வணக்கம்

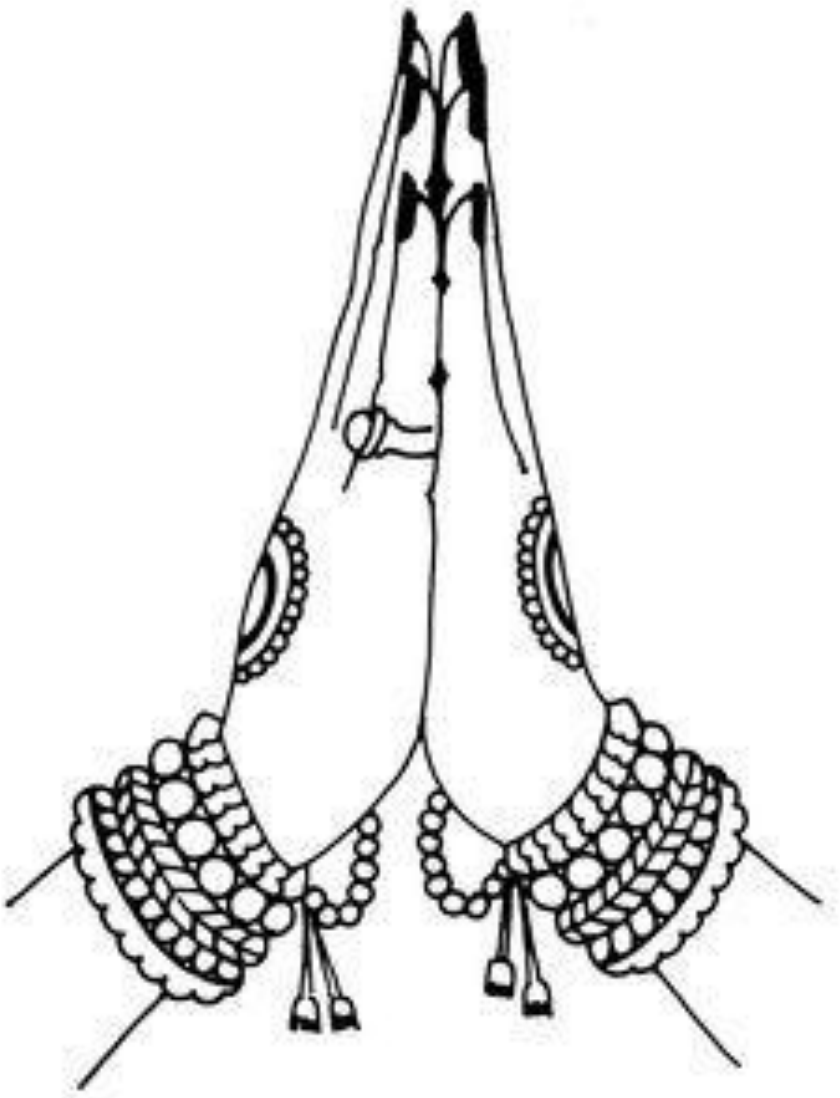
From the land of Tamils

யாதும் ஊரே; யாவரும் கேளிர்;

"Yaadhum Oore Yaavarum Kelir"
is a famous ancient Tamil phrase meaning

"All towns are our own, and all people are our kin".

Written by the poet **Kaniyan Poongundranar** over 2,000 years ago in **Purananuru**, it emphasizes universal brotherhood, humanity, and equality, essentially meaning the whole world is one family.



Extended Reality in Healthcare

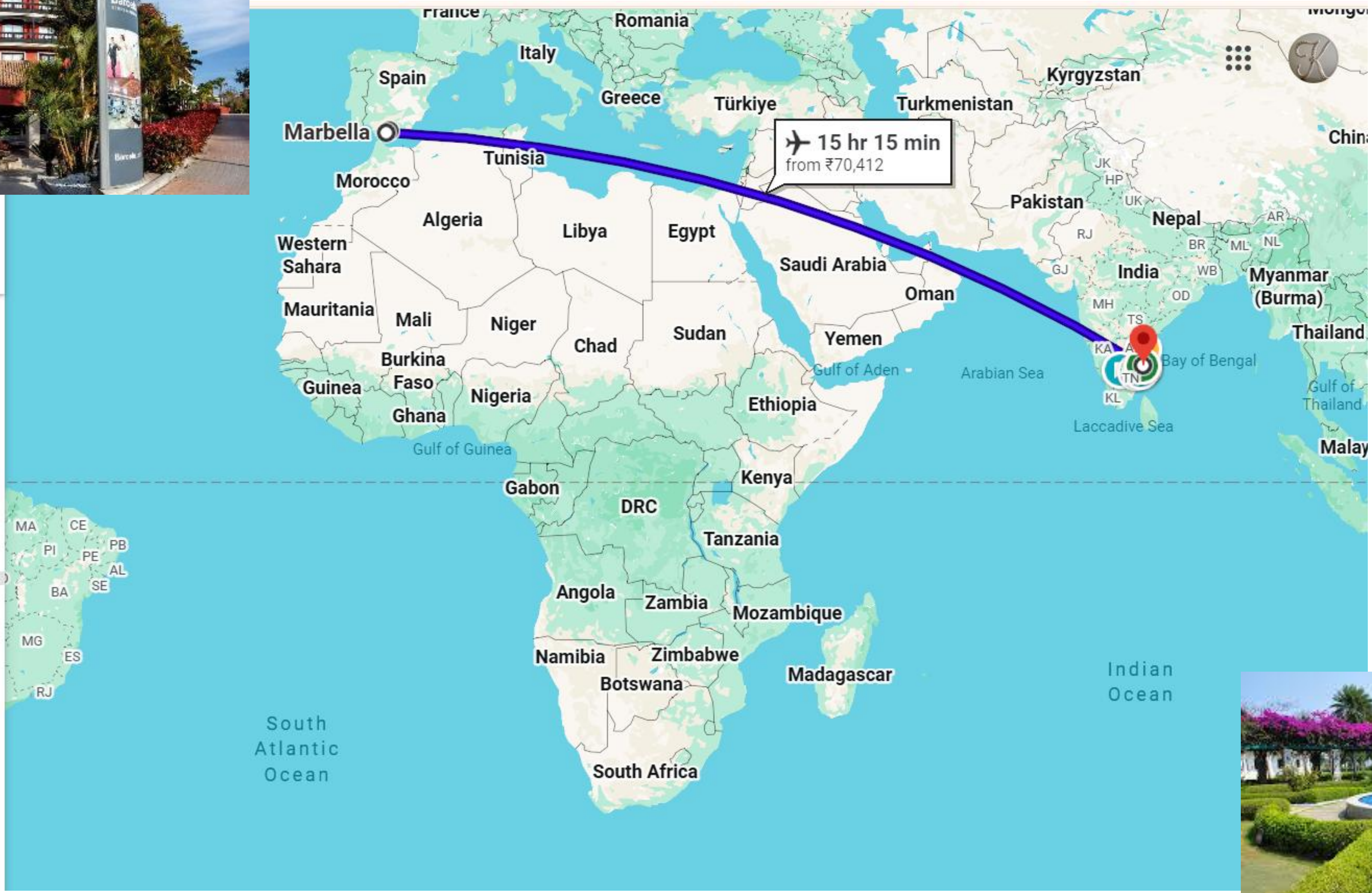
Dr. Kavitha Anandan

Professor & Head

Department of Biomedical Engineering

Centre for Healthcare Technologies

SSN College of Engineering. Chennai, India



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Pakistan
Nepal
India
Western Sahara
Saudi Arabia
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Mauritania
Mali
Niger
Chad
Sudan
Yemen
Thailand
Burkina Faso
Guinea
Nigeria
Ghana
Ethiopia
Gulf of Aden
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Bay of Bengal
Gulf of Thailand
Laccadive Sea
Gulf of Guinea
Malay
Gabon
Kenya
DRC
Tanzania
Angola
Zambia
Mozambique
Namibia
Zimbabwe
Botswana
Madagascar
South Africa
South Atlantic Ocean
Indian Ocean

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INTRODUCTION

- Extended Reality (XR) includes
  - Augmented Reality (AR),
  - Virtual Reality (VR), and
  - Mixed Reality (MR)

which allow digital and physical worlds to be merged in allowing immersion and engaging visualization.

- XR technologies are enhanced with advances in head-mounted displays, real-time tracking, rendering, and haptic interfaces
- Technologies like image guided surgery and VR therapy are becoming essential, high-impact tools in modern medicine.
- Can be used in applications where spatial knowledge and skill-based training is required.
- XR in Healthcare enhances precision in procedures and improves patient outcomes.

Dr. Sudhir, Spine Surgeon at SRIHER, India

VR Implementation at Shiv Nadar School, India

THE NEED FOR AR IN SURGICAL PLANNING AND SIMULATION

Image Courtesy – OR at SRIHER, Chennai, India

1. **Visualization of Complex, Hidden Anatomy** - In spinal surgery, AR helps visualize nerve roots and bone structures.
2. **Fatigue, Cognitive Load, and "Context Switching"** - A Head mounted display keeps all critical data in the surgeon's direct line of sight. This eliminates the need to look away, reducing inattentional blindness and cognitive load.
3. **Precision in Instrument Navigation** - AR allows surgeons to track instruments in real time, projecting the exact trajectory on the patient
4. **Reduced Radiation Exposure** - preoperative 3D data overlaid with real-time navigation, AR reduces the need for repeated intraoperative fluoroscopy, minimizing radiation exposure
5. **Managing Tissue Deformation** - intraoperative ultrasound or near-infrared fluorescence, allowing the 3D model to update and stay registered with the actual anatomy
6. **Training and Remote Assistance** - AR allows for preoperative rehearsal, allowing surgeons to practice on a digital "twin" of the patient

INTRODUCTION – XR @ SSN

The XR-based projects at the Centre for Healthcare Technologies, SSN College of Engineering, Chennai, India

in two major domains

(i) AR in clinical applications and

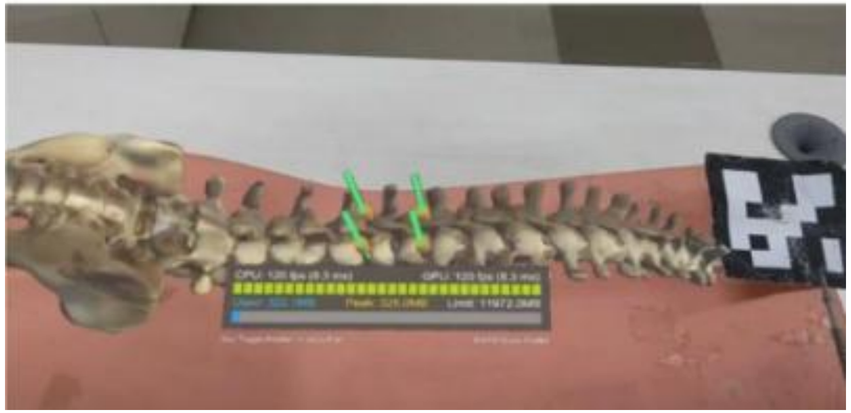
(ii) VR in education and training.

Surgical navigation and training systems - created in the AR domain, including

- AR-assisted spine and liver surgery,
- using the AR- guided 3D models of the anatomies,
- tracking of tools in real- time, and
- visualization of the ultrasound images over the surgeon's view to enhance perception of depth and precision during the surgery.

Also, Immersive environments have been created in the

- VR space, both in learning and rehabilitation, particularly in children with neurodevelopmental disorders.



AR environment created at SSN

VR Implementation at Shiv Nadar School, India

AUGUMENTED REALITY

- Virtual and augmented reality (VR/AR) offers
  - unprecedented levels of immersion
  - capability to seamlessly blend digital and physical spaces.

- However, even small amounts of disparity distortion can negatively affect the experience.

- Accurate depth perception is crucial for creating realistic and immersive AR experiences.

XR at SSN aims to address critical challenges in AR by
- improving the understanding of depth perception
- quantifying errors and
- analysing user performance.

We seek to enhance the realism, accuracy, and usability of AR applications across various medical domains.

AUGMENTED REALITY – Surgical Tracking And Rehabilitation

SURGICAL TRACKING

- AR-Based Spine Surgery Support and Depth Perception
- Haptic Feedback for AR-Based Surgical Support Systems
- AR-Guided Liver Surgery with Real-Time Tool Tracking Approach
- XR-Assisted Liver Surgery: Visualizing Using a Head-mounted Display (HMD)

REHABILITATION

- AR-Based Physical Therapy Assistant

SURGICAL TOOL TRACKING

Study 1 : Computer Vision Methods for Surgical Tool Tracking

Six **object tracking algorithms**, tested for surgical tool tracking

- Boosting Tracker,
- Multiple Instance Learning (MIL)
- Kernelized Correlation Filters (KCF)
- Median Flow Trackers,
- Minimum Output Sum of Squared Error (MOSSE)
- Channel and Spatial Reliability Tracking (CSRT)

Methodology

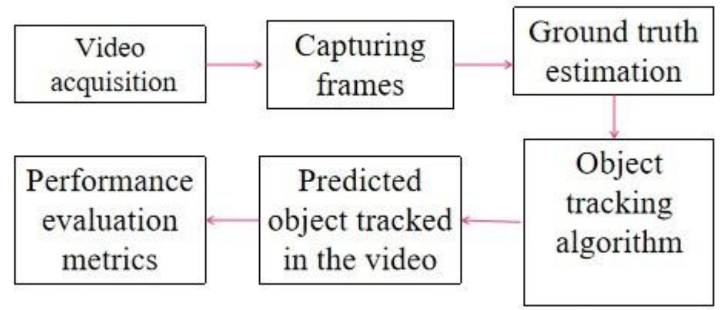


Figure 2. Analysis of detection and tracker approach

Performance metrics analysis

IoU (a,b) = Area(a) ∩ Area(b) / Area(a)∪Area(b) **(1)**

IoM (a,b) =Area(a) ∩ Area (b) / min (Area(a), Area (b)) **(2)**

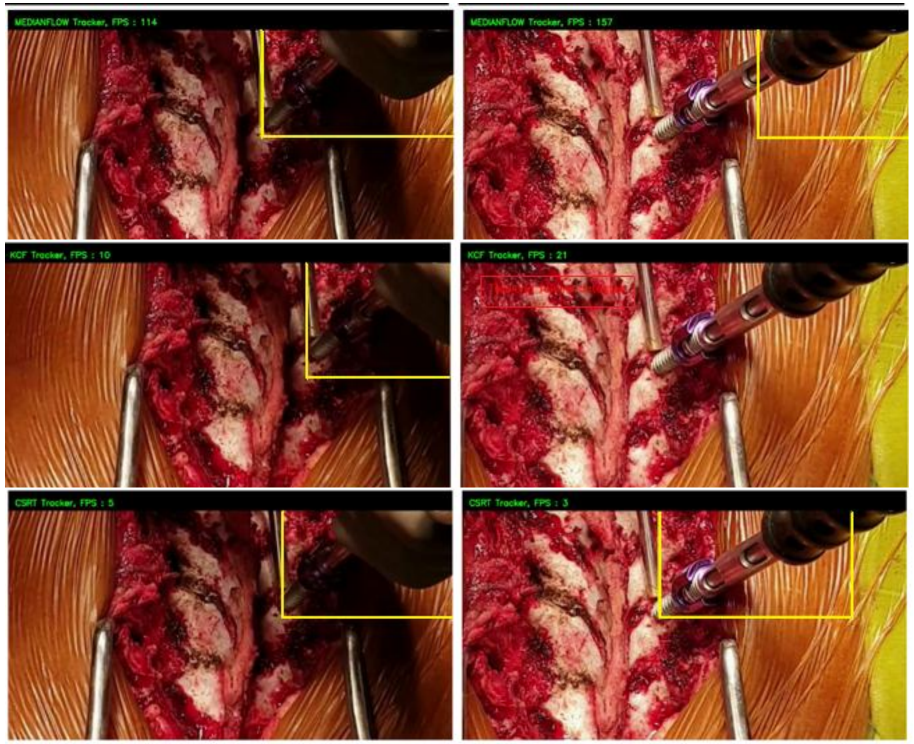


Figure 3. **Sample frame in which the tracked tool position is marked by a yellow bounding box**

Results

MIL and CSRT models outperforming other algorithms with perfect overlap in terms of performance metrics.

TABLE I. Overlap Ratio(IoU)

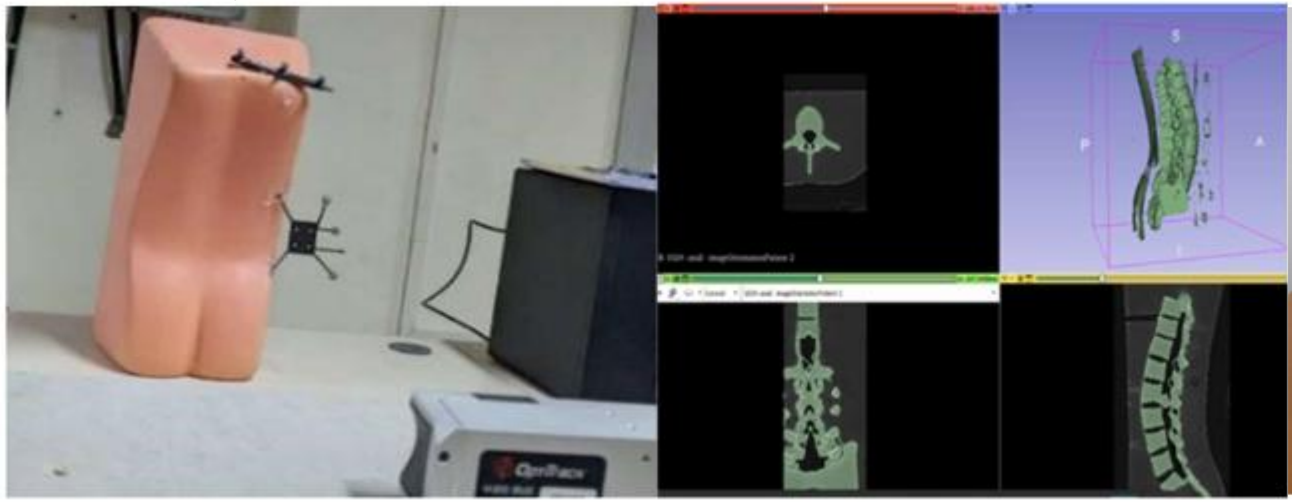
Algorithm	Frames	Overlap Ratio Range
CSRT	0-182	0.65-0.85
MIL	0-182	0.95-0.65
MOOSE	Tracking Failure	
KCF	Tracking Failure	
Median Flow	0-182	0.95-0.16
Boosting	0-182	0.1-0.08

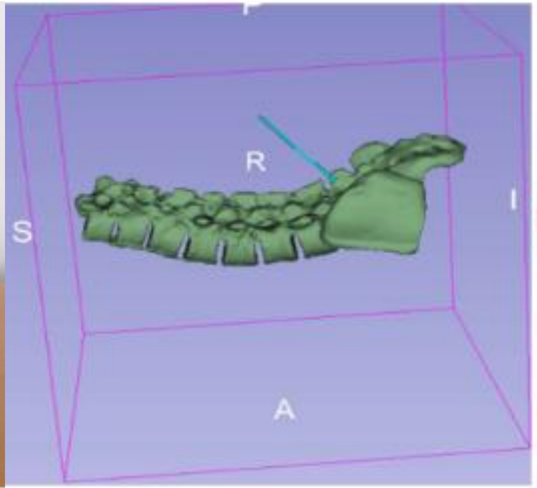
PRAVIN KUMAR S., KAVITHA A, DARSANA G, SUDHIR G., Computer Vision Methods For Surgical Tool Tracking, Proceedings of the IEEE EMBC, Australia, 2023

Study 2: Enhancing visualization of surgical tool through integrated motion tracking system

Navigation technology with minimal infrastructural requirement that supports surgical operations with a real-time non-obstructive view of surgical field enabling the surgeon to see three-dimensional (3D) structures of medical images.

System integrates optitrack hardware and 3D slicer software for visualization and image analysis





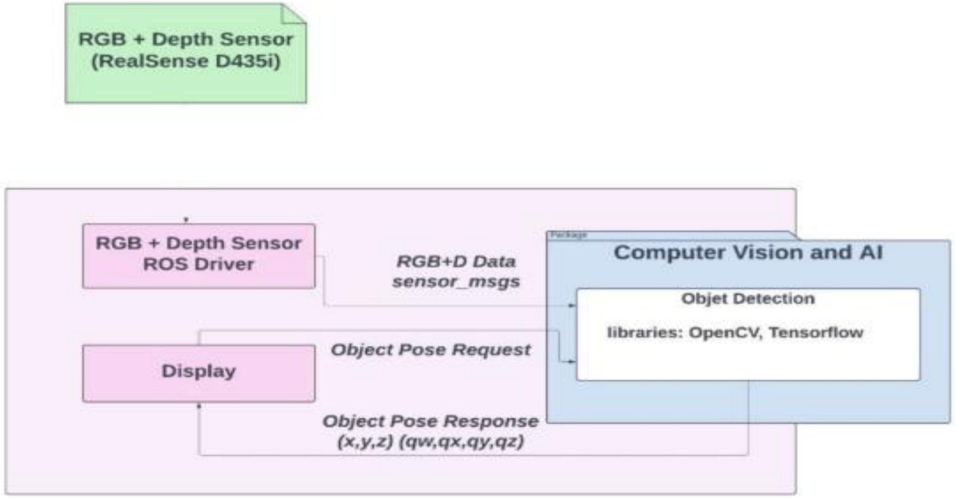
Spine Mannequin attached with IR reflective markers and 3D slicer - axial, coronal, sagittal views of CT Spine dataset

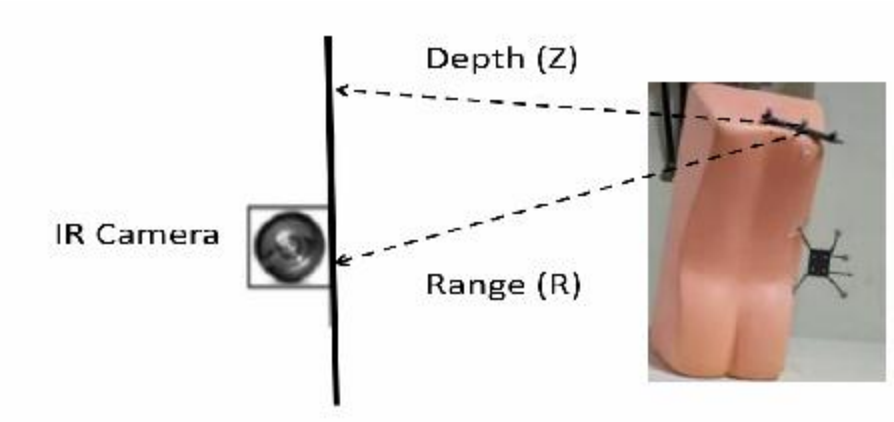
Kavitha, A., Kumar, S. P., Darsana, G., & Sudhir, G. (2023, September). Enhancing visualization of surgical tool through integrated motion tracking system. In International Conference on Extended Reality (pp. 395-404). Cham: Springer Nature Switzerland.

Study 3 - Comparative analysis of AR camera, optitrack IR, and real sense depth camera systems

Spinal surgeries often face intraoperative complications, highlighting the need for precise tool tracking procedures. Computerized navigation greatly enhances the accuracy of placing surgical tools during these procedures, with Augmented Reality (AR) based tool tracking being one such technique gaining importance.

A comparative analysis of three tracking methods: stereo camera-marker-based, OptiTrack IR marker-based, and RealSense Camera. The primary aim is to evaluate tool movement precision and accuracy in three dimensions.



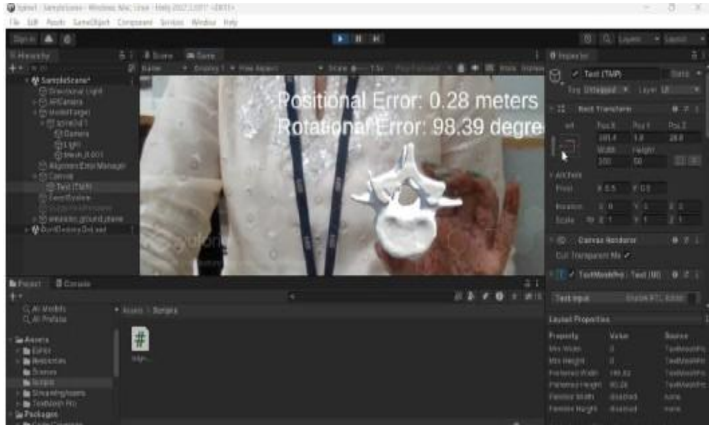


Anandan, K., Kumar, S. P., Elona, J. J., Balathay, D., Ragav, T. R., & Ganesan, S. (2024, September). Surgical tool tracking: Comparative analysis of AR camera, optitrack IR, and real sense depth camera systems. (pp. 163-177). Lecture Notes in Computer Science

Study – 4

INVESTIGATION OF DEPTH PERCEPTION IN AR - VIEW USING HMDs

- AR head-mounted display system was developed to improve **depth perception and tool alignment accuracy** in spine surgery.
- The study evaluated disparity errors and user accuracy in matching virtual pedicle screws with anatomical landmarks.
- **Model-based tracking, marker registration, and camera calibration** ensured precise **virtual-to-real overlay**.
- The system demonstrated enhanced spatial alignment and **visualization stability for surgical guidance**.



Error Calculation of the superimposition

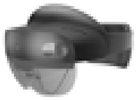
Supperimposition of Virtual Models

Pedicle Screw Navigation Tool

Sudhir, G., Anandan, K., Subbaraj, P. K., & Kumar, A. M. (2025). An augmented reality-based spine surgical training system with real-time alignment feedback and tool tracking. Journal of Minimally Invasive Spine Surgery and Technique, 10(Suppl 2), S126-S135.

TECHNICAL FLOW

HoloLens, Unity, Vuforia

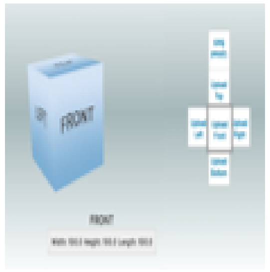


Unity

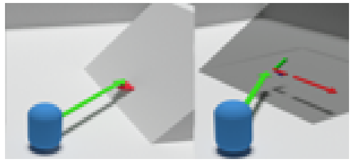
vuforia

3D model acquisition of spine and pedicle screw

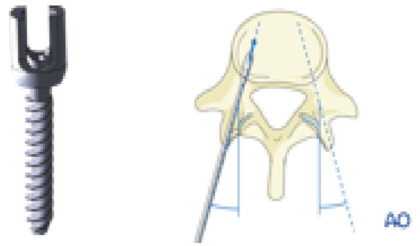
Creation of model-target in Vuforia Engine



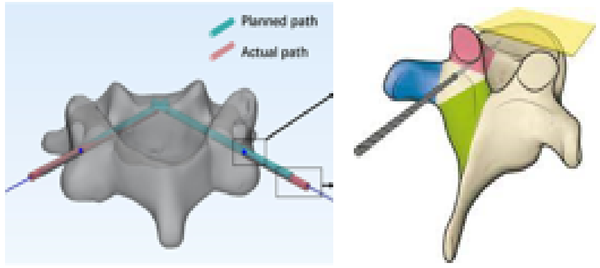
Tracking of real time object in Unity



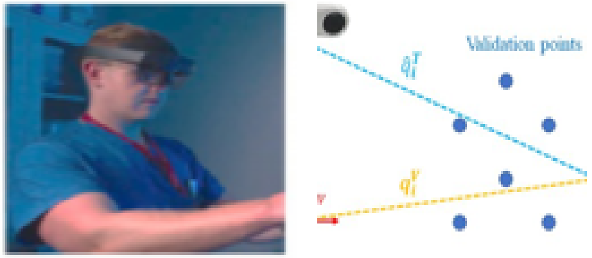
Pedicle screw placement



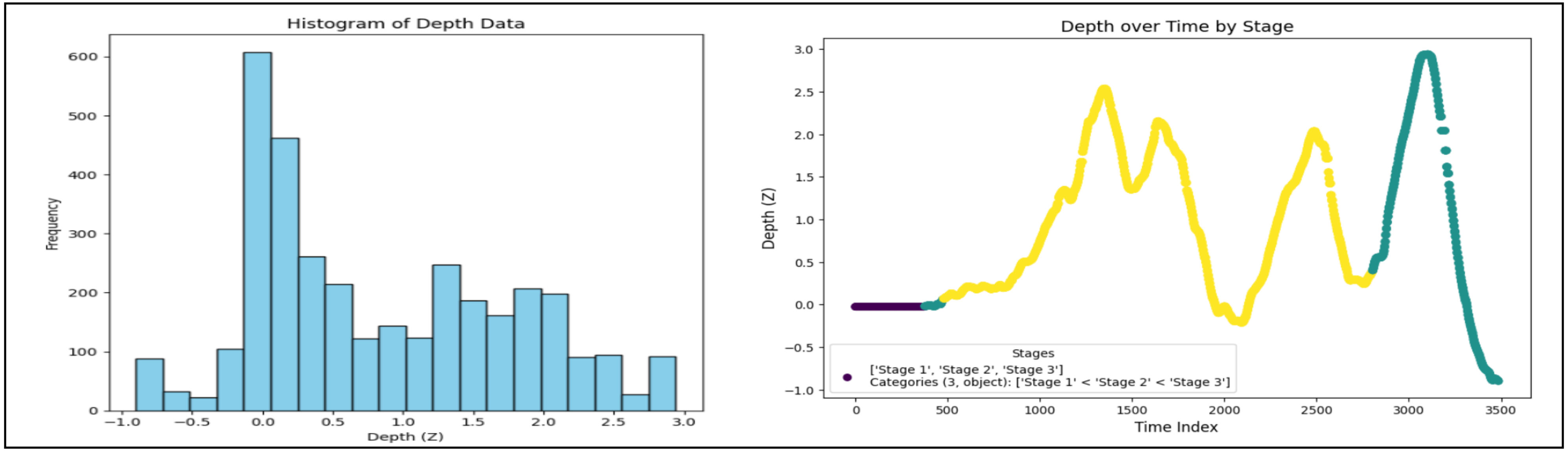
Visualization and tracking



Real time feedback and error analysis



ANALYSIS



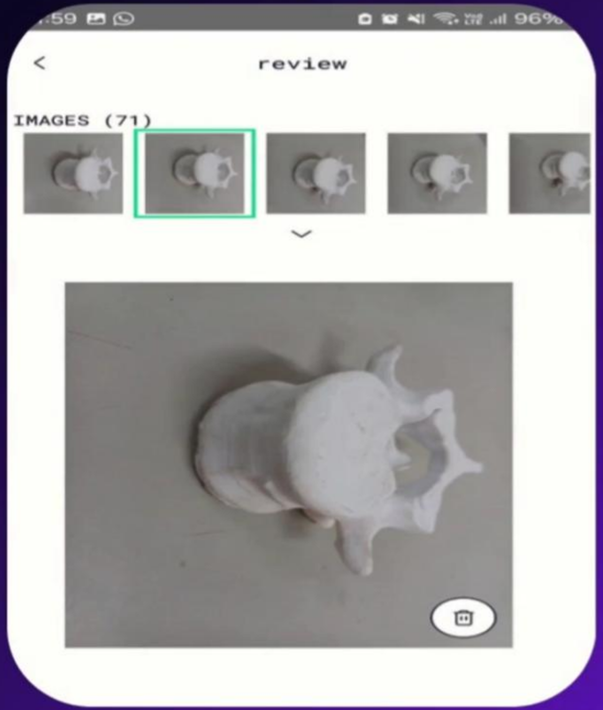
- ✓ The histogram displays the distribution of depth (Z-axis) measurements taken while tracking the pedicle screw tool in real-time.
- ✓ Colour coding in the scatter plot shows various stages, with each stage indicating how the tool is approaching or receding from the pedicle region of the spine model.

  - Stage 1 (Purple): Early stage, where depth is near 0.0 with minimal variation.
  - Stage 2 (Yellow): Depth fluctuations increase drastically, reaching as much as about 2.5 before falling sharply. This happens when the tool is near the L1 level of the spine.
  - Stage 3 (Teal/Greenish-Blue): Sudden spike and then sudden drop in depth, reflecting a momentous event or shift. This happens when the tool is near the L2 level of the spine.

Creation of 3D model of the spine (Vertebral disc)

The 3D model of the spine was created using Polycam software

Several images of the spine model were taken from 360 degrees under proper lighting and positioning

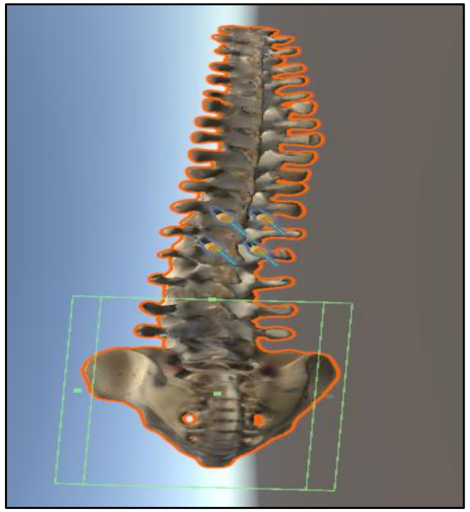


Study 5 –HAPTIC FEEDBACK FOR AR BASED SURGICAL SUPPORT SYSTEMS

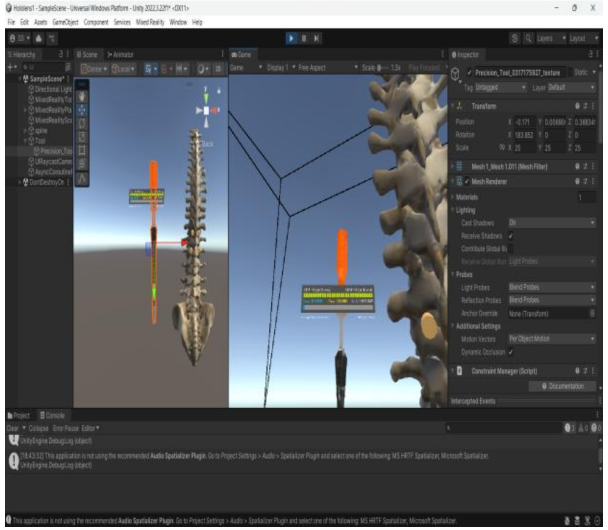
Haptic feedback provides **tactile cues in image guided surgical procedures**

AR+Haptic systems allow the **surgeon to see inside the body and feel the forces of the tool at the same time**

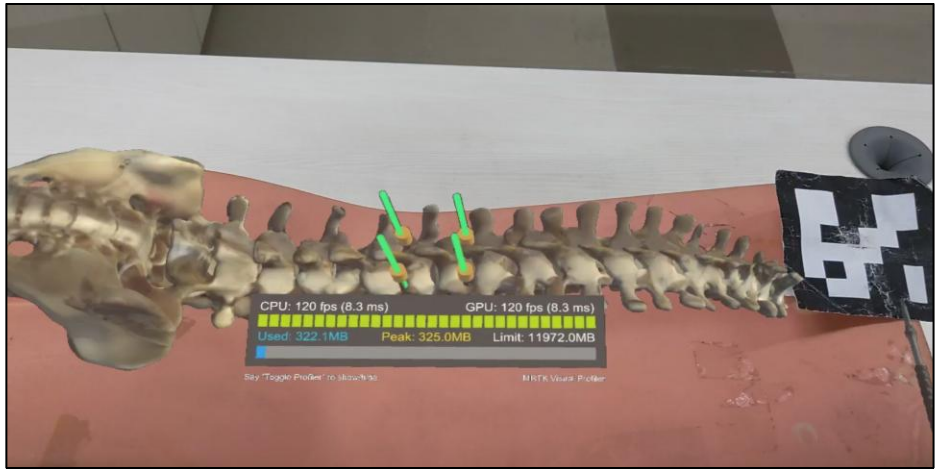
This multimodal interaction enhances **hand-eye coordination and spatial cognition – useful in intraoperative rehearsal**



3D Spine Model

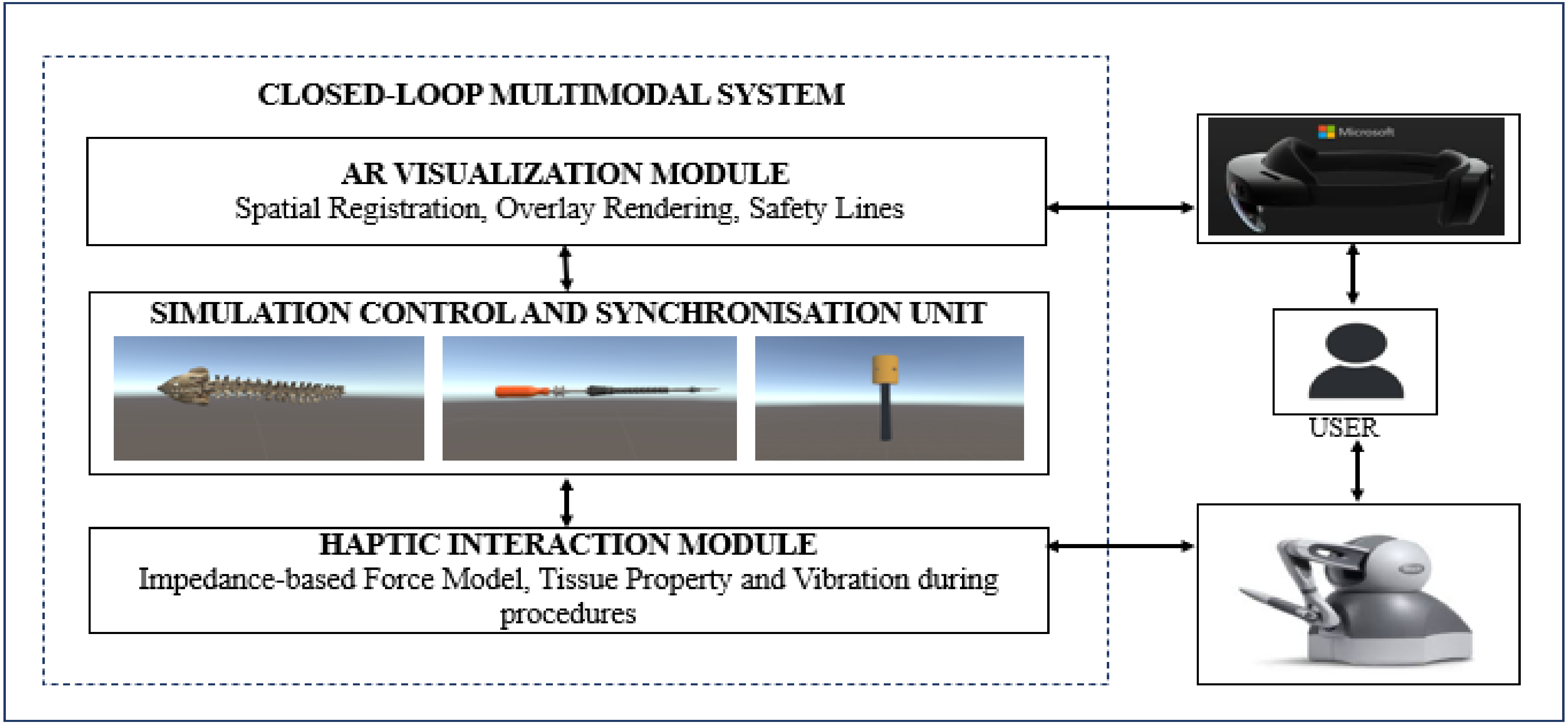


Unity simulation setup



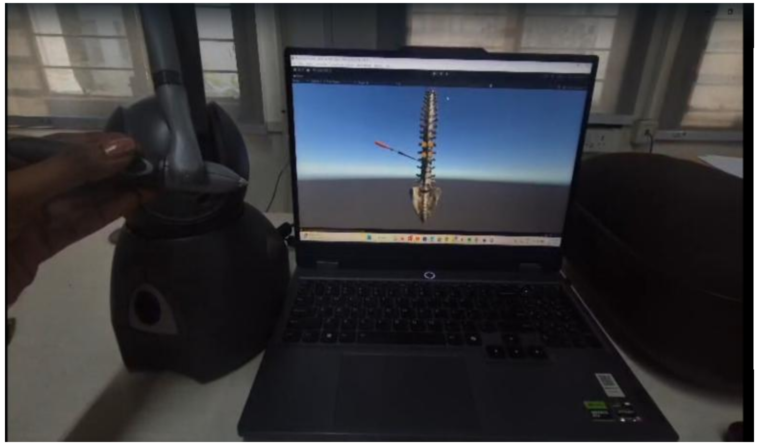
Demonstration of Pedicle Screw Insertion

TECHNICAL FLOW



ANALYSIS

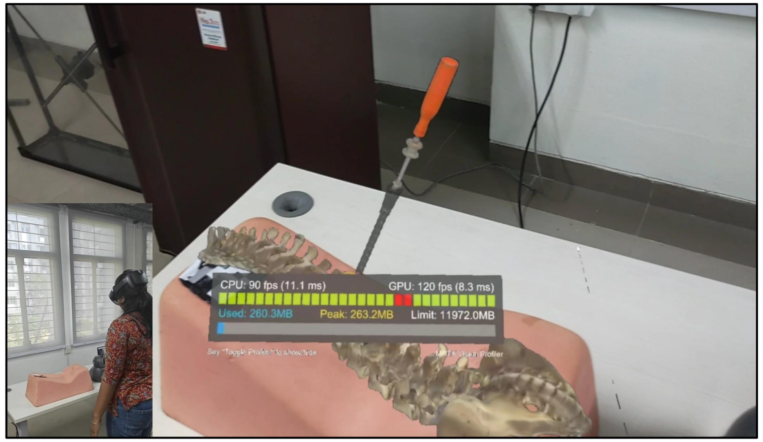
Parameters	Expression
Hooke's Law For Providing Haptic Feedback to the Virtual 3D Spine Model	**F(Haptic) = k(Bone) .δ x**
Static Friction	**$F_s = \mu_s \cdot N$** **μ_s →Static friction** **N→ Normal force**
Dynamic Friction	**$F_d = \mu_d \cdot N$** **μ_d →Dynamic friction** **N→ Normal force**
Damping (Velocity-Based Resistance)	**$F_{damping} = -c \cdot v$** **c→ Damping slider** **$\vec{v}$ →Tool velocity**
Total Haptic Force	**$F_{total} = k \cdot d \cdot n - c \cdot v$**



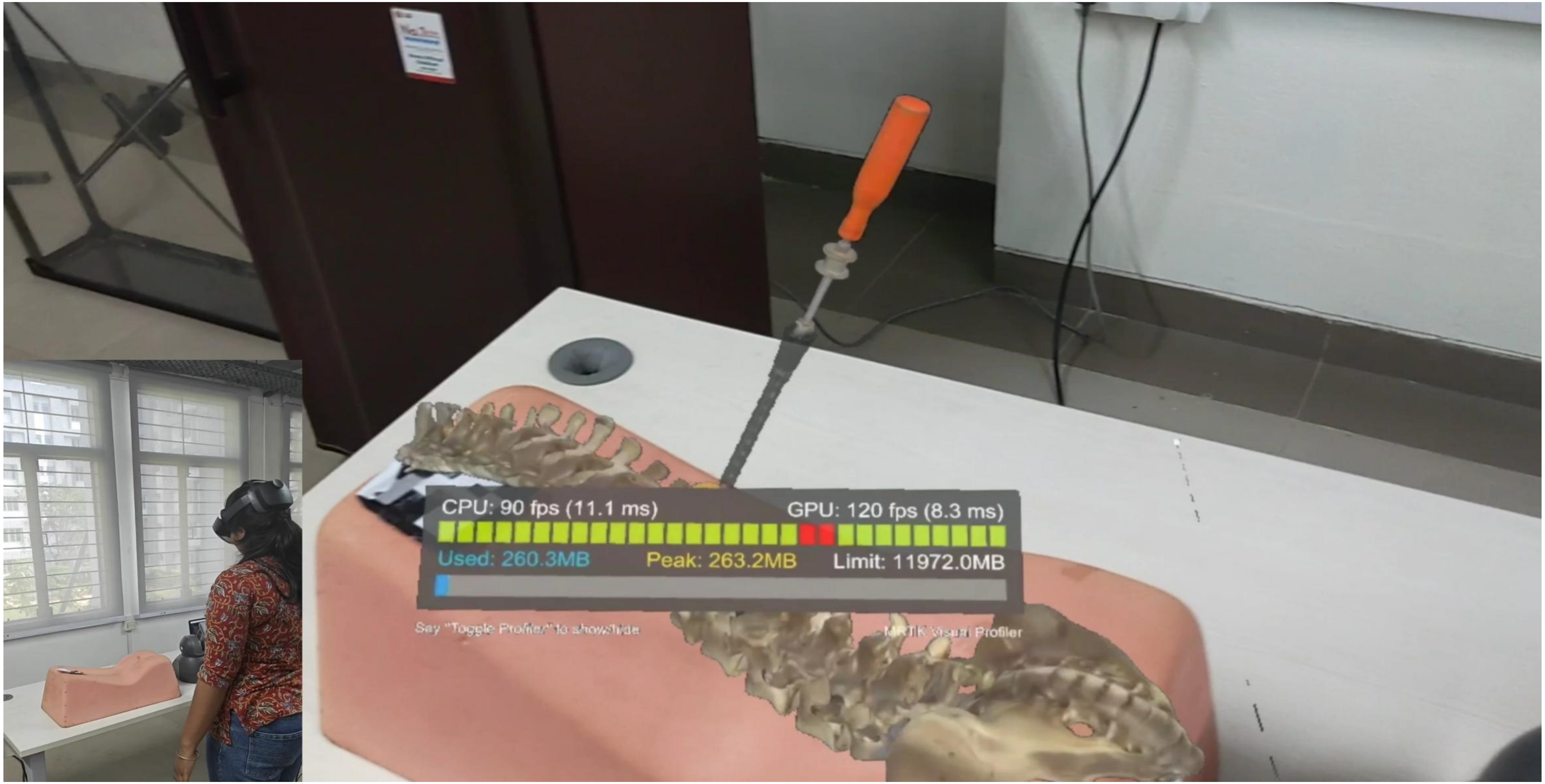
Unity setup of the AR setup with Haptic Integration

Test	Result
Collision Accuracy	93% (deviation while perspective is changed)
Manipulator Responsiveness	Responsiveness seems to be present at the place where the collider is present
Interaction Smoothness	Smooth most of the time except for fast movement.

The model tracking and depth cues were evaluated using **quantitative measures of positional and rotational error, target registration error, and overlay stability,** and an AR-based surgical simulator that applies haptic feedback was developed to have **realistic force interaction and skill training,**

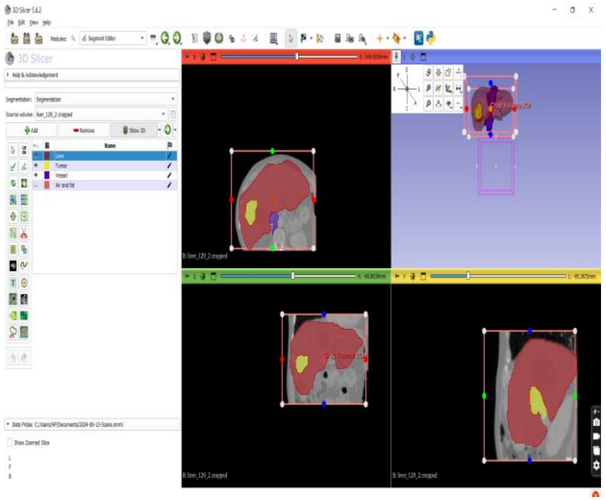


Simulation Integrated with Haptics

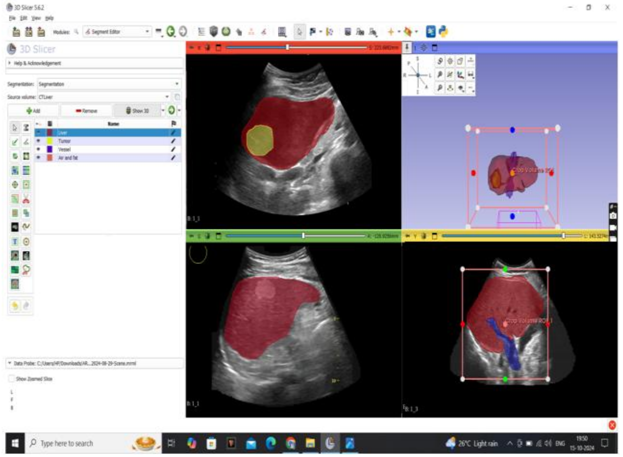

CPU: 90 fps (11.1 ms)
GPU: 120 fps (8.3 ms)
Used: 260.3MB
Peak: 263.2MB
Limit: 11972.0MB
Say "Toggle Profiler" to show/hide
MRTK Visual Profiler

Study – 6
AR BASED LIVER SURGICAL SYSTEM WITH REAL-TIME TOOL TRACKING APPROACH

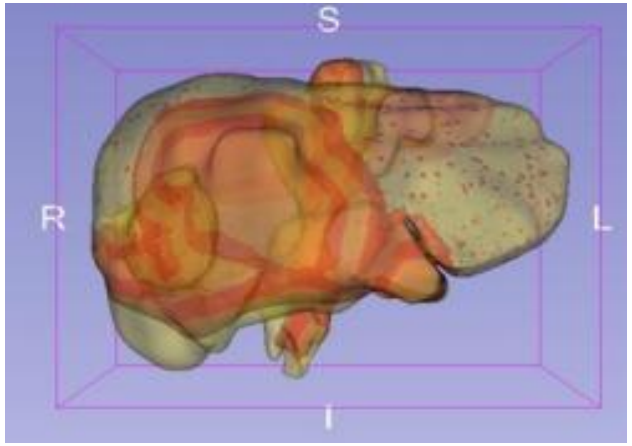
- This system integrates **preoperative CT-based 3D liver models with real-time 3D ultrasound to enhance intraoperative visualisation and tumour localisation.**
- Liver and tumour segmentation, along with **ArUco marker and IMU-based tool tracking, enable accurate real-time alignment.**
- Registration techniques **synchronise intraoperative and preoperative data** for improved navigation precision.



Liver And Tumor Segmentation



Ultrasound 3D Reconstruction



3D Model Registration

Kumar, P., Kavitha, A., Divya, B., & Sreeniveatha, P. (2025, April). AR-Guided Liver Surgery with Real Time Tool Tracking Approach. In 2025 3rd International Conference on Artificial Intelligence and Machine Learning Applications (AIMLA) (pp. 1-5). IEEE.

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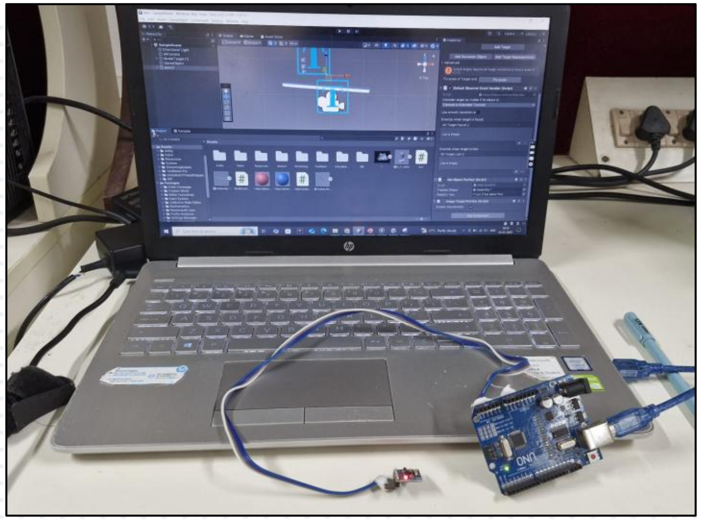
TECHNICAL FLOW

DATA COLLECTION

CT/MRI LIVER IMAGES OF THE PATIENT

Segmentation and Reconstruction

CREATING 3D LIVER MODEL (PREOPERATIVE MODEL)



Interfacing Arduino and Unity

US 2D IMAGES

Segmentation and Reconstruction

CREATING 3D LIVER MODEL (INTRAOPERATIVE MODEL)

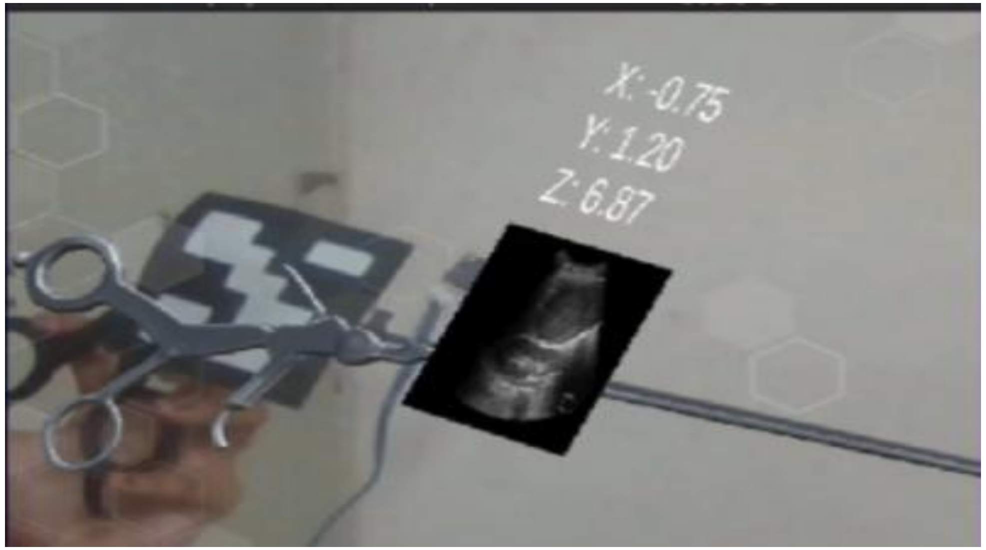
3D MODEL SUPERIMPOSITION

ACCURACY CALCULATION

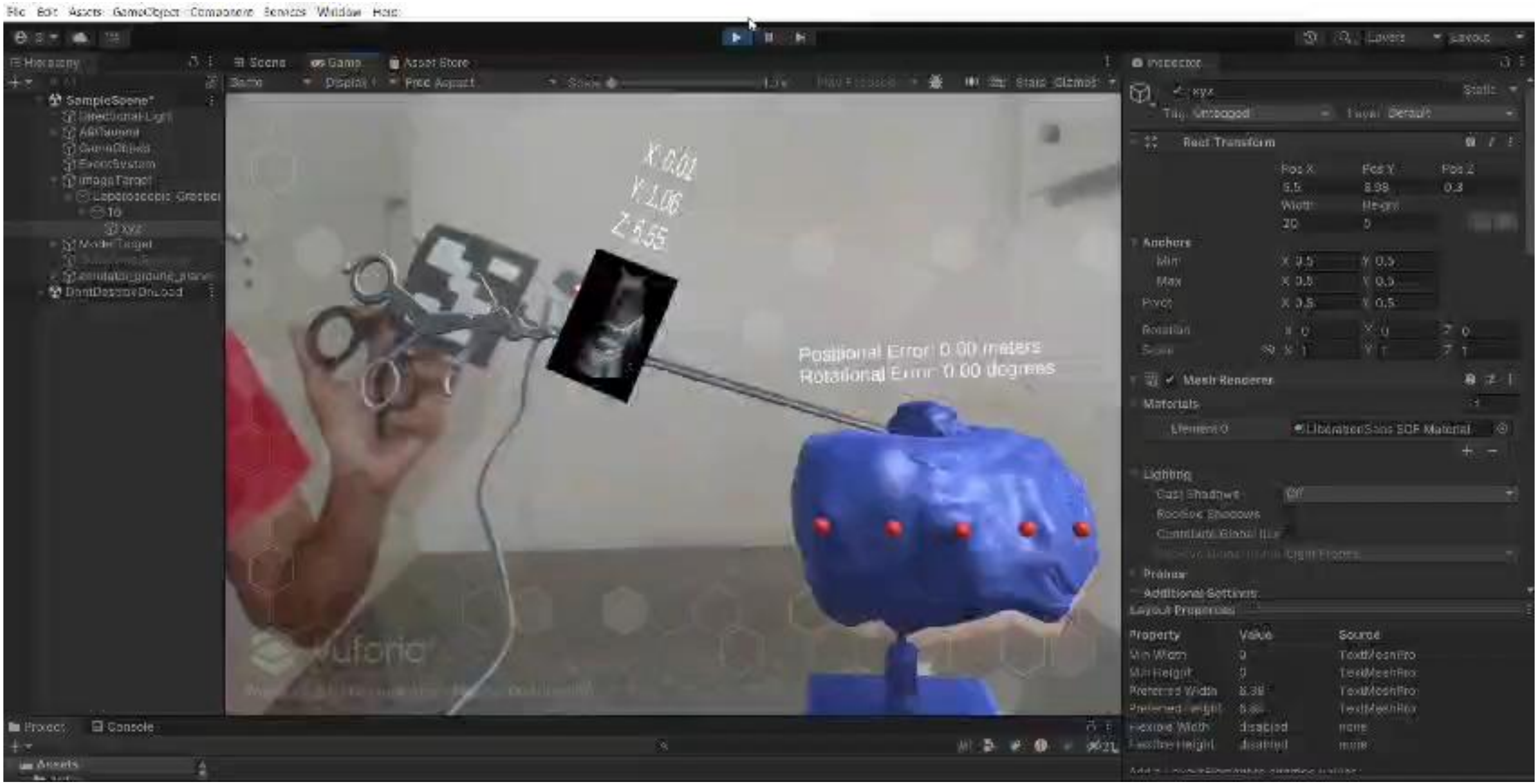
US IMAGE SUPERIMPOSITION ON 3D MODEL

AR VISUALIZATION

Integration of tool tracking with IMU sensor and real time ultrasound image superimposition enhances spatial awareness and increases surgical accuracy



Positional values


X 0.01
Y 1.06
Z 5.55
Positional Error: 0.00 meters
Rotational Error: 0.00 degrees

ANALYSIS

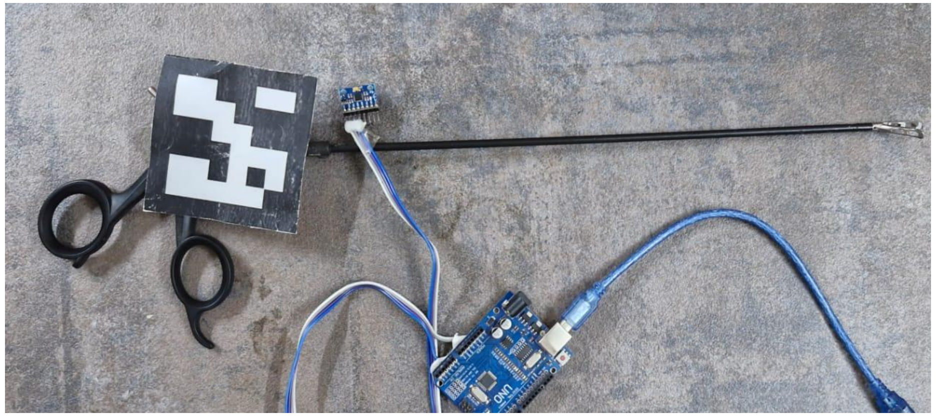
PARAMETER	ORIGINAL LIVER MODEL VALUE	DEFORMED LIVER MODEL VALUE
Position X	-0.156	-0.0476
Position Y	-0.385	-0.0118
Position Z	-1.259	0.0368
Rotation X	0	-0.967
Rotation Y	-100.05	-115.16
Rotation Z	0	-10.689
Scale X	0.98504	1.0957
Scale Y	0.98504	1.0957
Scale Z	0.98504	1.0957

Reference Points	Distance metrics using Scale (cm)	Distance between tool and point (cm)
0	0.8	0.8
1	0.7	0.8
2	0.7	0.7
3	0.7	0.7
4	0.5	0.6

The distance between the tool and the Reference Points

Image Superimposition on deformed liver model:

Liver deformation during surgery can occur due to various physiological and mechanical factors. The deviations primarily depend on the **position**, **rotation**, and **shape** (scaling) of the liver.



ArUco marker and IMU sensor attached to the laparoscopic grasper

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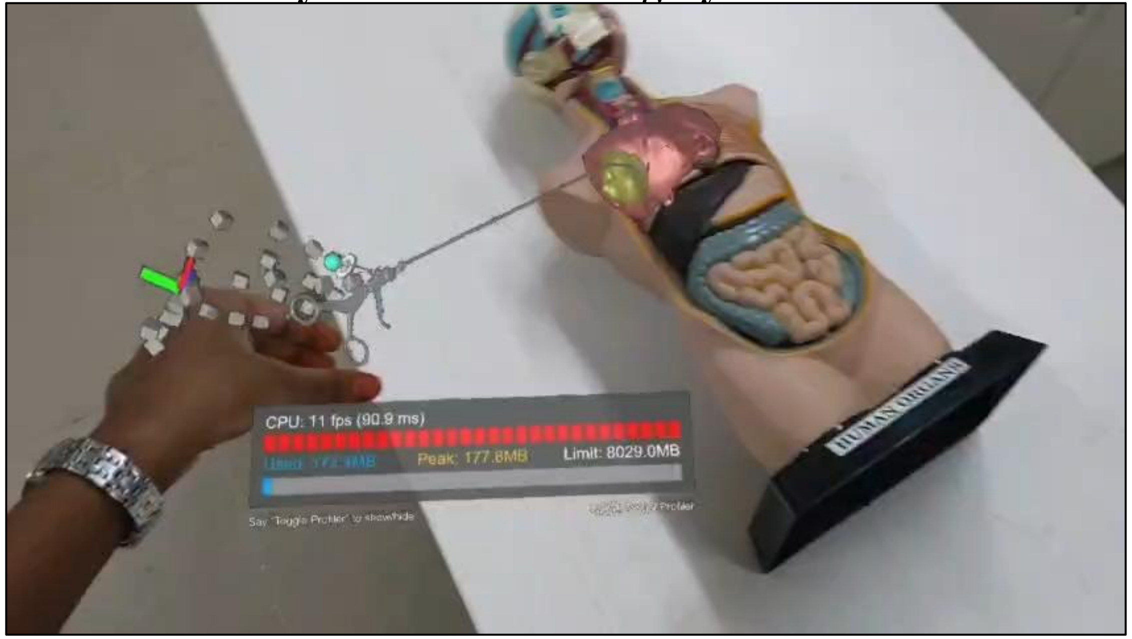
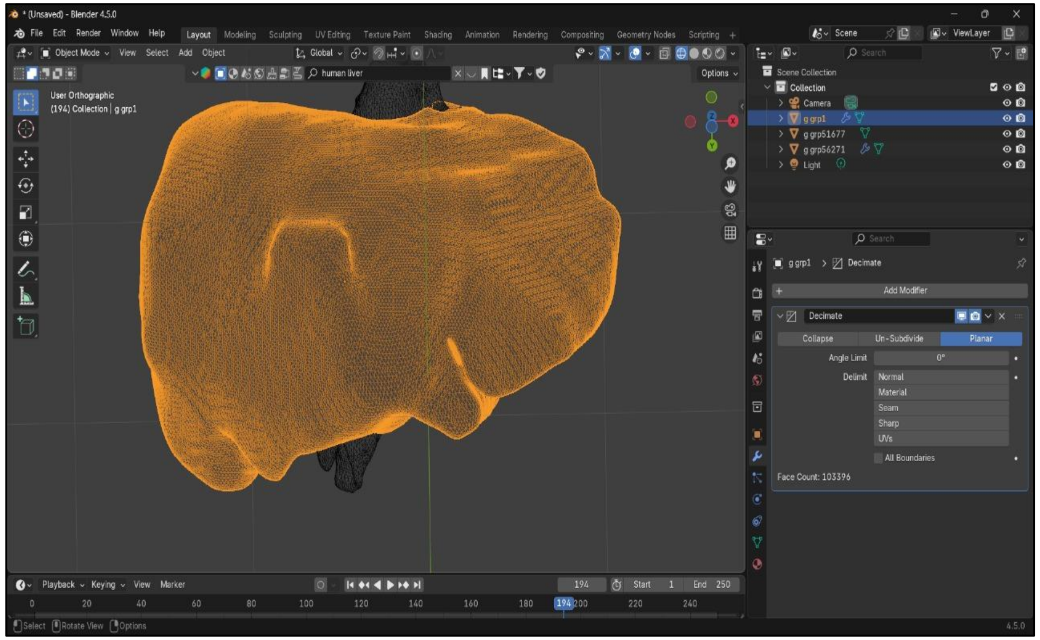
Study – 7
XR-ASSISTED LIVER SURGERY: VISUALISING USING HEAD-MOUNTED DISPLAY (HMD)

- This system uses Microsoft HoloLens 2 to **overlay patient-specific 3D CT/MRI models directly into the surgeon's field of view**.
- **Real-time 3D ultrasound is integrated with preoperative imaging to enhance tumour and vascular visualisation.**
- Advanced **tracking and registration using Unity, MRTK, Vuforia, optical markers, and IMU sensors ensure accurate alignment. Deformation compensation improves navigation precision, enhancing spatial awareness and supporting safer minimally invasive liver surgery.**



Demonstration of Liver Tumor Removal Using HoloLens 2



Modelling of Liver

SSN

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TECHNICAL FLOW

Real-World Surgical Model 

↓

MR Environment (HoloLens + Unity)

↓ 

 Instrument Tracking

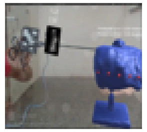
↓

Anatomical Region Identification 

↓

Proximity / Collision Detection

↓

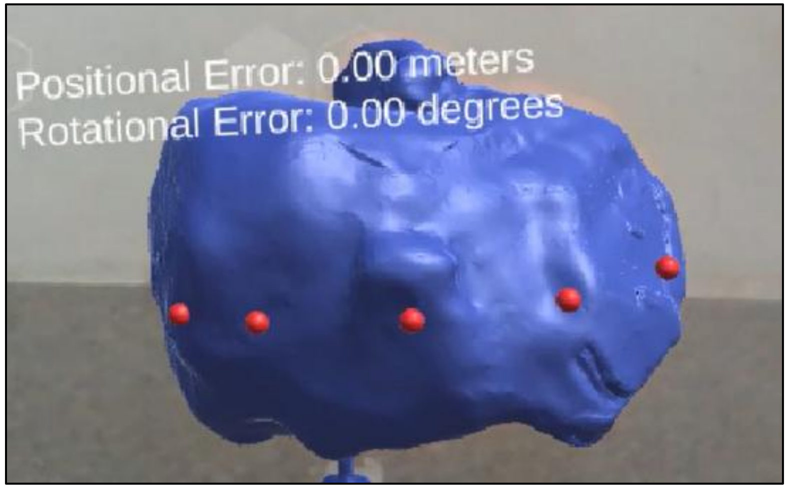
 Risk Assessment (Target vs Non-Target Tissue)

↓

Haptic Alert Generation (Vibration) 

↓

User Awareness & Corrective Action



Visualization of reference Points

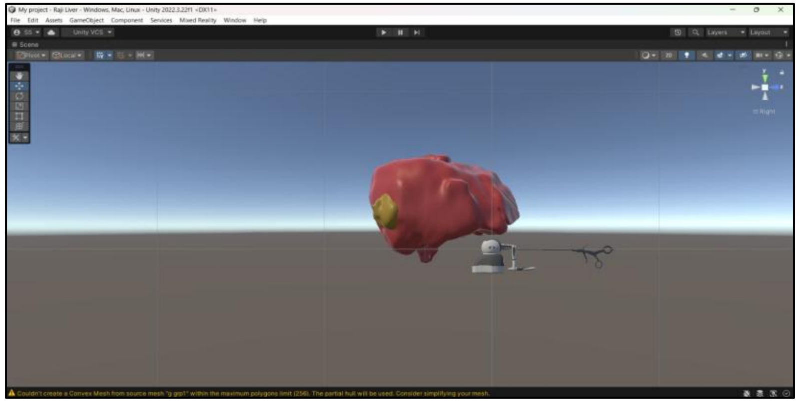
3D Liver Model

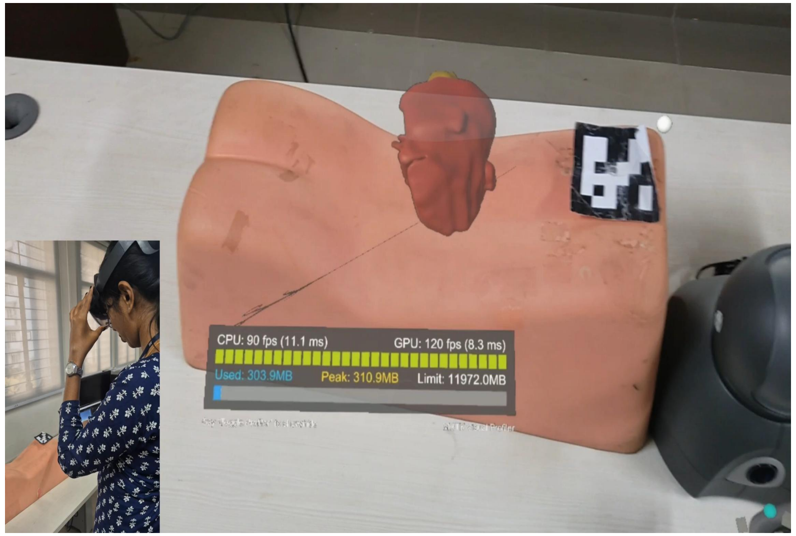
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

BIOSTEC 2026
19TH INTERNATIONAL JOINT CONFERENCE ON BIOMEDICAL ENGINEERING SYSTEMS AND TECHNOLOGIES
2 - 4 MARCH, 2026
Marbella, Spain
BIODEVICES
BIOIMAGING
BIOINFORMATICS
BIOSIGNALS
HEALTHINF

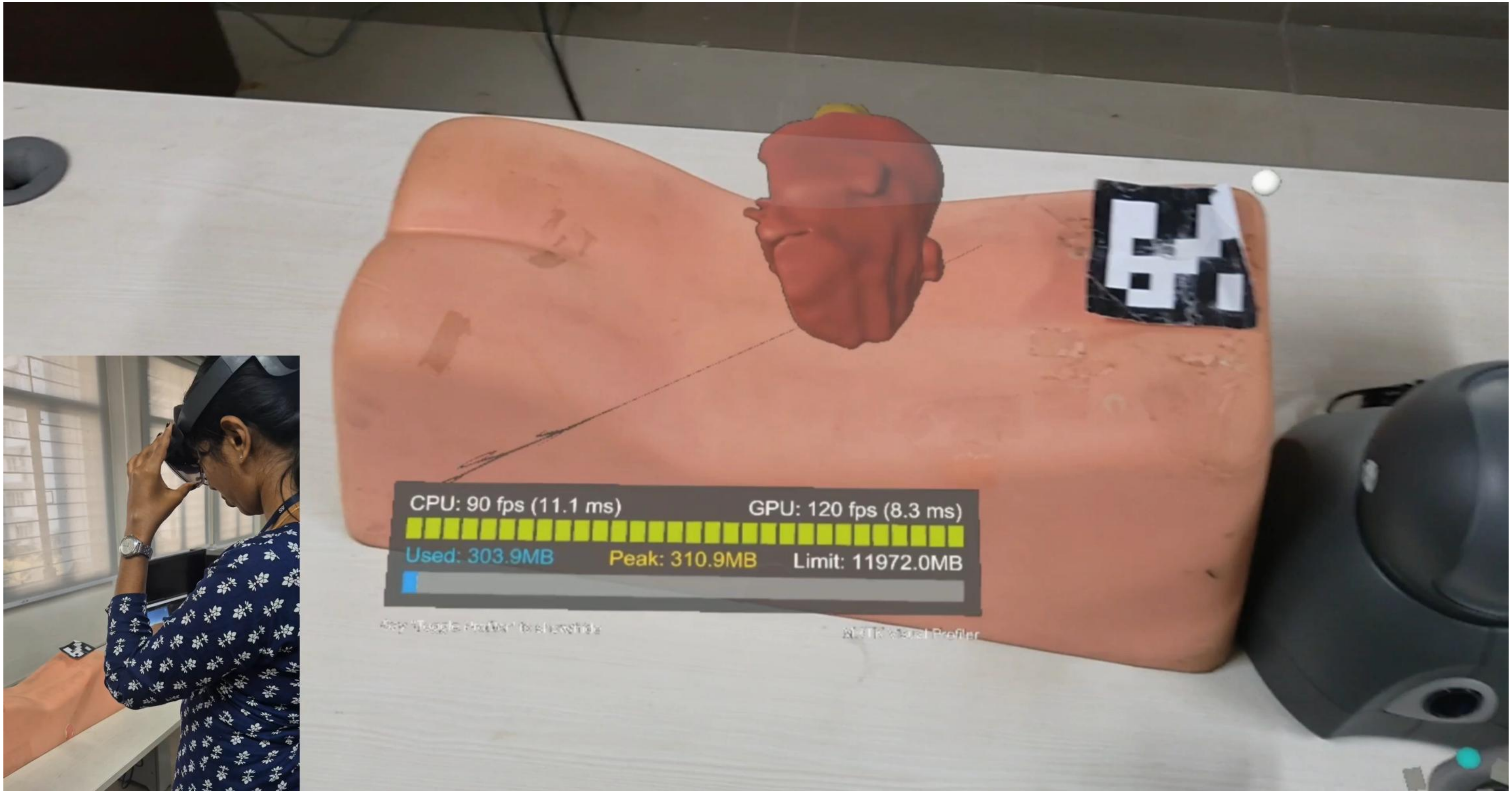
ANALYSIS

Formula Used	Expression
Hooke's Law For Providing Haptic Feedback to the Virtual 3D Spine Model	$F(Haptic) = k(Bone) . \delta x$
Static Friction	$Fs = \mu s \cdot N$ μ_s →Static friction N→ Normal force
Dynamic Friction	$Fd = \mu d \cdot N$ μ_d →Dynamic friction N→ Normal force
Damping (Velocity-Based Resistance)	$Fdamping = -c \cdot v$ c→ Damping slider $\vec{v}$ →Tool velocity
Total Haptic Force	$Ftotal = k \cdot d \cdot n - c \cdot v$


Unity setup of the AR Setup

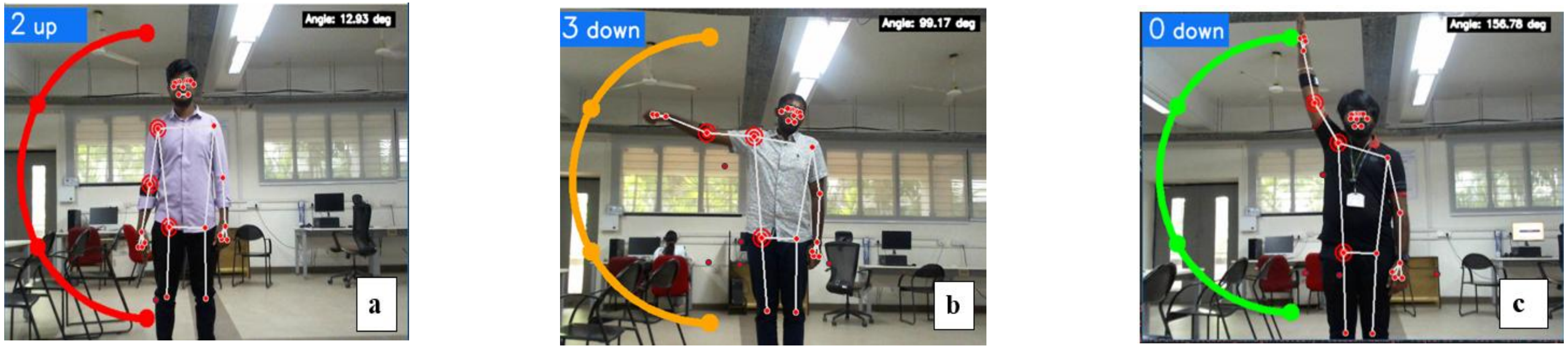


Implementation of haptics in liver surgery


CPU: 90 fps (11.1 ms)
GPU: 120 fps (8.3 ms)
Used: 303.9MB
Peak: 310.9MB
Limit: 11972.0MB

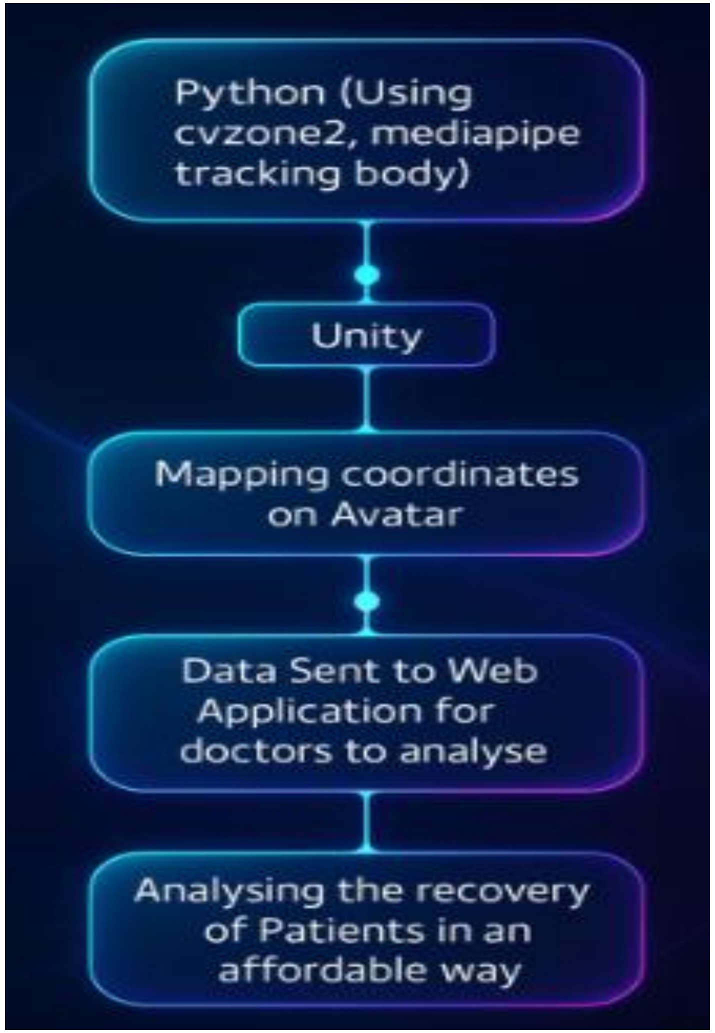
Study 8 – AR BASED PHYSICAL THERAPY ASSISTANT

- The AR-Based Physical Therapy Assistant is designed to **support stroke rehabilitation through real-time body tracking and interactive visual guidance.**
- By combining **Augmented Reality with IoT-based remote monitoring, the system provides instant feedback and tracks patient progress efficiently.**
- This approach enhances **engagement, improves recovery outcomes, and reduces the workload on healthcare professionals**

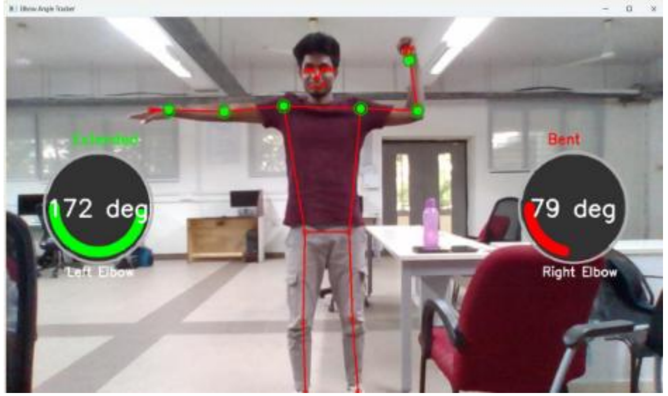


Kumar, S. P., Kavitha, A., & Saranya, S. (2025, July). Computer Vision and Augmented Reality Guided Shoulder Rehabilitation. In 2025 47th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (pp. 1-5). IEEE.

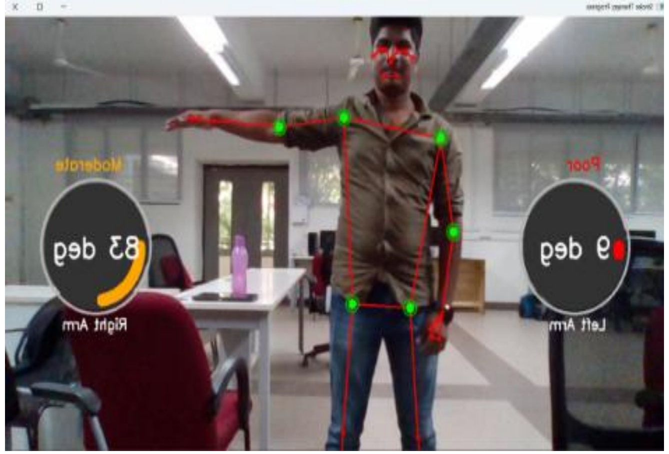
TECHNICAL FLOW



Right Elbow extension and Left Elbow Flexion



Left Elbow extension and Left Elbow Flexion



Right Arm Abduction

Right Arm Adduction

ANALYSIS

BIOSTEC 2026
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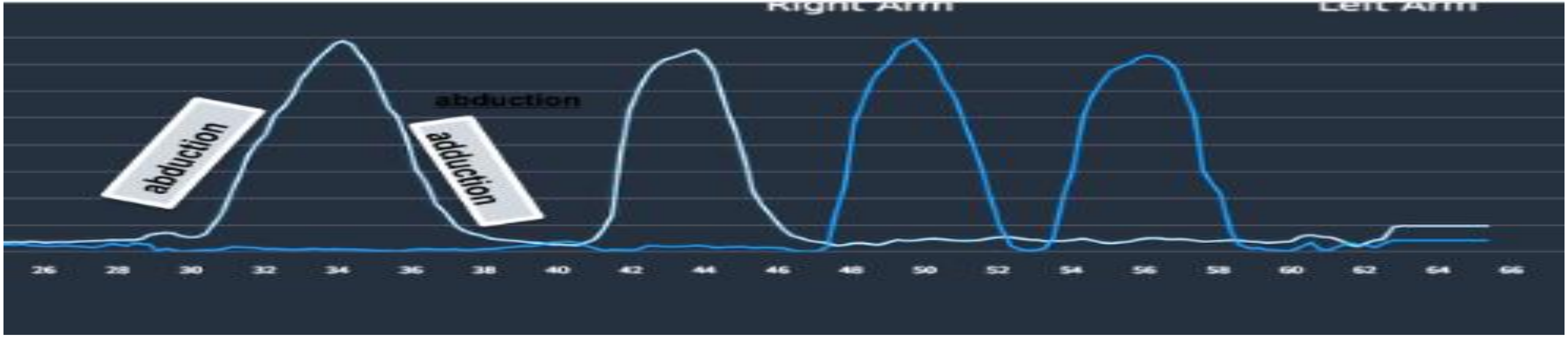
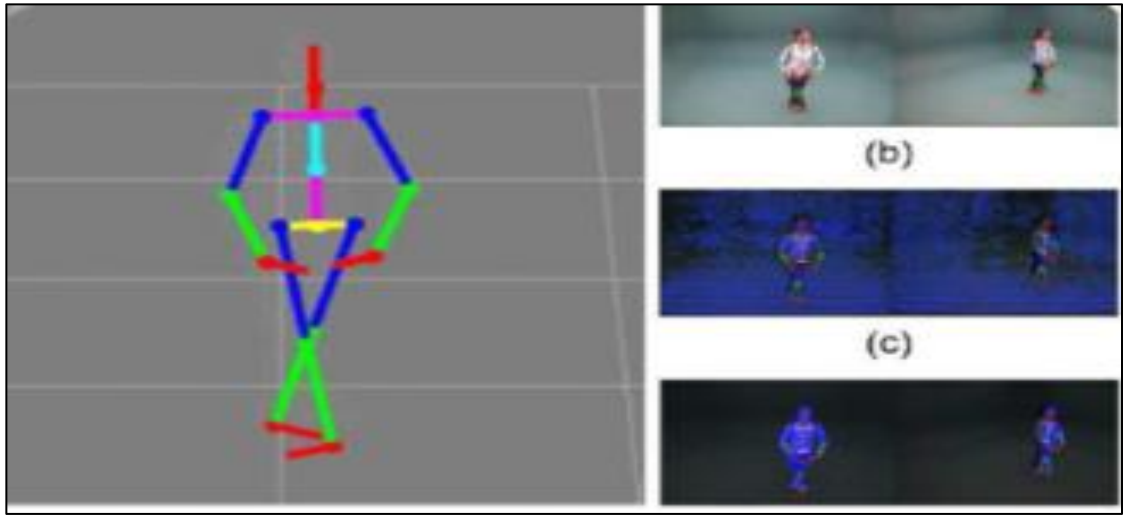
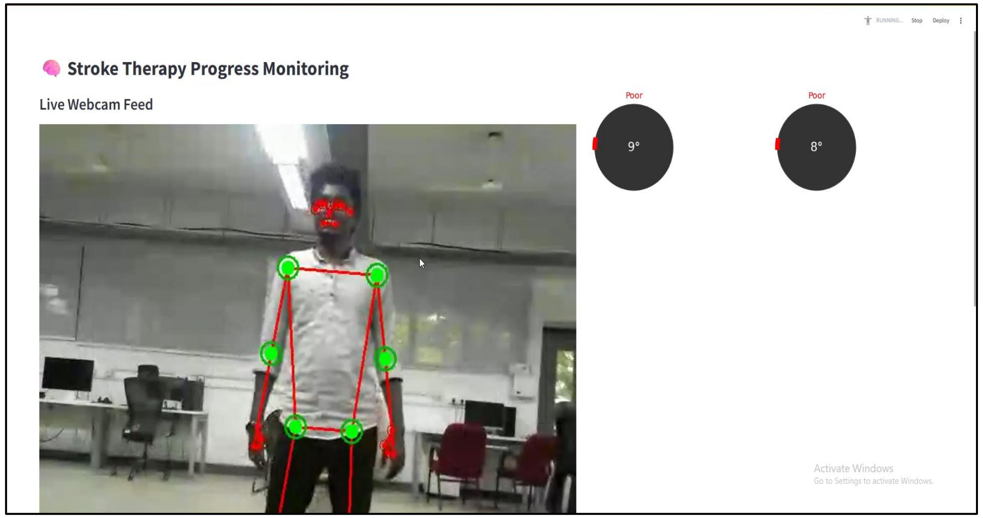


Dashboard and Graphical Representation of Abduction Adduction



Body Tracker



Demonstration of the system

RUNNING... Stop Deploy

Stroke Therapy Progress Monitoring

Live Webcam Feed

Poor

Poor

Activate Windows
Go to Settings to activate Windows.

VIRTUAL REALITY IN HEALTHCARE

Image Courtesy : Shiv Nadar School, Noida, India

Virtual reality (VR) in healthcare - use of **computer-generated, 3D, and immersive simulations via head-mounted displays (HMDs) or goggles to transform**

- **medical training**
- **diagnostics, and**
- **patient treatment.**

It creates a safe, interactive, and simulated environment to

- **improve clinical skills,**
- **patient experience, and**
- **therapeutic outcomes**

How it all started.....

VIRTUAL REALITY FOR AUTISTIC CHILDREN

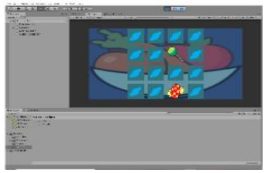
10 seconds
- REST

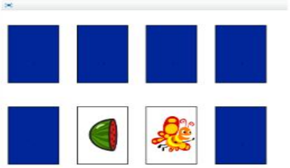
20 seconds
- GLANCE AT THE FLASHCARD / VR GAME

10 seconds
- REST

60 seconds
- MEMORY GAME

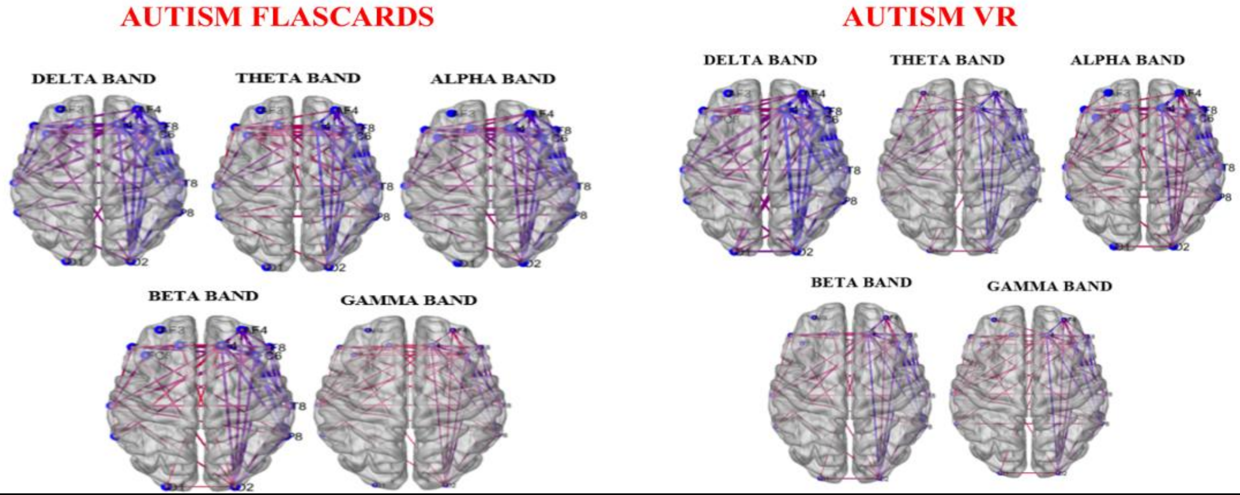
10 seconds
- REST





Memory Game Developed using scratch and unity

Memory game using cards.



VIRTUAL REALITY – Surgical simulation, Learning platforms

LEARNING PLATFORMS

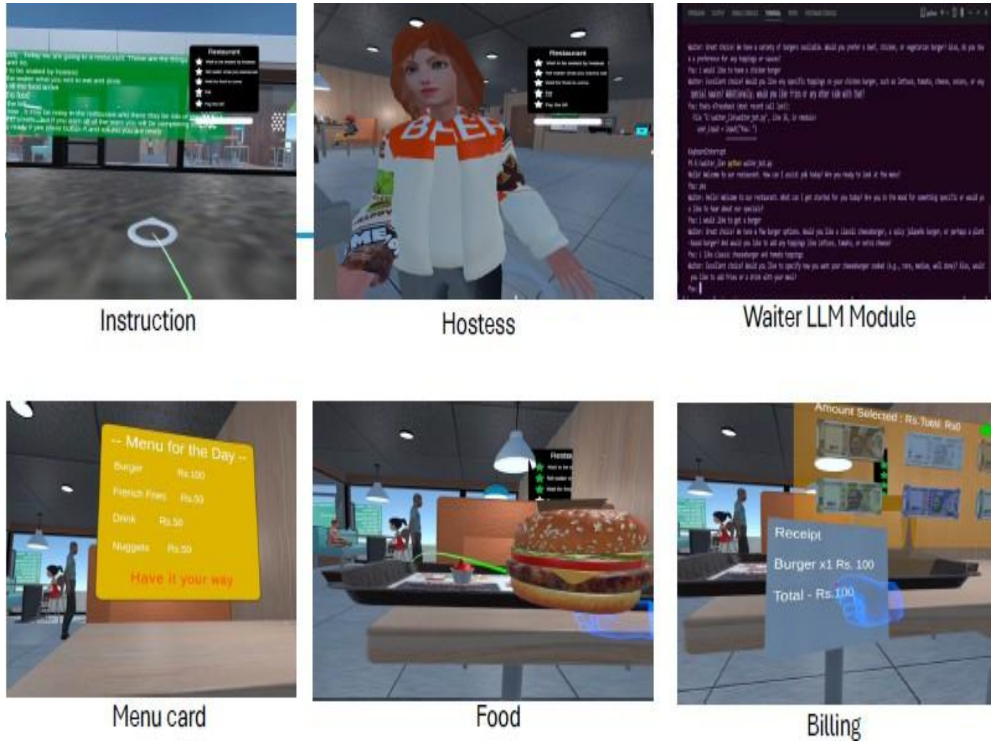
- VR Supermarket For Autism
- VR Restaurant For Autism
- VR-Buddy Phone Call Training
- VR For Enhancing Learning For ADHD
- VR Immersive Library Module
- Head And Hand Tracking Analysis In VR Buddy
- VR For Biomedical Engineering Education

SURGICAL SIMULATION

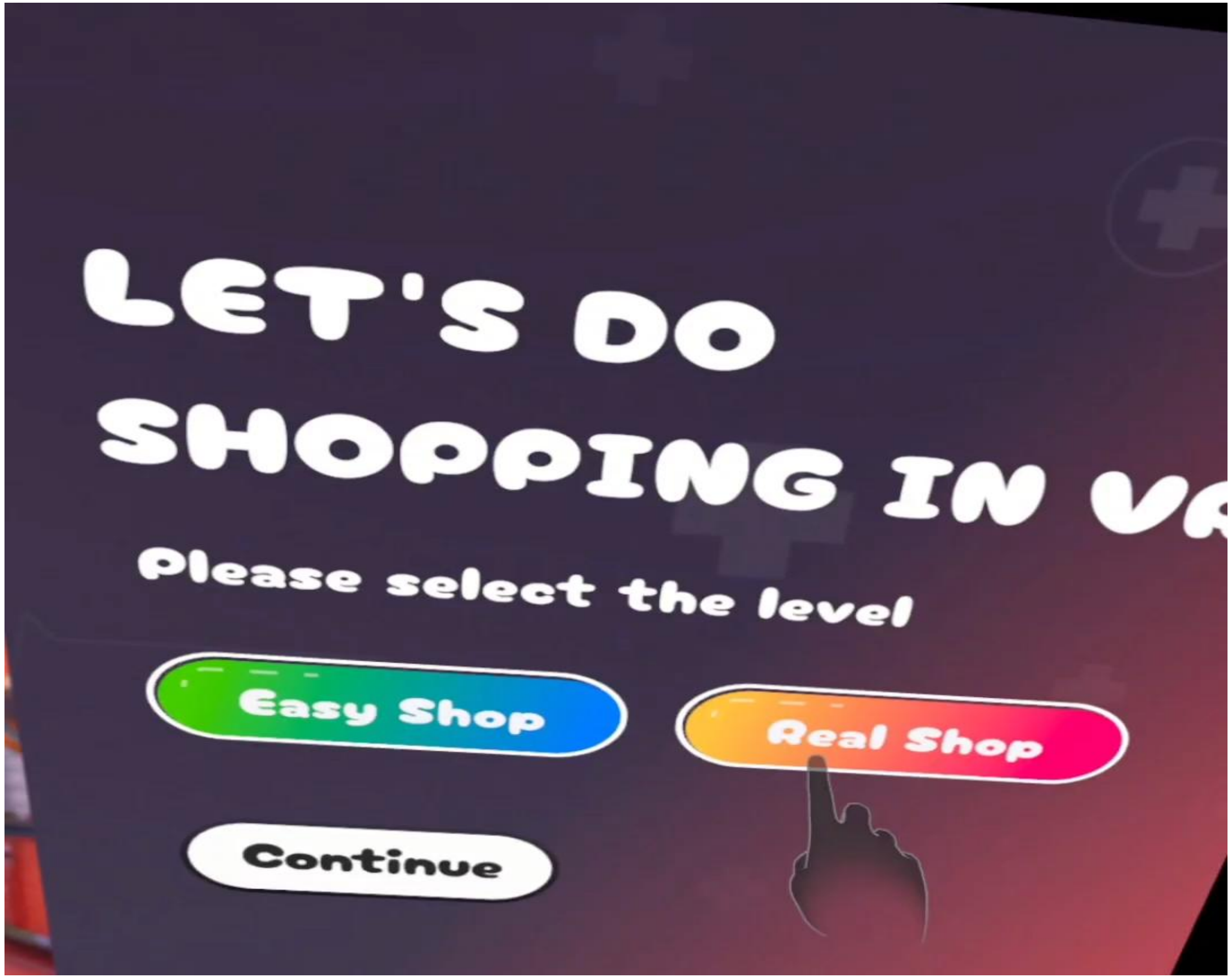
- VR-Based Surgical Stimulator With Haptic Feedback

STUDY 1 - VR SUPERMARKET FOR AUTISM

The Autism VR Supermarket simulates a realistic shopping environment with aisles, product racks, and checkout counters. It is designed to develop daily living skills such as item identification, sequencing, decision-making, and queue behaviour. The structured virtual setting enhances attention span, task completion ability, and independence in children with ASD.

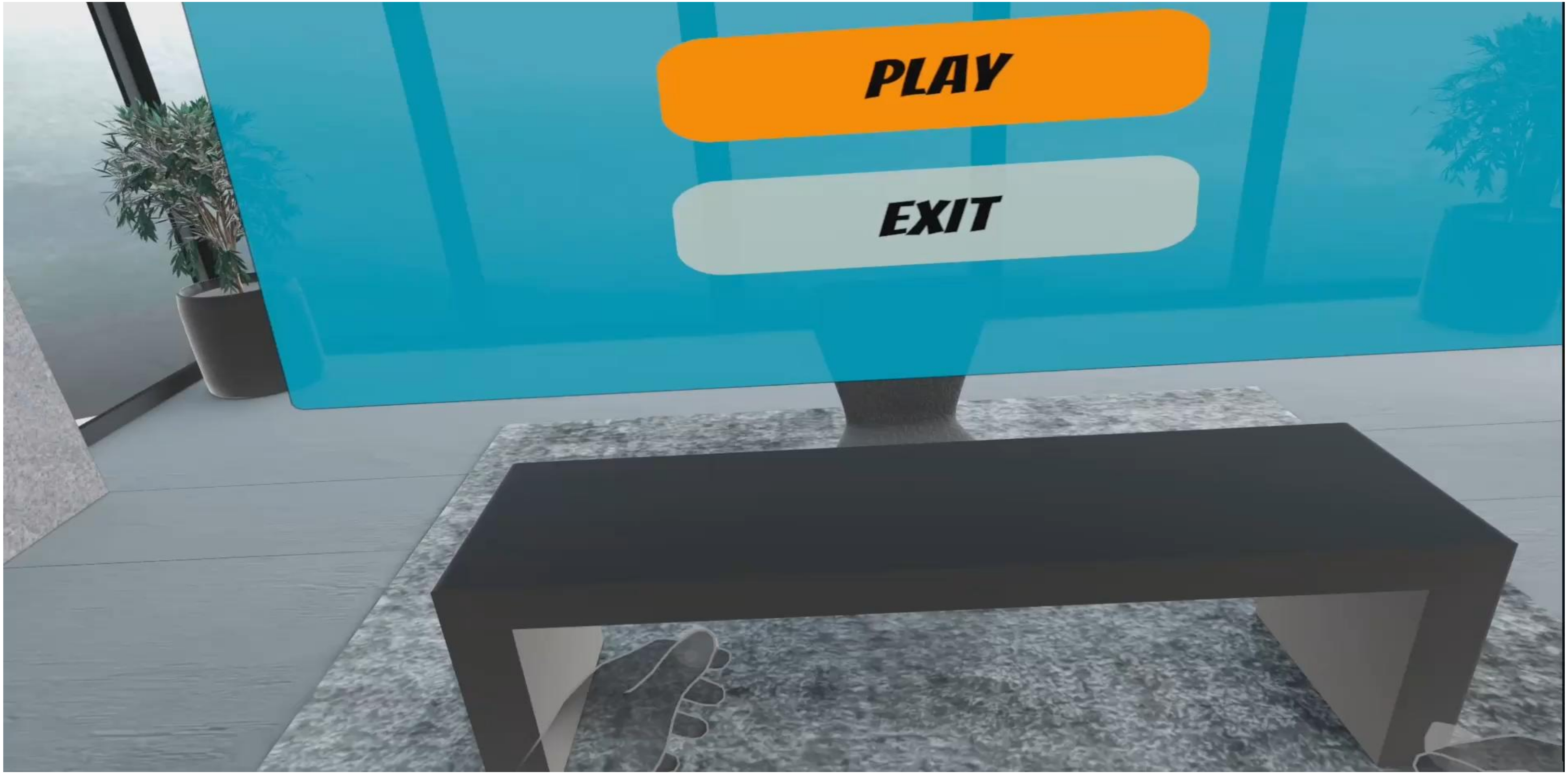


Autism - VR Supermarket



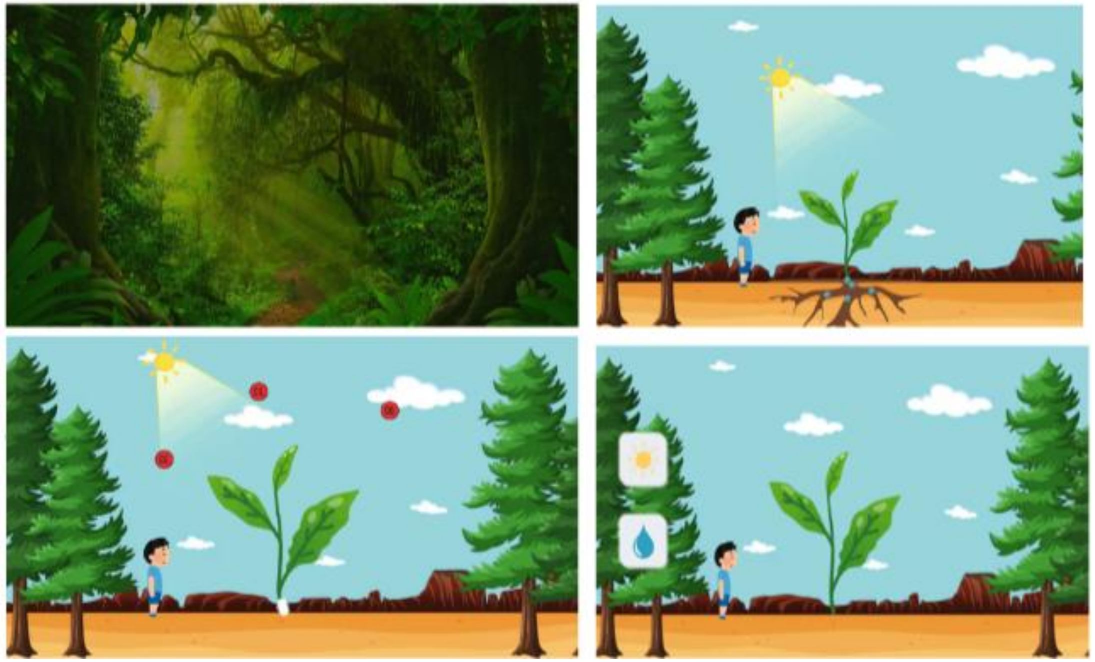
STUDY 2 - VR SOCIAL TRAINING FOR AUTISM – PHONE CALL

The module teaches children to talk over the phone, how to greet, listen and respond, and take a turn. It aids the growth of spoken language, hearing and listening, as well as social self-confidence using facilitated interaction and response.


PLAY
EXIT

STUDY 2 - VR FOR ENHANCING LEARNING IN ADHD

VR Buddy provides a multisensory learning platform for children with ASD and ADHD. It supports personalized pacing, improves attention, and enhances cognitive development through gamified and adaptive modules. The immersive Photosynthesis classroom promotes inclusive and engaging learning.



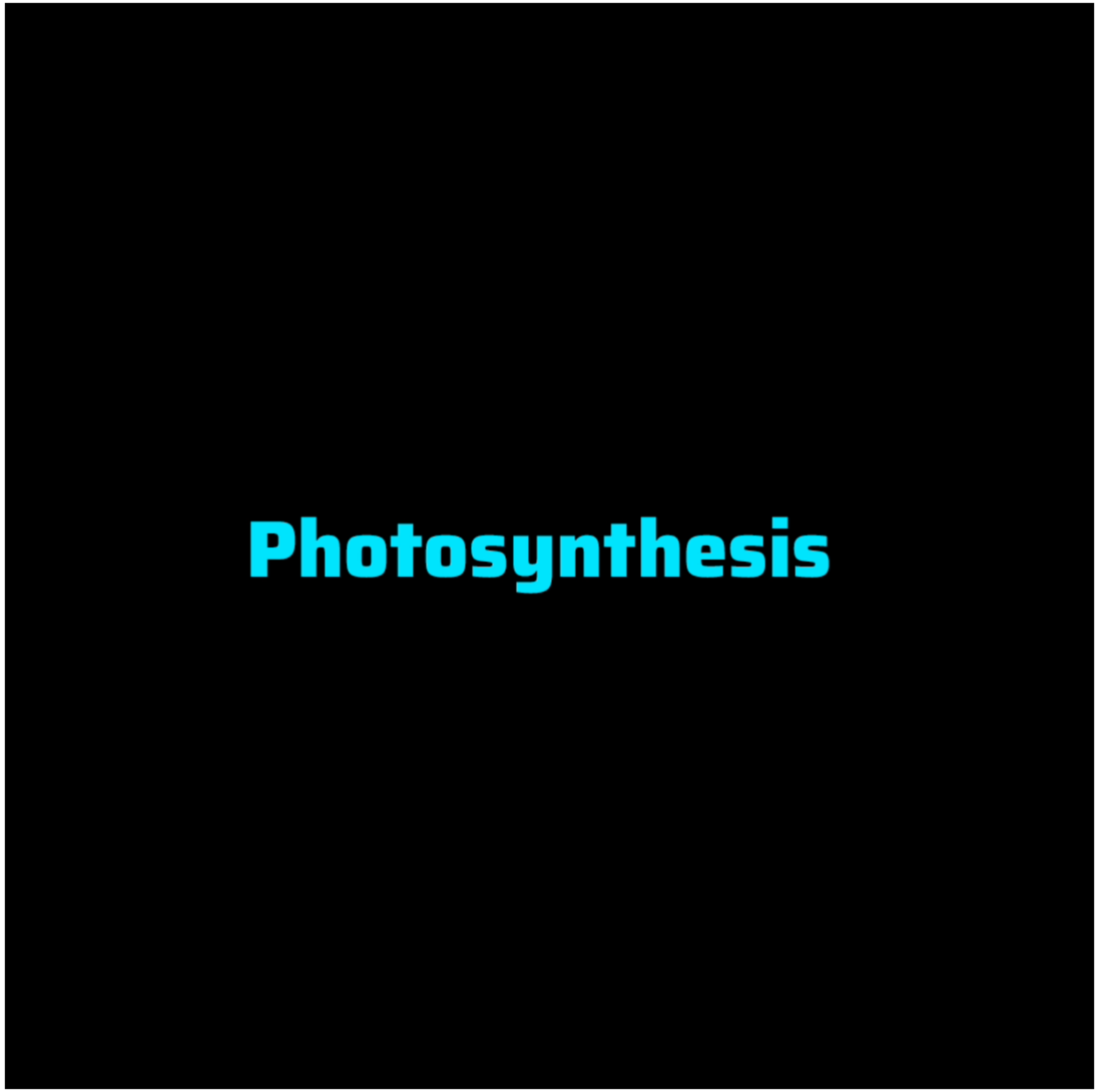
Photosynthesis

• Created a **pleasant forest environment** to engage and calm learners through natural surroundings.
• Includes **lightning and thunder effects** to simulate weather conditions. An **animated exercise** task helps guide children **to stay calm** during the lightning strike.

• Features a single animated plant that clearly demonstrates the photosynthesis process, including:

1. **Sunlight EFX**
2. **Rain EFX**
3. **Molecule animations** - showing the flow of CO_2, H_2O, and O_2 through the plant

• **Audio and visual instructions** are provided to support learning needs.
• **Background sound effects (SFX)** enhance immersion and bring the forest to life.

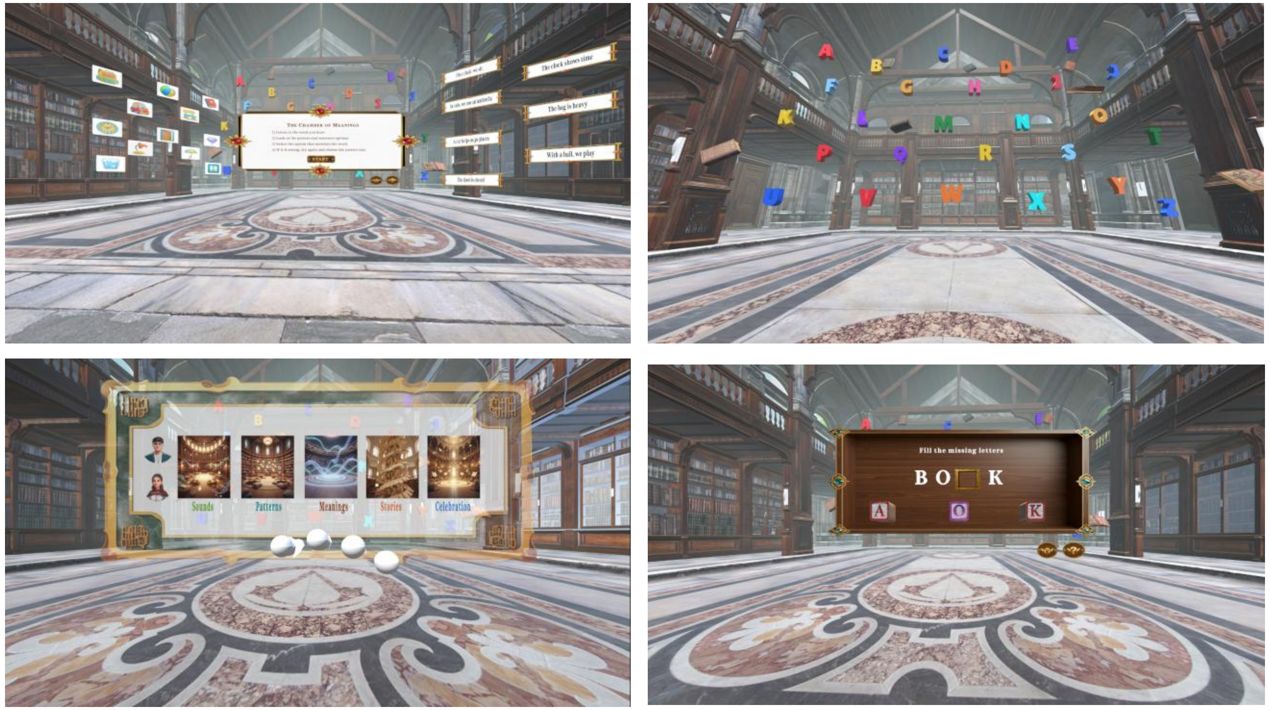


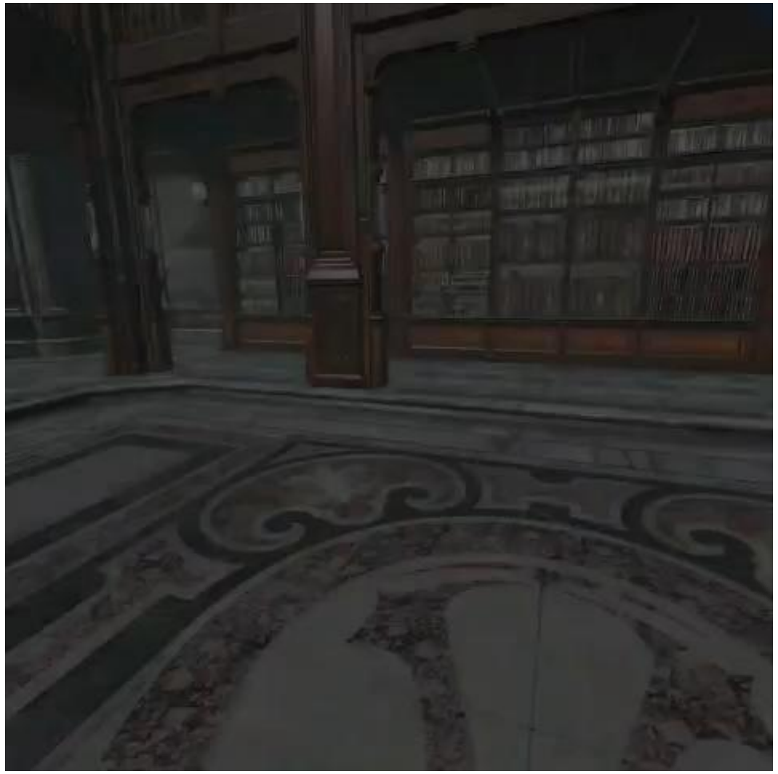
VR Environment – ADHD- Photosynthesis

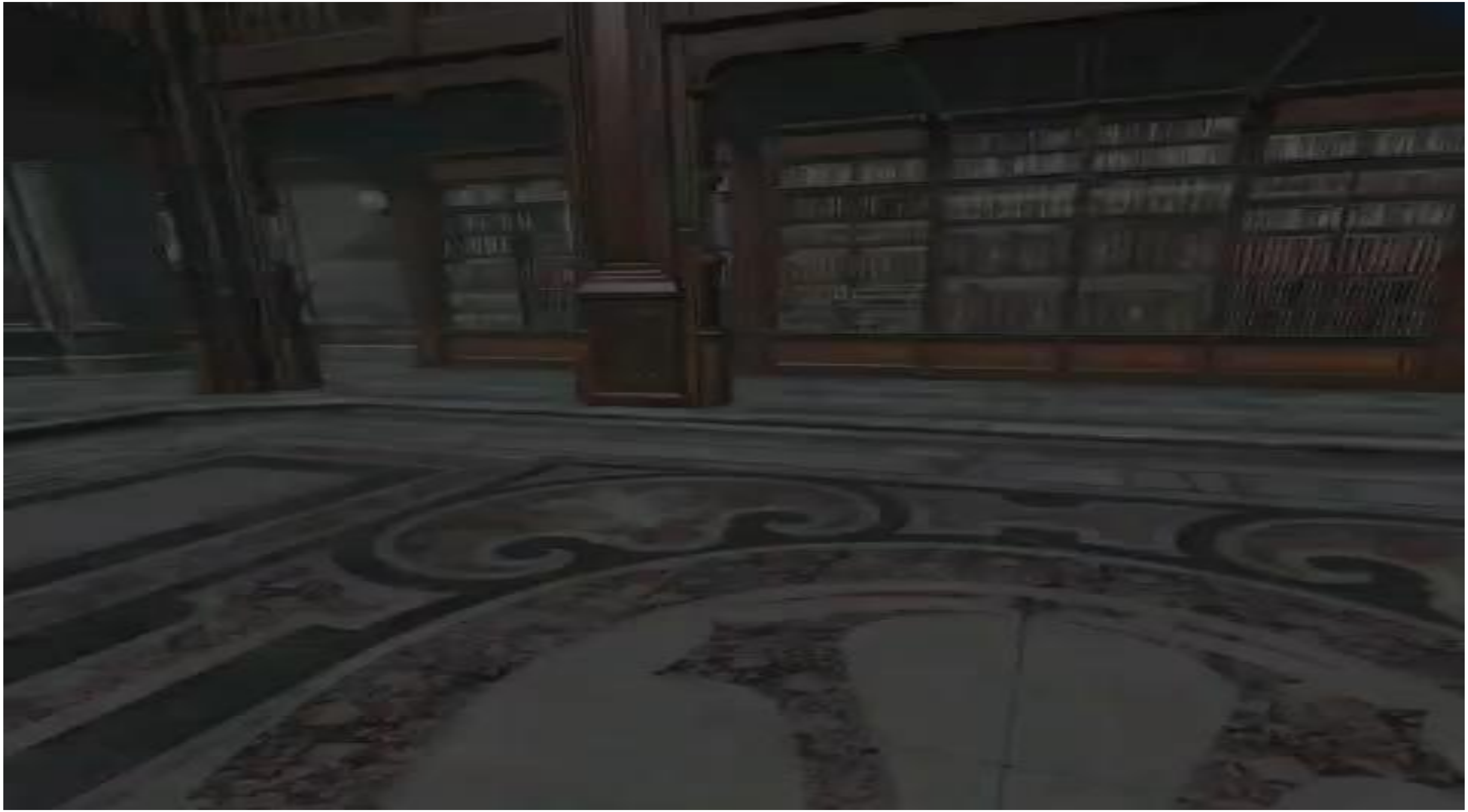
SSN GUVI SHIV NADAR SCHOOL Education for Life

STUDY 3 - VR IMMERSIVE LIBRARY MODULE FOR DYSLEXIA

The Magical Library is a story-driven immersive VR environment designed to stimulate curiosity, emotional regulation, and language development through interactive storytelling. It supports early cognitive and therapeutic development in a calm and engaging virtual setting.

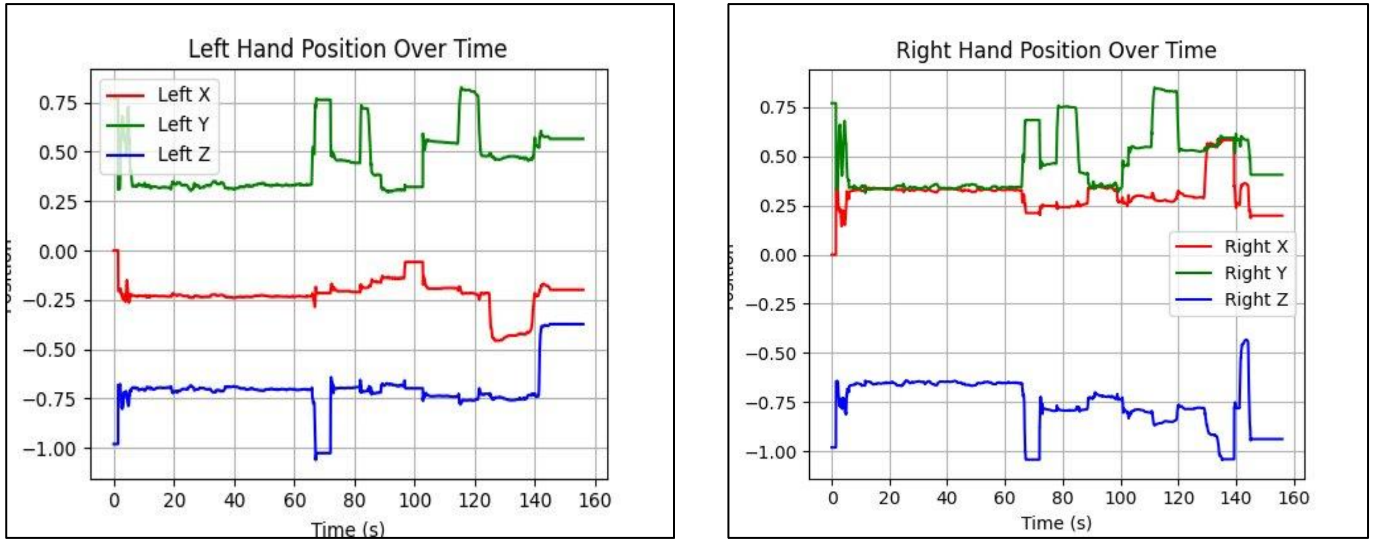






IMMERSIVE LIBRARY MODULE TESTED IN SHIV NADAR SCHOOL – NOIDA, INDIA

ANALYSIS



Left and Right Hand Position Tracking with Quantitative Motion Analysis in VR Interaction

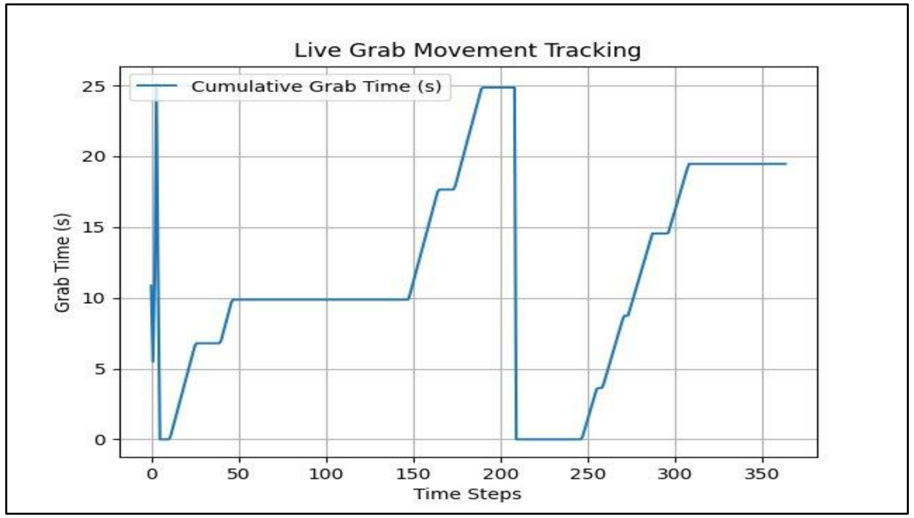
- Both hands show consistent motion patterns across the 160-second session, suggesting the user was actively engaged throughout.

- Head tracking allows for continuous evaluation of attention during training by **increasing the graph value when the user looks at the target object and staying constant when the gaze moves away.**

- Real-time motion along the X, Y, and Z axes is recorded by **hand tracking; the colored curves show reaching, lifting, and depth movements, while the flat areas show quick stops or stabilization.**

ANALYSIS

Parameter	Left Hand	Right Hand	Interpretation
X-axis	Stable	Active	Right hand explores lateral space
Y-axis	Strong vertical motion	Strong vertical motion	Lifting/reaching coordination
Z-axis	Stable depth	Dynamic depth	Right hand reaches forward/back
Engagement	Moderate	High	Right hand dominant in interaction
Motor Control	Smooth	Smooth	Indicates coordinated and deliberate movements

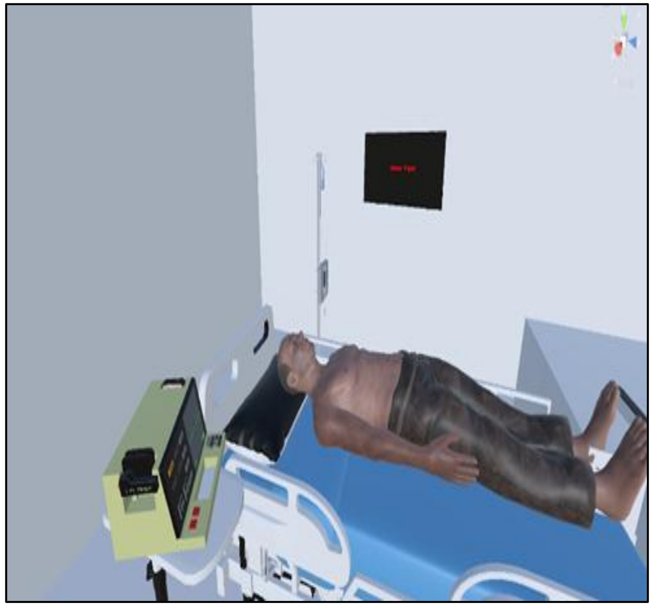


- The graph shows **three major grab activity phases**, separated by idle or release periods.
- The **Cumulative Grab Time (y-axis) increases** in steps, indicating multiple grab-and-hold events followed by release intervals.
- This pattern signifies **repeated engagement** with virtual objects rather than continuous holding — reflecting **interactive task-based training.**

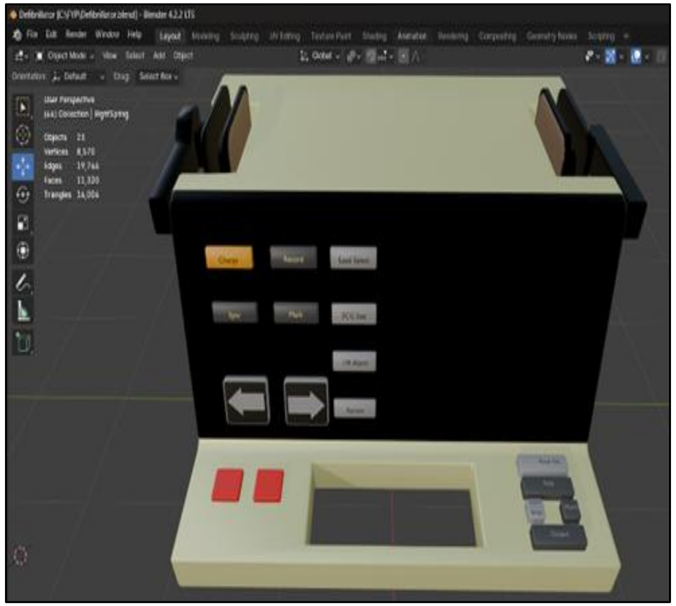
STUDY 4 - VR FOR BIOMEDICAL ENGINEERING EDUCATION

Virtual Reality (VR) enhances Biomedical Engineering education by providing immersive and interactive simulations of medical equipment. It enables students to safely practice real-time procedures, understand ECG abnormalities, and develop technical skills without physical risk.

By integrating physiological analysis such as HRV, VR training also evaluates cognitive load and learning effectiveness.



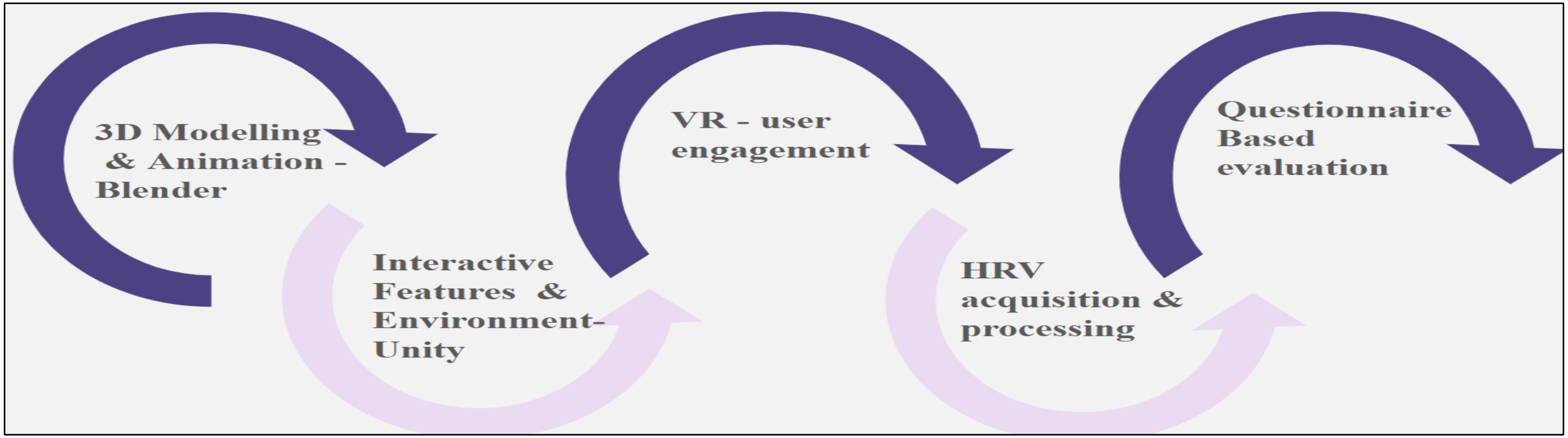
Unity Simulation Setup



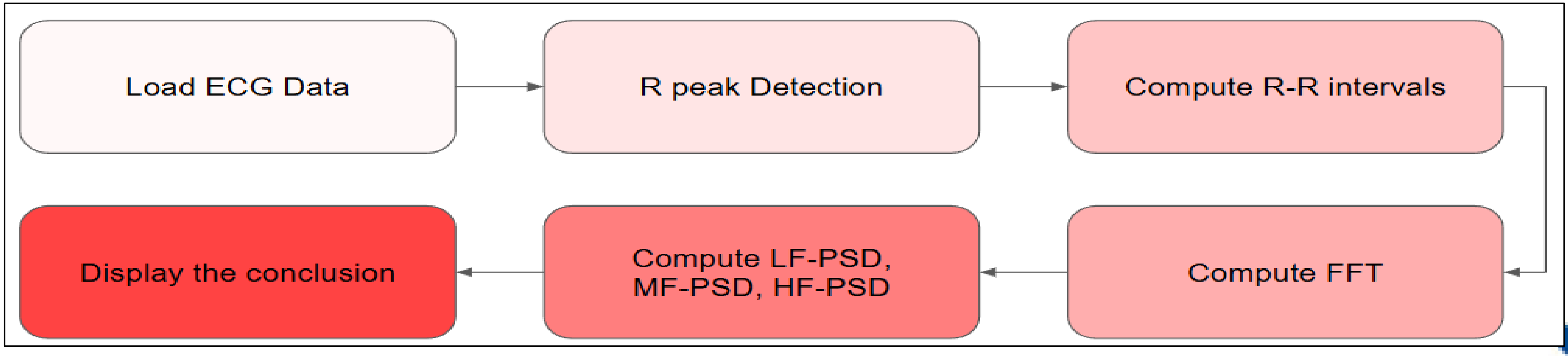
Defibrillator Model

TECHNICAL FLOW

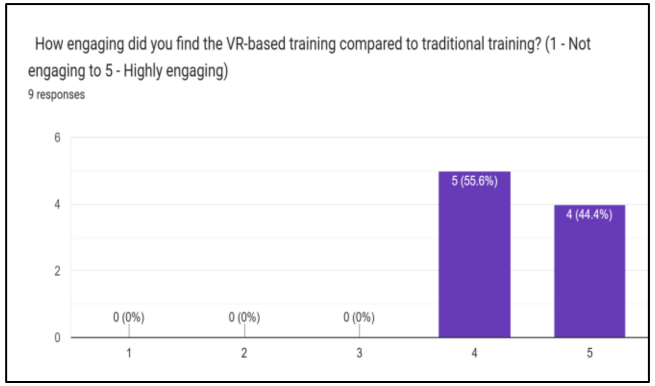
METHODOLOGY

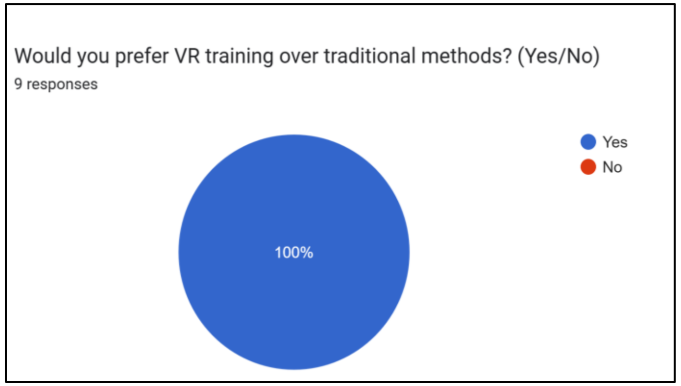


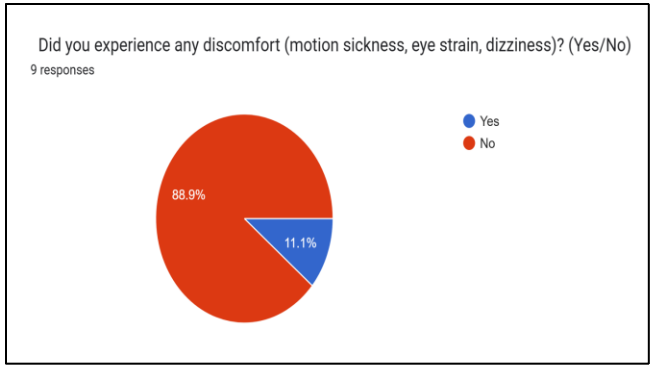
HRV PROCESSING

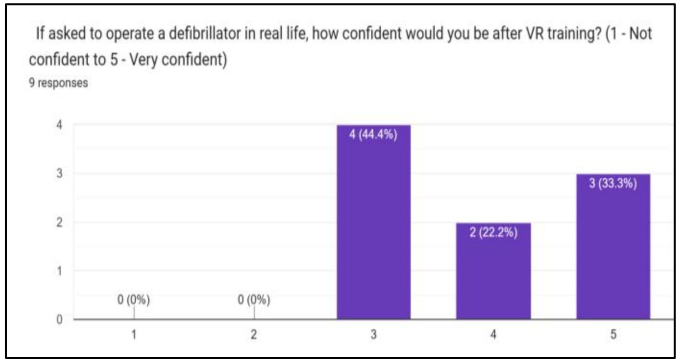


ANALYSIS







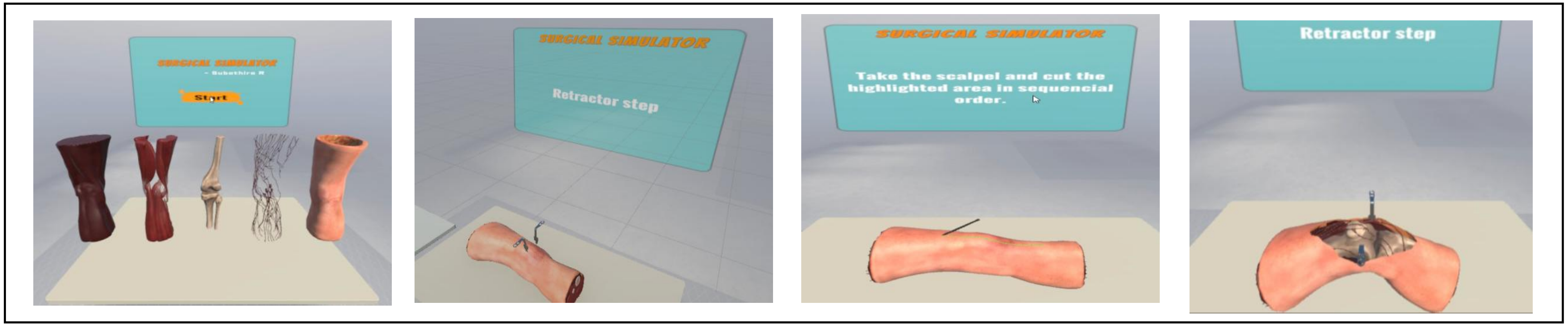


- VR- based training proves promising and effective alternative among students, stating that it provides realism and is more immersive than the traditional method.
- Physiological analysis of the LF Band of PSD appears less in VR training compared to Traditional methods. However, due to the limited sample space, this difference is not statistically significant.


Search for worlds, apps and more
FYP Test1
Resume
Quit
11:52
FYP Test1

STUDY 5 –VR BASED SURGICAL STIMULATOR WITH HAPTIC FEEDBACK

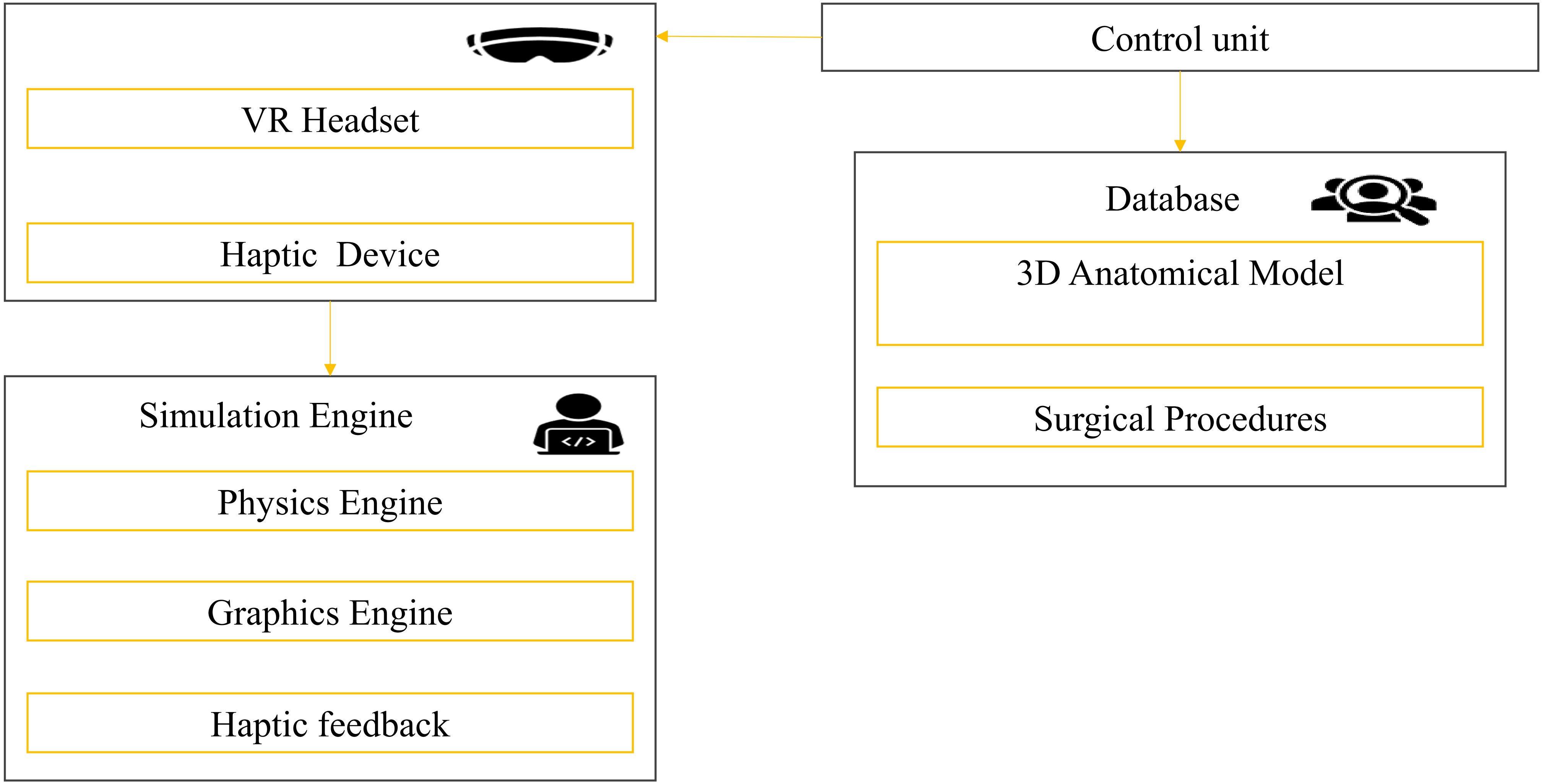
- VR-haptic simulators create immersive and tactile training environments using anatomically accurate 3D models and tissue deformation simulation.
- Force feedback rendering allows users to experience realistic resistance during cutting, drilling, and palpation procedures.
- Developed using platforms such as Unity or Unreal Engine, the system evaluates trainee performance through force accuracy, motion smoothness, error rate, and task completion time.
- This approach provides a safe, repeatable, and cost-effective alternative to cadaver-based surgical training.



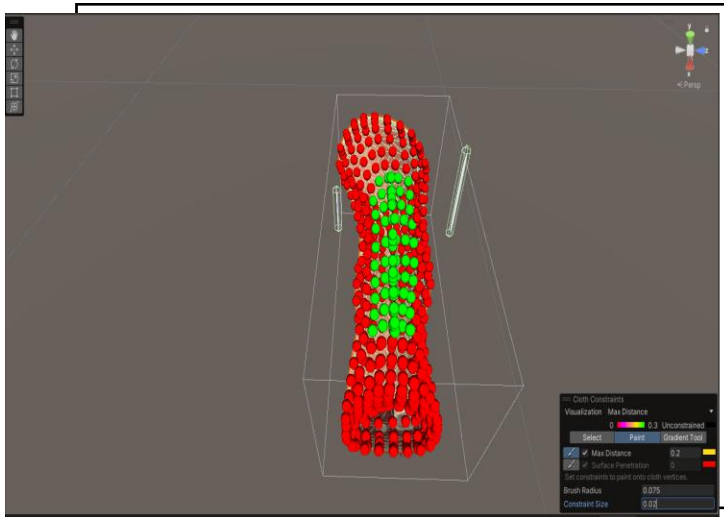
Simulation Environment

Divya, B., Kavitha, A., Pravin Kumar, S., & Subathira, R. (2025, April). Comparative Analysis of Realistic 3D Models for VR Based Knee Surgery Simulation. In 2025 3rd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA) (pp. 1-6). IEEE.

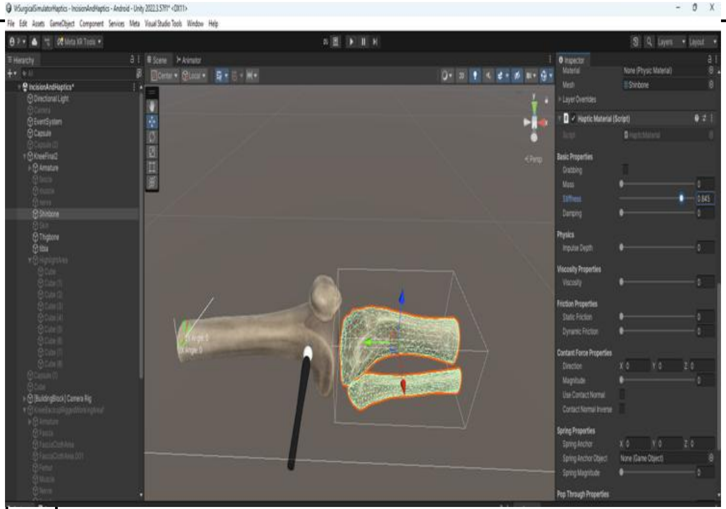
TECHNICAL FLOW



ANALYSIS



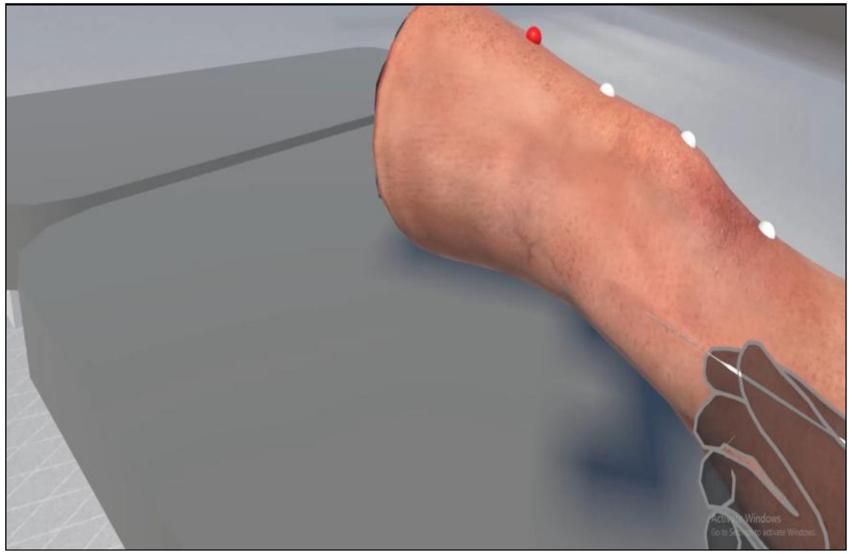
Depth- Based Resistance



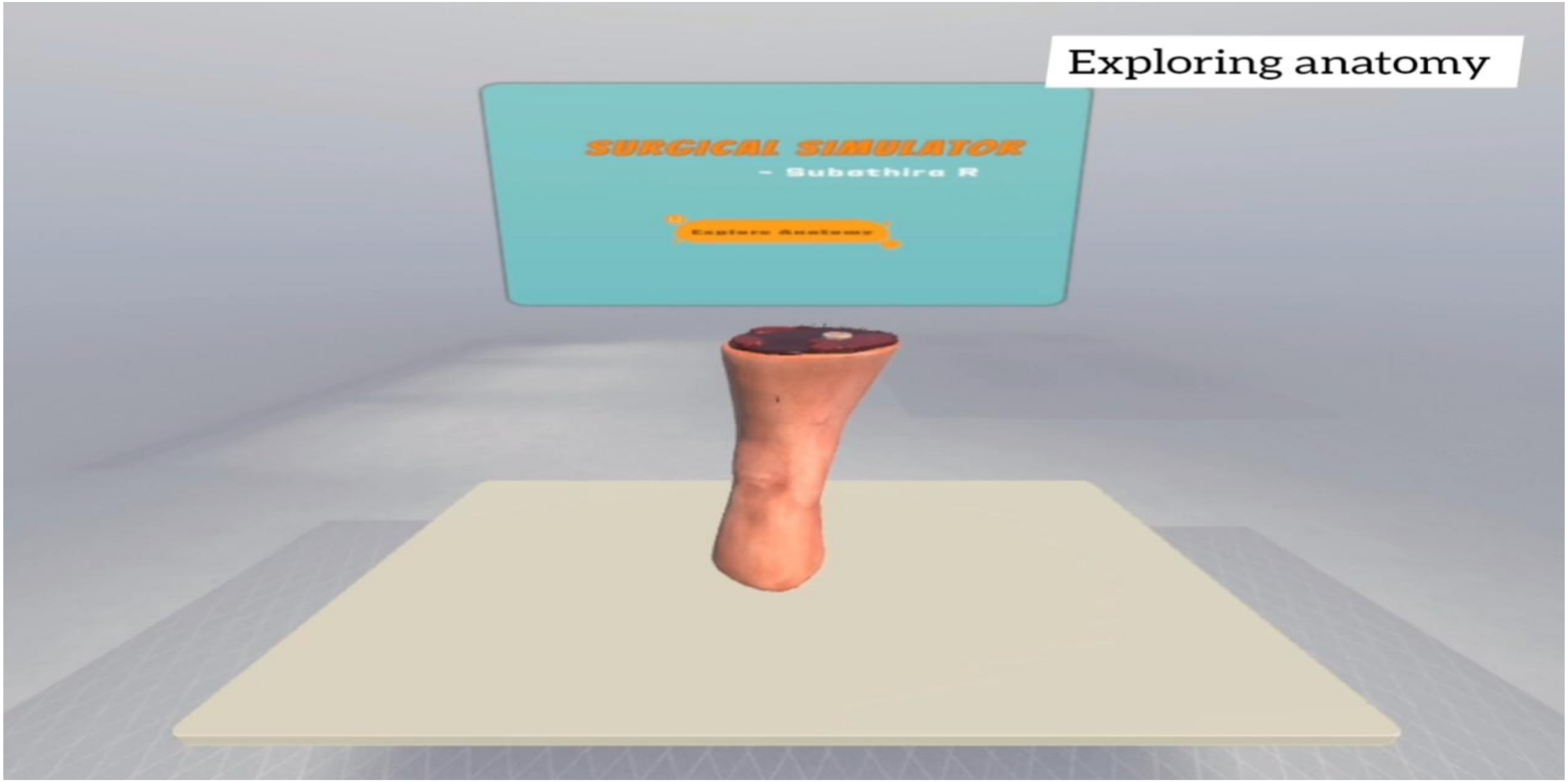
Soft Body Physics Constraint Setup

- Configuring Cloth Constraints in Unity to simulate soft tissue behavior.
- **Red vertices indicate fully constrained areas, while green vertices represent movable regions.**
- Adjusted **Max Distance and Constraint Size for controlled deformation.**

Layer	Stiffness	Damping	Friction	Tuning Adjustments
Skin	Ref : 0.6 - 0.9 Imp: 0.7	Ref: 0.4 - 0.6 Imp: 0.5	Ref: 0.3 - 0.5 Imp: 0.3	Soft but slightly resistant
Muscle	Ref: 0.3 - 0.5 Imp: 0.5	Ref: 0.2 - 0.4 Imp: 0.3	Ref: 0.1 - 0.3 Imp: 0.2	Soft, lower resistance
Bone	Ref: 1.0 Imp: 1.0	Ref: 0.8 - 1.0 Imp: 0.9	Ref: 0.5 - 0.7 Imp: 0.6	Hardest surface, high resistance



Demonstration of the Knee Insertion process


Exploring anatomy
SURGICAL SIMULATOR
- Subathira R

Challenges and Limitations

IN AR

Issues that compromise accurate registration between virtual and real time anatomy in liver surgery

- **Soft tissue deformation**
- **Motions of the patient**
- **Sensor noise**

HMDs have

- **small field of view**
- **latency**
- **optical perception error**

That affect depth perception in spine surgery

Haptic devices require

- **space**
- **force fidelity and**
- **expensive equipment**

IN VR

Issues that limits the effectiveness of the environments include

- individual differences in children
- Cybersickness
- lack of massive clinical validation

GENERALLY XR SYSTEMS NEED

- to be integrated into actual clinical workflows
- Regulatory approvals
- Sterilization compatible hardware
- Integrated electronically with hospital information systems

Future work

We intend to extend our work in AR through

- Real- time non rigid registration
- Sensor fusion with AI based tracking
- Adaptive depth correction to improve overlay accuracy
- Advanced Haptic Integration for Surgical Realism
- ML based force prediction and
- Patient specific biomechanical material modelling
- Clinical Trials with more subjects

And in VR through

- Cloud based multi user collaborations.

In general our XR systems would have

- Combination of AI, digital twins and multimodal sensing to improve precision surgery, individual rehabilitation and immersive medical training

Acknowledgement

- SSN College of Engineering, India
- Science & Engineering research Board, India
- Shiv Nadar Foundation, India

Team XR @ SSN

Partnering Researchers

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(Deemed to be University)

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Ortho Spine Surgeon
SRIHER, Chennai, India

allreal

Mr. Vishnu TU
All real
Coimbatore, India

SHIV NADAR SCHOOL
Education for Life

Ms, Harleen Ahulwalia
Head, Special Education
SNS Noida, India

GUVI | HCL
Skill Up. Level Up

Ms, Durga Rajasekaran
Associate Director
HCL GUVI
Chennai, India

RECOGNITIONS

Augmented Reality-based Surgical Support Systems" has won the TNOA Prof. A. Subramaniam Gold Medal for 2026—a highly prestigious, specialised award presented by the Tamil Nadu Orthopedic Association (TNOA)

Invited to the ASEAN WOMEN SCIENTISTS CONCLAVE to present the work


XIth INTERNATIONAL CONFERENCE ON
BIOSIGNALS, IMAGES, AND INSTRUMENTATION
(ICBSII 2025)
organized by


DR. A. KAVITHA
PROF. FONG-CHIN SU

Thank you

நன்றி