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Advancing Medical Imaging with AR: A Survey on Transforming 2D images into Immersive 3D Models

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***Abstract*—Medical imaging technologies, such as Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans, have revolutionized the medical field by offering precise and detailed visualizations of internal structures, aiding in diagnosing and treating complex conditions like tumors, fractures, and organ abnormalities. However, these images are typically presented as 2D slices, requiring medical professionals to mentally reconstruct 3D anatomical relationships. This process can lead to spatial perception errors and increased cognitive load, limiting diagnostic accuracy and surgical planning. Augmented Reality (AR) emerges as a transformative solution to break these limitations, allowing the conversion of 2D medical scans into interactive 3D models. AR enhances the visualization of complex anatomy, aids in treatment planning, and supports medical education by providing an intuitive and immersive experience for clinicians and students alike. Our project focuses on developing an AR-based tool using ARCore/ARKit to enable real-time 3D visualization of MRI and CT scans. This tool has the potential to improve diagnostics, streamline surgical procedures, and make medical education more engaging and effective, paving the way for better patient outcomes.**

***Index Terms*—Medical imaging, Augmented Reality, 3D models, MRI, CT.**

I. INTRODUCTION

Medical imaging has long been a cornerstone of modern healthcare, offering unparalleled insights into the human body. Technologies such as MRI and CT scans have become essential in diagnosing a wide range of conditions, from neurological disorders and cardiovascular diseases to musculoskeletal injuries and tumors [1]. These imaging modalities generate precise and detailed views of internal structures, significantly advancing the accuracy of diagnosis and treatment. Despite these strengths, the 2D slice-based representation of imaging data presents a fundamental challenge: it requires healthcare professionals to mentally reconstruct 3D anatomical relationships, which can be laborious and prone to spatial interpretation errors.

This limitation becomes especially problematic in fields such as neurosurgery, orthopedics, and cardiology, where a precise understanding of spatial relationships is critical.

The cognitive effort required to interpret multiple 2D slices not only increases the likelihood of diagnostic errors but also adds to the workload of clinicians [2]. Furthermore, traditional imaging methods often fail to provide the clarity and contextual depth needed for patient-specific therapies, where even minor inaccuracies can have significant consequences [3]. Augmented Reality (AR) offers a groundbreaking solution to these challenges by transforming 2D medical imaging data into interactive 3D models.

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AR combines advanced algorithms and visualization technologies to create immersive, lifelike representations of anatomical structures that can be explored from any angle. Unlike traditional imaging confined to flat screens, AR projects these models into a real-world environment, making them intuitive and accessible for healthcare providers.
This paper proposes the use of AR to enable real-time 3D visualization of MRI and CT scans. By leveraging platforms like ARCore and ARKit, clinicians could gain a more comprehensive understanding of patient anatomy. The approach discussed aims to enhance diagnostic precision, improve surgical planning, and offer immersive medical education experiences, potentially transforming how medical professionals interact with imaging data.

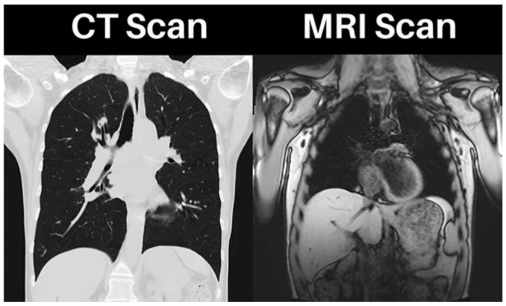

Figure 1. CT and MRI Scans

Figure 2. Doctors using AR

Beyond diagnostics and treatment planning, AR holds tremendous potential for medical education. Traditional teaching methods, which often rely on cadavers, diagrams, and 2D scans, fail to capture the complexity of living anatomy. AR addresses this gap by allowing students to interact with 3D models in real time, deepening their understanding of anatomical structures. Additionally, AR can simulate medical procedures, providing trainees with a risk-free environment to practice and refine their skills [4].
As AR technology continues to advance, its integration with medical imaging represents a significant step forward in bridging the gap between technology and patient care. By addressing the inherent limitations of existing systems, AR empowers clinicians with tools that enhance diagnostic accuracy, streamline workflows, and improve patient outcomes. Moreover, the fusion of digital precision with real-world interaction opens new possibilities for personalized medicine, paving the way for a future where medical decisions are informed by unparalleled clarity and insight [5].

II. Literature Survey

TABLE I. LITERATURE SURVEY OF PAPERS

No.	Year	Author	Title	Summary	Key Findings	Drawbacks
1	2021	Pak-Hei Yeung	Learning to Map 2D Ultrasound Images into 3DSpace with Minimal Human Annotation	Uses CNN to map 2D ultrasound imagesinto 3D space, with self-supervised learning to generate 3D predictions.Benchmarks on real and synthetic fatal 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: AReview	Comprehensive review on 3D deep learning applications in medical imaging, including segmentation, classification, detection, and localizationfor modalities like MRI, CT, PET. Covers architectures like U-Net for organ and lesion	3D CNNs provide superior performance in organ segmentation,lesion detection, and disease classification. Integration withLSTMs improves neuroimaging classification.	High computational cost, small datasets lead to overfitting, and class imbalance for rare conditions like tumour detection.

No.	Year	Author	Title	Summary	Key Findings	Drawbacks
				segmentation, and CNNs with LSTM for disease classification.		
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) from2D 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 orthopaedics.	Lower accuracy for ulna reconstructions, limited datasetof healthy bones reduces generalizability, single-direction X-rays lead to lower accuracy compared to multi-directional imaging.
4	2021	Mythreye Venkatesan	Virtual and Augmented Reality for Biomedical Applications	Comprehensive review of XR technologies, highlighting VR and AR immersive capabilities in medical education, training, and healthcare, with key features in surgical planning and molecular modelling.	XR enhances spatial awareness and learning in medical education, surgical planning, and molecular visualization. Hand tracking and volume rendering techniques can improve interactivity.	Interaction limitations, multiplayer support lacking, anda need for more clinical validation.
5	2021	Filipi Pires	On the Use of VirtualReality for Medical Imaging Visualization	Explores how VR/MR enhances medicalimaging visualization, covering immersive 3D tools for disease analysis, surgical planning, and medical education. Reviews the limitations of DICOM-based VR systems.	Volume rendering techniques and intuitive user interaction methods like hand tracking can improve medical visualization and engagement.	High latency issues and relianceon the DICOM standard limits compatibility with other formats.
6	2024	Andrea Lastrucci	Exploring AR Integrationin Diagnostic Imaging: Myth or Reality?	Examines AR's potential in diagnostic imaging for surgical planning, education,and collaboration. Highlights integrationwith AI, robotics, and VR for healthcare innovations.	AR overlays digital information onto real-world data, enhancing understanding of medical images. Game engines like Unity/Unreal Engine enable real-time AR rendering.	Limited clinical validation, complex workflows, and need for comprehensive training for healthcare professionals.
7	2021	Javad Fotouhi	Development an dPre-Clinical Analysis of Spatiotemporal-Aware AR in Orthopedic Interventions	Investigates AR integration in orthopaedic surgeries, focusing on improving workflows and intra-operative planning with head-mounted displays and spatiotemporal-aware concepts.	Improved surgical accuracy for K-wire placement and hip arthroplasty using AR with spatiotemporal tracking.	Complex setup, training requirements for surgical teams, and tracking limitations with visual SLAM.
8	2021	Mohammad Fahim Hossain	Augmented Reality in Medical Education: AR Bones	Develops a mobile AR app for human skeleton visualization in anatomy education, offering an affordable solution for medical students.	Improves accessibility of anatomy learning through a marker less AR experience using smartphones.	Limited to skeletal visualization,potential device compatibility issues, and dependence on internet connectivity.
9	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.
10	2020	Fei Tong	X-ray2Shape: Reconstruction of 3DLiver Shape from a Single2D Projection Image	The study presents a framework for reconstructing 3D liver models from single 2D projection images using a combination of CNNs and GCNs. The system uses a mean liver shape template deformed based on image features to match patient-specific anatomy.	Provides a low-radiation, cost-effective alternative to CT scans, aiding in surgical and radiotherapy applications.	Low image quality from 2D X-rays, limited representation due to a mean shape template, and high computational demands.
11	2023	Kwok Chuen Wong	Mixed Reality Improves 3D Visualization and Spatial Awareness of BoneTumours for	Explores the use of mixed reality (MR) to enhance 3D visualization and spatial awareness in preoperative planning for bone tumour	MR significantly improves spatial awareness and reduces cognitive load for surgeons, highlighting its potentialas an alternative	Small sample size of nine patients, possibly not representative of diverse conditions. Further research needed to verify

No.	Year	Author	Title	Summary	Key Findings	Drawbacks
			Surgical Planning in Orthopaedic Oncology: A Proof of Concept Study	surgeries. MR overlays holographic 3D models on the patient's body through a head-mounted display (HMD), reducing cognitive load and improving spatial awareness, based on evaluations using a Likert-scale questionnaire and NASA Task Load Index (NASA-TLX).	to 2D images and physical models in surgical planning.	MR's impact on surgical outcomes. Learning curves and equipment-related challenges for broader clinical adoption.
12	2024	Xuanyu Zhao	Clinical Evaluation of Augmented Reality-Based 3D Navigation System for Brachial Plexus Tumour Surgery	Evaluates an AR-based 3D navigation system for brachial plexus tumour surgeries, using holographic models from MRI data for preoperative and intraoperative visualization.	Improves surgical precision and reduces the risk to surrounding tissues.	Positional inaccuracies, dependency on precise patient positioning, and reliance on high-resolution MRI data.
13	2024	Alexander Gall	Immersive Analysis: Enhancing Material Inspection of X-Ray Computed Tomography Datasets in Augmented Reality	Discusses an AR framework to improve immersive analysis of X-ray computed tomography (XCT) data, particularly for non-destructive testing in materials science. AR enables hands-free inspection and spatial analysis, integrating XCT data with physical objects for a more intuitive workflow.	AR framework improved spatial awareness, data comprehension, and workflow efficiency in material inspection, showing promise as an alternative to traditional 2D inspection methods.	Limited field of view in AR devices, performance issues with large datasets, colour fidelityissues in bright environments, and processing limitations for broader industrial application.
14	2023	H. Kase	Spatial Awareness Application Using MixedReality for 3D X-ray CT Examination	Introduces an MR application to enhancespatial understanding of X-ray CT images in medical contexts, addressing 2D viewing limitations. MR allows for intuitive 3D manipulation and viewing of cross-sectional images, aiding spatial diagnosis and surgical preparation.	MR allows users to view and interact with 3D representations of internal structures, enhancing accuracy in spatial diagnosis and aiding in pre-surgical planning.	Accuracy limitations across dimensions, dependency on specialized hardware and software, and usability issues that may limit clinical workflow integration.
15	2022	Payel Maken	2D-to-3D: A Review for Computational 3D Image Reconstruction from X-rayImages	Reviews computational 3D image reconstruction methods from 2D X-rays, comparing their effectiveness and challenges.	Highlights alternatives to CT and MRI for 3D imaging with lower radiation exposure.	Challenges with image overlap, spatial information loss, and complex calibration processes.
16	2023	Yuan Gao	3DSRNet: 3D Spine Reconstruction Network Using 2D Orthogonal X-Ray Images Based on Deep Learning	3DSRNet, a deep learning model, reconstructs 3D spine images from orthogonal X-rays using a GAN framework and CNN-transformer structure for enhanced detail.	Achieves high-quality reconstructionswith strong metric performance.	Dependence on high-quality orthogonal X-rays, training instability, and potential overfitting.

Augmented reality (AR) and artificial intelligence (AI) have revolutionized medical imaging in recent years, offering new possibilities for visualizing and analysing 2D and 3D medical data. For instance, a paper [1] introduces a novel approach to converting 2D ultrasound images into 3D space using convolutional neural networks (CNNs) with minimal human intervention. This study addresses the challenge of aligning 2D scans with their corresponding 3D planes to enhance neurosonography, particularly for fatal brain scans. The model achieved remarkable success in producing accurate 3D predictions from 2D slices but encountered limitations in image quality and performance in complex brain regions. Building on the significance of 3D models in medical imaging, a review paper [2] emphasizes the role of 3D convolutional neural networks (3D CNNs) in various imaging tasks, including segmentation, classification, and detection across different imaging modalities. Techniques such as 3D U-Net have made substantial progress in tumour segmentation and disease classification. However, the paper identifies several critical challenges when applying 3D deep learning in real-world clinical settings. These include high computational costs, limited data availability, and class imbalance. These challenges are not unique to 3D deep learning but are common across the development of AR/VR applications in medical imaging, which often require real-time processing and high-quality visualization.

In a more specific application, the study paper [3] demonstrates the feasibility of reconstructing 3D bone models from 2D X-ray images using convolutional neural networks (CNNs) and generative adversarial networks (GANs). By employing DRR-like images, the model was able to effectively reconstruct 3D bone models, although it encountered challenges in reconstructing intricate anatomical structures like the ulna. This paper underscores the potential of reducing the reliance on high-radiation imaging techniques like CT by utilizing less invasive 2D X-ray images. However, the accuracy and generalizability of this approach are limited, particularly in pathological cases.

The paper [4] extensively discusses the application of augmented reality (AR) in medical education and visualization. The authors illustrate the transition from traditional 2D imaging analysis to immersive 3D experiences in areas such as surgical planning and medical education. They highlight the current limitations, including performance issues and hardware constraints. Similarly, the review paper [5] echoes these sentiments, focusing on how extended reality (XR) technologies enhance learning outcomes and spatial awareness in medical training. However, it also acknowledges the technical limitations and high costs that have hindered widespread adoption. These limitations pose significant challenges for developers aiming to make AR systems more accessible for educational purposes.

Furthermore, the paper [6] delves deeper into the technical aspects of AR and VR adoption, specifically addressing latency issues and the reliance on standard formats like DICOM as barriers to real-time applications in clinical environments. Similarly, the work of paper [7] emphasizes the potential of AR in enhancing diagnostic imaging by overlaying digital information onto real-world images. However, the paper also emphasizes the need for further research to validate the clinical efficacy of AR systems, ensuring that they outperform traditional diagnostic methods.

In addition to their diagnostic applications, augmented reality (AR) technologies are also being utilized for patient-specific modelling, as demonstrated in the paper [8]. This paper delves into the process of converting DICOM files into 3D printable and AR-compatible models, particularly in fields such as cranio-maxillofacial surgery and renal cancer. While the paper highlights its usefulness, it acknowledges that the multi-step process may be overly complex for beginners and could require specialized software and hardware, thereby limiting its accessibility. These complexities underscore the need for streamlined workflows and user-friendly applications.

Furthermore, the paper [9] examines the role of AR in orthopedic surgeries. It reports improvements in surgical accuracy, particularly in procedures like total hip arthroplasty, while also discussing challenges related to tracking accuracy and system complexity. Similarly, the paper [10] showcases a mobile-based AR application that assists students in visualizing human bones, offering a practical and cost-effective alternative to physical models. However, device compatibility issues and technical glitches hinder the widespread adoption of such applications.

The paper [11] explores the application of AR in fracture mapping for middle-aged adults. It enhances the visualization of fracture patterns using CT and X-ray data. Although the study demonstrates the potential of AR in orthopedic visualization, it does not fully explore real-time interaction or usability, leaving room for future advancements in these areas. Recent advancements in medical imaging and augmented reality (AR) technologies have led to innovative solutions in surgery and diagnostic practices. One such development is the use of deep learning frameworks, such as the X-ray2Shape method, which employs convolutional neural networks (CNNs) and graph convolutional networks (GCNs) to create 3D liver models from 2D X-ray projection images. This approach offers a promising and cost-effective alternative to traditional 3D imaging methods, addressing concerns about radiation exposure and accessibility. However, challenges remain, including low image quality and computational requirements that may hinder real-time applications [12].

In recent studies, mixed reality (MR) and augmented reality (AR) have demonstrated their potential in enhancing visualization and spatial awareness in medical and industrial applications. In orthopedic oncology, MR has been utilized to improve 3D visualization and spatial awareness for preoperative planning of bone tumour surgeries. This approach enables surgeons to superimpose holographic 3D models directly onto the patient's body using a head-mounted display (HMD), significantly reducing the cognitive load associated with interpreting 2D images or physical models. Initial trials have shown that MR can enhance spatial awareness and reduce cognitive demands on surgeons, suggesting its potential to streamline surgical planning and improve precision during complex surgeries [13].

Building on these AR integration efforts, clinical applications have leveraged 3D holographic visualizations based on magnetic resonance imaging (MRI) data to support complex surgeries, such as those for brachial plexus tumours. While beneficial for precision and planning, challenges like positional inaccuracy and the necessity of high-resolution MRI scans highlight ongoing challenges [14].

Further investigations into SLAM algorithms for AR have revealed the necessity of robust navigation systems in dynamic environments. A comparative analysis of monocular VISLAM algorithms highlights the limitations posed by single-sensor configurations and complex testing conditions, which can obscure the specific effects of various variables. Despite providing valuable insights, this research underscores the challenge of achieving consistent SLAM performance under variable real-world scenarios [15]. Expanding on the capabilities of MR in enhancing spatial analysis, AR has been adopted to enhance immersive inspection processes in material science, particularly for non-destructive testing (NDT). By integrating X-ray computed tomography (XCT) data with physical objects, AR enables experts to interact hands-free with data during inspections, leading to increased efficiency and a more intuitive understanding of material properties. Testing on fiber-reinforced polymers has demonstrated that AR not only improves spatial awareness but also optimizes workflow and data comprehension, suggesting its potential for broader inspection fields [16].

Furthermore, Medical Research (MR) has been applied to medical imaging, enhancing the spatial representation of X-ray CT images for diagnosis and surgical preparation. Traditional 2D viewing methods require considerable mental effort to reconstruct 3D anatomical structures. However, MR allows users to manipulate cross-sectional images in 3D, aiding spatial understanding. By providing precise 3D visualizations through an intuitive, gesture-based interface, this approach has shown promise for improving accuracy in spatial diagnosis and preoperative planning, potentially impacting surgical outcomes [17]. Reviewing 3D reconstruction methods, researchers have highlighted the utility of computational frameworks for generating 3D images from 2D X-ray data. Although effective in reducing radiation exposure compared to CT scans, these methods are often hindered by spatial information loss and complex calibration processes [18].

More advanced deep learning architectures, such as 3DSRNet, push the boundaries of 3D spinal reconstructions using Generative Adversarial Networks (GANs) and transformer-based networks. However, their reliance on high-quality orthogonal X-rays and potential training instability indicates a need for more resilient models that can handle varied patient anatomy [19].

Lastly, a Convolutional Neural Network (CNN) approach for 3D knee bone reconstruction from bi-planar X-rays showcases an end-to-end solution that bypasses traditional shape modelling methods. This method delivers accurate and cost-efficient results but still heavily relies on high-quality labelled data and preprocessing, limiting its application across different body parts [20]. [21] paper leveraging advanced algorithms and machine learning techniques to improve the accuracy and effectiveness of their respective application. [22] discussed advanced feature selection approach and [23] discussed decision tree clubbed nearest neighbour classification.

Despite advancements, challenges persist in widespread adoption of AI-driven 3D modeling due to high computational demands, latency issues, and limited AI integration in AR. Our work addresses these gaps by utilizing cloud-based WebAR systems for 3D medical imaging visualization. Offloading computational tasks to the cloud reduces device burden and enables smoother real-time interaction. Advanced AI algorithms for 2D-to-3D reconstruction enhance model accuracy, even with limited input data, making it more accessible for education and healthcare.

III. Research Gaps

Several research gaps hinder the broader adoption and clinical efficacy of AR/VR and 3D reconstruction technologies in medical applications. Limited or specialized datasets restrict the generalizability of proposed models. While studies like 3DSRNet and X-ray2Shape show promising results under controlled conditions, they fail to adapt to diverse patient populations or real-world variability. Some methods, like End-to-End CNN for 3D Knee Bones, are designed for specific anatomical regions and require extensive retraining or modification for scalability.

Computational and hardware limitations also hinder real-time application. Many AR/VR systems face challenges like limited fields of view, latency issues, and handling large datasets. These issues are problematic in scenarios requiring real-time performance, such as surgical planning or intraoperative navigation. Current

AR devices struggle with processing large 3D medical datasets efficiently, leading to compromises in visualization and interaction. Similarly, the high computational demands of 3D CNNs and GAN-based models make it challenging to deploy solutions in environments with limited computational resources.

Rigorous validation of the clinical impact of AR/VR technologies is lacking. While studies show improvements in spatial awareness, visualization, and cognitive workload, there's limited evidence of how these advancements translate into improved clinical outcomes like enhanced surgical precision and reduced errors. Large-scale studies and longitudinal evaluations are needed to assess their efficacy. Many studies also overlook how these technologies integrate into existing clinical workflows, such as seamless integration with medical imaging systems, electronic health records, and surgical tools.

Usability and accessibility are challenges. Specialized training for effective use creates a steep learning curve for healthcare professionals. For instance, AR Bones and Spatial Awareness Using Mixed Reality highlight usability issues for professionals unfamiliar with AR technology. High costs associated with advanced hardware, like head-mounted displays and real-time processing units, limit accessibility, especially in resource-constrained settings. Even cost-effective solutions like mobile-based AR Bones face barriers like device compatibility and internet dependency.

Accuracy and alignment persist in 3D reconstruction and AR systems. Methods relying on sparse data, like X-ray2Shape and 2D-to-3D Forearm Reconstruction, suffer from positional inaccuracies and spatial fidelity loss. Misalignments compromise their surgical utility. Synthetic datasets, like End-to-End CNN for Knee Bones, may fail in real-world variability. Techniques ensuring accuracy and reliability are needed.

Cross-disciplinary collaboration is lacking. While technical advancements occur, clinical practitioners, radiologists, and surgeons are often underrepresented. This disconnect leads to tools that don't address practical needs. Emerging trends like monocular Visual Inertial SLAM (VISLAM) and mixed reality solutions show promise, but their integration with AI, robotics, and advanced computational frameworks is under-explored.

Cross-disciplinary collaboration is lacking in many studies, leading to the development of sophisticated tools that fail to address practical clinical needs or usability challenges. Emerging trends like monocular Visual Inertial SLAM (VISLAM) and mixed reality solutions show promise, but their integration with complementary technologies remains underexplored.

To address these gaps, a multifaceted approach is needed, including diverse and inclusive datasets, scalable computational models, seamless integration into clinical workflows, usability studies, cost-effective hardware solutions, and large-scale clinical trials. Collaborative efforts between technical researchers and clinical practitioners are essential for designing practical and impactful systems. These advancements would enhance the usability and efficiency of AR/VR and 3D reconstruction technologies, leading to significant improvements in patient outcomes and healthcare delivery systems.

IV. Conclusion

Augmented reality (AR), virtual reality (VR), and 3D reconstruction technologies have emerged as potent tools for revolutionizing medical imaging, diagnostics, and surgical planning. These advancements, as explored in this survey, showcase remarkable potential in enhancing spatial visualization, reducing cognitive load, and enabling patient-specific anatomical modelling. However, despite significant progress, several interconnected challenges persist, hindering their broader adoption and clinical impact. These include the reliance on limited or specialized datasets, scalability constraints of existing methods, and the high computational demands that impede real-time applications in resource-constrained settings. Furthermore, usability challenges, such as steep learning curves and high hardware costs, continue to impede accessibility and adoption among healthcare professionals.

Additionally, the lack of rigorous clinical validation and seamless integration into existing medical workflows hinders the practical applicability of these technologies in real-world scenarios. Accuracy and alignment issues in 3D reconstruction methods, especially those relying on low-contrast or synthetic data, further diminish their reliability in critical applications such as surgical planning and diagnosis. The disconnect between technical advancements and clinical requirements, coupled with unexplored opportunities for integrating complementary technologies like AI and robotics, underscores the necessity for interdisciplinary collaboration and user-cantered design.

To address these gaps, future research should prioritize developing diverse datasets, scalable models, and computationally efficient solutions that can operate in real-time. Emphasis on usability studies, cost-effective hardware development, and large-scale clinical trials will be crucial in validating the effectiveness and impact of these systems. Collaborative efforts between technical researchers and healthcare practitioners are essential to ensure that these innovations align with clinical workflows and address real-world challenges. By overcoming these obstacles, AR/VR and 3D reconstruction technologies can revolutionize medical imaging and healthcare delivery, leading to improved patient outcomes and more effective medical education.

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