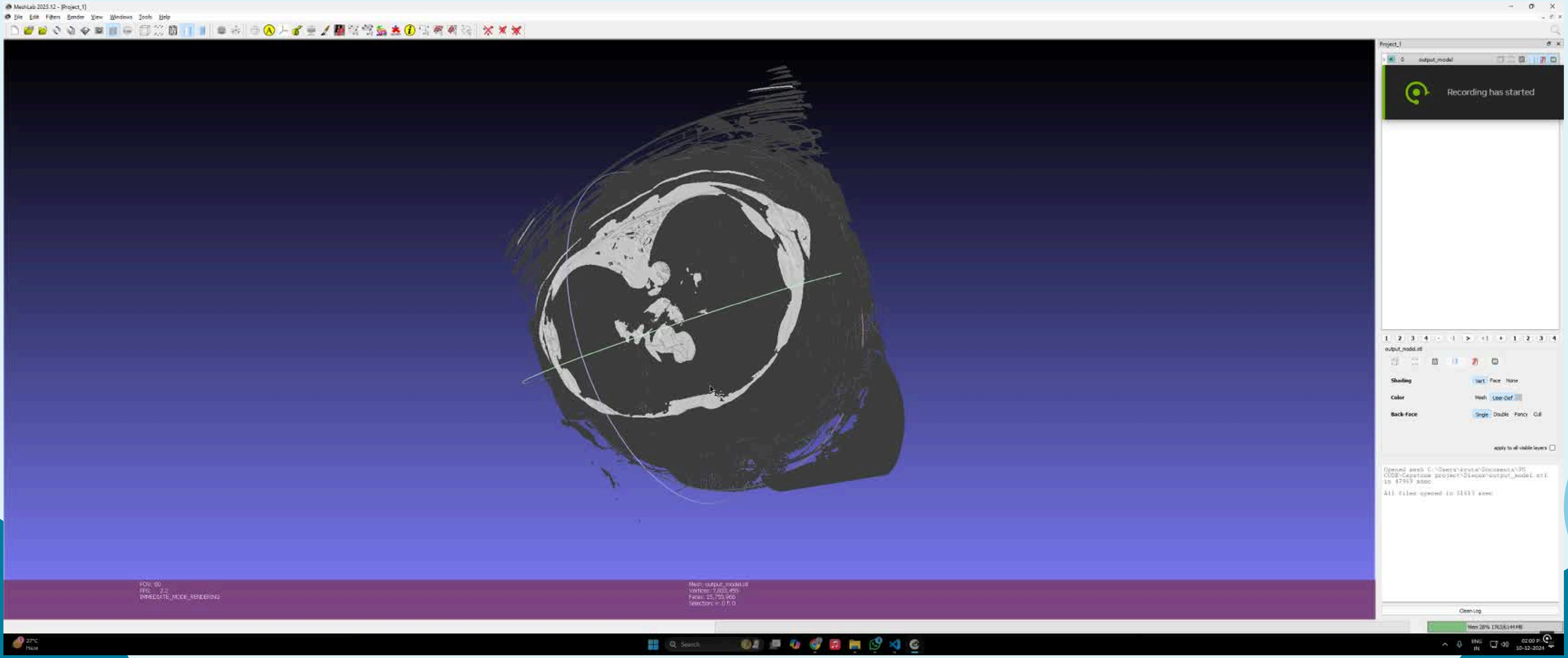
PROPOSED SOLUTION

- **3D Model Reconstruction:** Utilize tools like 3D Slicer and ITK-SNAP to convert 2D X-ray images into precise and interactive 3D models, specifically optimized for image visualization.
- **Augmented Reality Integration:** Leverage AR technology to overlay 3D bone models onto real-world environments, allowing medical professionals to interact with them intuitively in real time.
- **Web-Based Accessibility:** Implement a WebAR solution for accessing and manipulating 3D models directly through web browsers, eliminating the need for expensive AR hardware.
- **Interactive Features:** Enhance the application with functionalities such as model manipulation (zoom, rotate), annotations, and multi-layer views to enable detailed analysis of bone structures and fractures.
- **Optimized Performance for Medical Use:** Streamline the 3D models for seamless real-time AR usage in medical environments, ensuring high accuracy and performance without requiring extensive computational resources.

METHEDOLOGY


DICOM DATA
Data AQUISITION
Use publicly available MRI/CT datasets like the **Medical Segmentation Decathlon** or **MICCAI BraTS Dataset**. **NYU FastMRI Data**
Data ORGANIZATION
Organize the Data Locally Extract and organize data into folders, making sure it is DICOM dataset
Document the Dataset
Maintain metadata. Using tools such as **BrainVoyager**, **dicom3tools, Java DICOM Toolkit**
2D-3D CONVERSION
Data Pre-Processing
Stack 2d slices on one another to create 3d volumetric dataset and normalize it by scaling all the intensities of pixels between 0 and 1
Marching Cubes algo
Identifies iso-surfaces within a 3D volume by interpolating voxel values. The algorithm generates a polygonal mesh representing the surface, making it ideal for medical imaging.
3D-VISUALIZATION(MESH/Voxel Grid)
image gets converted to **STL/OBJ/PLY.** Use of tools such as **PyVista PyThree JSBlender and MeshLab**
3D objects created to AR/XR objects
Convert the 3d object to format like **GLTF, OBJ,** or **USDZ** (preferred for AR). **ARKit (iOS)** or **ARCore (Android)**: platforms for building AR experiences.
AR/XR objects visualization
Use AR-specific libraries to load and place the 3D object in real-world coordinates.
Web-Based AR (WebXR):
WebXR API: Allows AR and VR content to be displayed directly in browsers.

IMPLEMENTATION



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THANK YOU