Augmented and Virtual Reality Integration with Digital Twin Technology

Les Folio, DO, MPH, ACHIP, CIIP, Chest Radiologist and Imaging Informatics Section Chief, James A. Haley VA Hospital
Sara Aghamiri, MSc; João Santinha, PhD; Rada Amin, PhD; Pedro Gouveia, PhD

Introduction

A digital twin (DT) is a computational model visually representing a specific physical object, system, or process. While the DT provides virtual representations of real-world systems, Augmented, Mixed, and Virtual Reality (AR/MR/VR) provides an immersive experience.
In recent years, DT-AR/MR/VR integrations in healthcare have gained significant traction due to their potential to revolutionize training attending and resident physicians.

Hypothesis

DT-AR/VR integration creates a robust medical training platform for healthcare professionals, offering a more realistic and engaging learning environment, planning and image-guided-interventions.

Methods

This study reviews trends and applications of integrating cutting-edge technology of digital twins with augmented and virtual reality to discuss the opportunities, implementation, and challenges in medicine.
AI advancements in medical image processing and quantitative analysis are associated with augmented and virtual reality (AR/VR) head-mounted displays that allow enriched visualization and manipulation of these digital twins in various clinical scenarios.

Results

Medical imaging modalities, especially cross-sectional modalities (e.g., MRI, CT, PET/CT), provide high-resolution anatomical data essential for building virtual replicas that are essentially DTs.
DT-AR/VR integration also enhances the training of attending and resident physicians by enabling virtual environments to practice various medical procedures, improving their skills and decision-making. As an example, Surgical Planning and Intervention Guidance. DTs created from medical imaging data enable surgeons to virtually plan and simulate complex procedures, explore various approaches, identify potential risks, and optimize surgical strategies for improved outcomes. Additionally, these DTs can be overlayed on patients, enabling their use as a guide for interventions.

Challenges inherent to DT-AR/VR integration that must be addressed include:
Data Acquisition and Integration: Integrating real-time data from various sources, including diverse medical imaging modalities.

Procurement of sophisticated technology is still in its infancy, and convincing leadership to acquire is difficult.
Data Privacy and Security: Protecting sensitive patient information derived from medical imaging and complying with regulations is paramount.

Conclusion

DT-AR/VR integrations grounded in rich medical imaging data hold immense promise for advancing healthcare. The future trajectory of this technology relies on further integration of AI for advanced image analysis and predictive modeling, ultimately enabling real-time DT refinement for continuous monitoring, personalized interventions, and more accurate predictions of disease progression and treatment response. Addressing the challenges through collaborative efforts and robust frameworks will be crucial to fully realizing the transformative potential of DT-AR/VR in healthcare.

Figure(s)

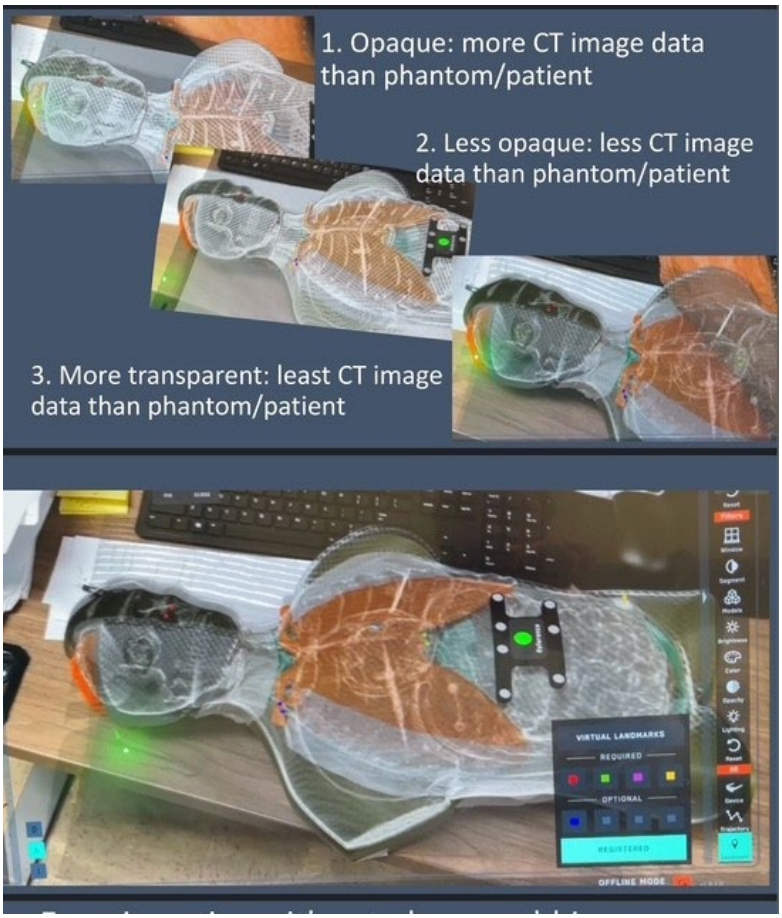

Figure 1. DT-AR integration as phantom/patient from CT image data.

Keywords

Applications; Artificial Intelligence/Machine Learning; Emerging Technologies