ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Impact Factor: 8.206

Volume 9, Issue 4, April 2026

© 2026 IJMRSET | Volume 9, Issue 4, April 2026 | DOI:10.15680/IJMRSET.2026.0904391

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

AR PC Building Guide with Interactive 3D Component Visualization

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ABSTRACT- This project presents the design and development of a Gesture-Controlled Mobile AR PC Building Guide using AI Intelligence aimed at transforming traditional hardware learning into an immersive and interactive educational experience. Conventional computer hardware education relies heavily on theoretical explanations and limited laboratory exposure, which restricts practical understanding and hands-on experience. Existing simulation platforms often lack real-world spatial interaction and intelligent validation mechanisms. The proposed system integrates Augmented Reality using AR Foundation with real-time hand interaction and rule-based AI guidance to enable virtual assembly of personal computer components in a real-world environment. The architecture combines AR-based surface detection, 3D motherboard placement, gesture-driven component manipulation, compatibility validation, and performance evaluation modules. A structured dataset-based performance engine calculates power consumption, component balance, and overall system rating dynamically. Experimental implementation demonstrates stable AR placement, accurate slot validation, interactive learning support, and real-time performance feedback. The proposed framework highlights the integration of immersive visualization, gesture-based interaction, and intelligent assistance into a unified mobile learning platform, contributing to modern digital hardware education systems.

KEYWORDS: Augmented Reality, AR Foundation, PC Assembly Simulation, Hand Interaction, AI Guidance System, Performance Evaluation Engine, Compatibility Validation, Unity 3D, Mobile AR Application, Educational Technology.

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I. INTRODUCTION

The rapid advancement of augmented reality and mobile computing technologies has significantly transformed the way interactive learning systems are designed and deployed. In the field of computer hardware education, students often rely on textbooks, static diagrams, and limited laboratory exposure to understand the structure and functioning of internal PC components. Although physical assembly practice provides valuable experience, access to hardware labs is frequently restricted due to cost, risk of component damage, and limited availability of modern systems. Traditional desktop-based simulation software offers partial visualization support but lacks immersive real-world interaction and intelligent validation features.With the development of AR Foundation and mobile AR frameworks, it is now possible to create interactive systems that blend virtual components with physical environments. Augmented Reality enables real-time surface detection, spatial tracking, and three-dimensional visualization, allowing users to place and manipulate digital objects within their surroundings. This technology creates opportunities for practical hardware education without requiring physicalcomponents. However, many existing AR applications focus primarily on visualization and do not incorporate intelligent guidance systems, compatibility validation, or dynamic performance evaluation.

The integration of gesture-based interaction further enhances user experience by enabling natural object manipulation such as grabbing, rotating, and placing components. When combined with rule-based AI guidance, such systems can provide contextual explanations, compatibility feedback, and performance insights during the assembly process. Despite these advancements, there remains a gap in developing a comprehensive mobile AR platform that integrates immersive visualization, intelligent assembly validation, performance calculation, and real-time AI assistance into a unified educational framework.

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This research proposes a Mobile AR PC Assembly Simulator with AI Guidance and Hand Interaction that addresses these limitations by combining AR surface detection, interactive 3D component visualization, compatibility validation mechanisms, performance analytics, and structured AI-based guidance within a scalable mobile architecture. The system aims to enhance conceptual clarity, improve practical understanding, and provide an accessible digital platform for modern PC hardware learning.

II. LITERATURE REVIEW

Recent advancements in Augmented Reality have significantly influenced educational technology and interactive simulation systems. Researchers have explored the integration of AR into training environments to enhance experiential learning and improve user engagement. Several studies have demonstrated that immersive AR platforms enable users to interact with three-dimensional objects in real-world environments, thereby increasing conceptual understanding compared to traditional two-dimensional instructional methods.

Cheng et al. presented an in-the-wild evaluation of AR productivity systems, analyzing workspace interaction patterns and usability constraints in real-world environments. Their study emphasized the importance of spatial tracking accuracy, field-of-view limitations, and hardware constraints in AR deployment. Although the research focused on productivity applications rather than educational simulation, it highlighted practical challenges that influence the stability and usability of AR systems.

Ens et al. proposed a taxonomy for mixed reality workspaces, categorizing interaction models and spatial arrangements in immersive environments. Their framework provided insights into the structural organization of AR interfaces and window-based layouts. However, the work primarily addressed workspace classification and did not extend to intelligent object validation or performance analytics.

Other research efforts have investigated gesture-based interaction techniques for AR systems. Hand tracking methods using computer vision and landmark detection have enabled natural user interaction such as object grabbing and placement. While these studies demonstrated effective gesture recognition accuracy, they did not integrate rule-based compatibility checking or structured educational feedback mechanisms.

In the context of virtual assembly systems, several simulation platforms have been developed for industrial training. These systems focus on mechanical component placement and procedural guidance but are typically limited to desktop-based visualization without mobile AR deployment. Furthermore, most assembly simulations lack dynamic performance evaluation models that analyze system-level behavior based on selected components.

Educational AR platforms for engineering have also been explored to support conceptual learning through visualization of internal hardware structures. Although these systems provide 3D representations of devices, they rarely include intelligent guidance engines capable of validating compatibility between components such as CPU sockets, RAM slots, and power requirements.

From the existing literature, it is evident that current AR systems emphasize visualization, productivity analysis, or interaction modeling independently. There is limited research integrating immersive AR visualization, gesture-based assembly interaction, compatibility validation mechanisms, and performance analytics into a unified mobile platform specifically designed for PC hardware learning. This gap motivates the development of the proposed Mobile AR PC Assembly Simulator with AI Guidance and Hand Interaction, which aims to combine these components into a comprehensive educational framework.

III. PROBLEM DEFINITION

Understanding the internal structure and compatibility of computer hardware components remains a challenging task for beginners, students, and first-time PC builders. Traditional learning methods such as textbooks, video tutorials, and static diagrams provide only theoretical explanations without allowing users to experience the actual assembly process. As a result, learners often struggle to understand how different hardware components interact with each other within a computer system.

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In practical scenarios, assembling a personal computer requires proper knowledge of hardware compatibility, correct installation procedures, and system configuration. Users must identify the correct placement of components such as the motherboard, CPU, RAM, GPU, storage devices, and power supply units. However, without hands-on guidance or visual assistance, beginners frequently face confusion during the assembly process. Incorrect installation of components can lead to hardware damage, system malfunction, or performance issues. This lack of interactive learning tools limits the ability of students to gain practical experience in computer hardware assembly.

Existing educational resources mostly rely on two-dimensional instructional materials or prerecorded demonstrations. Although these resources provide general guidance, they do not allow users to interact with hardware components in a realistic environment. In many cases, students do not have access to physical hardware for practice due to cost constraints or laboratory limitations. Consequently, the learning process becomes theoretical rather than experiential, reducing the effectiveness of hardware education.

Recent developments in augmented reality technology provide new opportunities to address these challenges. AR allows digital objects to be placed within the real-world environment, enabling users to visualize and interact with virtual components as if they were physically present. However, many current AR applications focus only on visualization without providing structured assembly guidance, compatibility validation, or performance analysis of the assembled system.

Therefore, there is a need for an interactive learning platform that combines augmented reality visualization with intelligent guidance mechanisms to simulate the complete PC assembly process. Such a system should allow users to select hardware components, visualize their placement on a virtual motherboard, receive step-by-step instructions, and understand system performance based on the selected configuration. The proposed Mobile AR PC Assembly Simulator with AI Guidance and Hand Interaction aims to address these limitations by creating an immersive educational environment where users can learn computer hardware assembly through real-time AR interaction and intelligent guidance support.

IV. PROPOSED SYSTEM

The proposed system introduces a Mobile AR PC Assembly Simulator with AI Guidance and Hand Interaction designed to assist users in learning the process of computer hardware assembly through an immersive augmented reality environment. The system integrates augmented reality visualization, intelligent guidance mechanisms, and gesture-based interaction to create an interactive educational platform for PC building simulation.

The main objective of the system is to provide a practical learning experience where users can visualize computer components in three-dimensional space and assemble them step by step on a virtual motherboard. By using AR technology, the application overlays virtual hardware components such as CPU, RAM, GPU, storage devices, and power supply units onto the real-world environment.

This approach allows users to understand the spatial arrangement of components and the correct installation sequence in a realistic manner.The system operates through a structured interaction pipeline. Initially, the user launches the mobile AR application and scans a flat surface using the device camera. Once the environment is detected, the virtual motherboard is placed within the detected AR surface. The application then displays a list of available PC components that the user can select for assembly. When a component is selected, the system guides the user with step-by-step instructions for correct placement.

Artificial intelligence guidance plays an important role in the proposed system. The AI module analyzes the selected components and provides compatibility validation to ensure that the chosen hardware can function together in a real computer system. For example, the system checks CPU socket compatibility with the motherboard, RAM type compatibility, and power supply requirements for graphics cards. If an incompatible component is selected, the application alerts the user and provides recommendations for suitable alternatives.

The system also incorporates hand interaction and gesture recognition to improve user engagement. Users can interact with virtual components by dragging, rotating, and placing them in the appropriate slots. When a component is positioned correctly, the system confirms successful installation and proceeds to the next assembly step. This

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interactive approach improves the user's understanding of hardware placement and assembly procedures.

In addition to assembly simulation, the system includes a performance estimation module that evaluates the selected hardware configuration. After completing the assembly process, the simulator displays estimated system performance metrics such as processing capability, graphics performance, and overall system balance. This feature helps users understand how different hardware combinations influence the final system performance.The proposed Mobile AR PC Assembly Simulator offers several advantages compared to traditional learning methods. It provides an immersive visualization environment, interactive hardware assembly experience, real-time compatibility validation, and intelligent guidance throughout the learning process. By combining augmented reality with AI-driven assistance, the system enables students and beginners to learn PC assembly safely without requiring physical hardware components.Overall, the proposed system creates a practical educational tool that bridges the gap between theoretical computer hardware knowledge and real-world assembly experience. The platform enhances learning efficiency by allowing users to practice assembling computer components in a simulated environment while receiving continuous guidance and feedback.

V. SYSTEM ARCHITECTURE

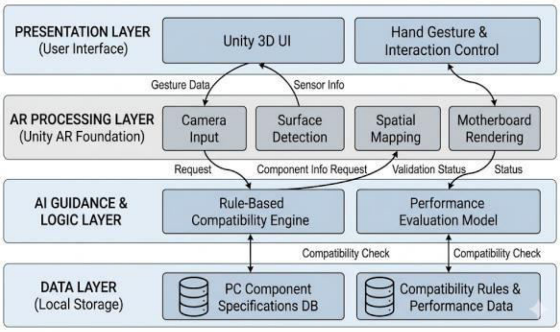

Figure 1: System Architecture Diagram

The architecture follows a layered design:
• Presentation Layer: A Unity-based mobile application interface that provides the user with an interactive AR environment for PC assembly simulation. The interface allows users to scan a surface, initialize the AR environment, select computer components, and receive real-time visual instructions. It includes a component selection panel, AR visualization screen, assembly guidance panel, and performance analysis dashboard.**AR Processing Layer:** This layer manages augmented reality functionality using **Unity AR Foundation and ARCore/ARKit** technologies. It performs surface detection, spatial mapping, and object tracking to place virtual hardware components within the real-world environment. The AR engine ensures stable positioning of the motherboard and other components on the detected surface, enabling realistic assembly interaction.

• **AI Guidance Layer:** The AI guidance module acts as the intelligent assistance system that provides step-by-step assembly instructions and compatibility validation. It checks whether selected components such as CPU, RAM, GPU, and storage devices are compatible with the motherboard configuration. If an incorrect component is selected or improperly placed, the system provides corrective suggestions and highlights the correct installation location.

• **Interaction and Gesture Control Layer:** This layer handles user interaction with virtual hardware components. Using touch gestures or hand interaction, users can drag, rotate, and place components into the appropriate motherboard slots. Gesture recognition ensures intuitive manipulation of AR objects and allows realistic assembly operations such as inserting RAM modules or connecting GPUs.

• **Hardware Simulation Layer:** The hardware simulation module manages the digital representation of PC components and their logical relationships. It simulates hardware connections such as CPU sockets, RAM slots, PCIe interfaces, and storage connectors. This module ensures that the assembly process follows correct hardware configuration rules.

• **Data Layer:** The data layer stores hardware specifications, compatibility rules, component models, and system configuration data. It includes a component database containing details of processors, motherboards, graphics cards, memory modules, and storage devices. This layer also stores performance evaluation data used to generate system performance estimates after assembly completion.

• This layered architecture ensures clear separation between the user interface, augmented reality processing, AI guidance mechanisms, hardware simulation modules, and system data storage. The modular design improves system scalability and maintainability while allowing future enhancements such as advanced AI-based learning support, additional hardware component libraries, and multi-user AR training environments

VI. METHODOLOGY

The proposed system follows a structured development pipeline integrating mobile augmented reality visualization, artificial intelligence guidance mechanisms, hardware simulation modules, and gesture based interaction. The methodology ensures an interactive learning environment where users can visualize and assemble computer hardware components in a real world environment while receiving intelligent guidance and performance feedback.

a. Data Collection

The system utilizes a structured dataset of computer hardware components as the primary source of information for the AR simulation platform. The dataset includes technical specifications of various PC components such as processors, motherboards, RAM modules, graphics cards, storage devices, and power supply units. Each component entry contains detailed attributes including socket type, memory compatibility, power requirements, performance ratings, and manufacturer specifications.

To support the AR simulation environment, high quality three dimensional models of hardware components are collected and integrated into the system. These models represent realistic hardware structures including the motherboard layout, RAM slots, CPU socket, PCIe slots, storage ports, and cooling systems. Each component model is associated with metadata describing its functionality, compatibility rules, and installation procedure.

Preprocessing

Document data is cleaned by removing redundant headers, footers, page numbers, and unnecessary whitespace to ensure high-quality text extraction. The raw text undergoes structural normalization, where special characters and non-standard symbols are filtered while maintaining the integrity of legal or financial terminologies. Long documents are segmented into smaller, overlapping chunks to preserve semantic continuity for embedding generation.

b. Feature Extraction

After preprocessing the system extracts important hardware features and compatibility attributes required for assembly validation and performance analysis. Each hardware component is represented through a set of key features including socket compatibility, memory capacity, power consumption, processing capability, and interface type.

These extracted features are used by the AI guidance module to evaluate the compatibility of selected hardware components during the assembly process. For example, the system verifies whether a selected CPU matches the motherboard socket type, whether RAM modules correspond to supported memory standards, and whether the graphics card interface is compatible with the motherboard PCIe slot.

c. Assembly Guidance and Component Validation

An intelligent assembly guidance approach is implemented to support accurate PC hardware simulation and interactive learning. When a user selects a hardware component, the system retrieves relevant compatibility information from the internal component database. The guidance module analyzes the selected component and identifies the appropriate motherboard slot or installation position.

The retrieved compatibility data is combined with the current assembly configuration and processed by the AI guidance module to generate clear and context-aware instructions for the user. During the assembly process, the system continuously verifies whether the component is placed in the correct location and whether it matches the hardware specifications of the motherboard and other installed components.

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

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d. Interactive AR Processing

Three dimensional hardware component models and real world camera input are processed through the AR framework to generate a synchronized augmented reality environment. The AR engine analyzes the camera feed to detect flat surfaces and spatial coordinates required for accurate placement of virtual objects. If complex scene conditions are detected, the AR surface tracking module stabilizes the environment to maintain consistent object positioning.Storage and Analytics

All document chunks, SBERT embeddings, retrieval logs, and AI-generated auditing insights are stored in a structured local database. Vector indexes and quantized model weights are maintained for efficient offline retrieval and high-speed similarity searching. System logs and auditing interaction records support performance evaluation and future local dataset expansion. This structured methodology ensures secure integration of document intelligence, vector retrieval, model optimization, and privacy-first data processing within a unified auditing framework.

ALGORITHM

This This section describes the core algorithms and computational techniques used in the proposed Mobile AR PC Assembly Simulator for interactive hardware visualization, component compatibility validation, and intelligent assembly guidance. The system integrates augmented reality surface detection, hardware component interaction, compatibility analysis, and performance estimation mechanisms within a unified processing framework to support an immersive learning experience.

e. AR Surface Detection Algorithm

The AR initialization module follows a surface detection approach to create a stable augmented reality environment. When the mobile application is launched, the device camera continuously scans the surrounding environment to detect flat surfaces using AR Foundation tracking capabilities. Feature points extracted from the camera feed are analyzed to identify horizontal planes suitable for virtual object placement.

f. Component Selection and Interaction Algorithm

A The system provides an interactive component selection mechanism that allows users to choose hardware components from a structured component library. When a component such as a CPU, RAM module, or graphics card is selected, the corresponding three dimensional model is activated in the AR environment.The interaction module processes user gestures such as dragging, rotating, and positioning components within the assembly space. Object snapping logic is applied when a component approaches its correct installation slot. This mechanism ensures that hardware components align precisely with their corresponding motherboard interfaces, simulating the real PC assembly process.

g. Hardware Compatibility Validation Algorithm

The compatibility validation module analyzes the relationship between selected hardware components to ensure that the system configuration follows correct hardware standards. Each component contains predefined compatibility attributes including socket type, memory interface, and power requirements.When a component is placed within the AR environment, the system compares its attributes with the motherboard specifications and previously installed components. If compatibility conditions are satisfied, the installation is confirmed and the system proceeds to the next assembly step.

h. Performance Evaluation Algorithm

After completing the assembly process, the system performs a performance evaluation to estimate the overall capability of the assembled computer configuration. The algorithm analyzes the selected components based on parameters such as processor performance, memory capacity, graphics capability, and storage efficiency.Each component contributes a weighted score to the final system rating. The algorithm calculates the combined performance score and identifies potential bottlenecks that may affect system efficiency. This evaluation helps users understand the impact of different hardware combinations on the overall system performance.

i. AI Guidance and Assembly Assistance Algorithm

The The AI guidance module functions as the intelligent assistance system within the AR simulation platform. It analyzes the current assembly stage and provides contextual instructions to guide the user through the installation process. When a component is selected or moved within the AR environment, the guidance engine retrieves relevant assembly instructions and compatibility rules.

The system generates step by step guidance messages explaining the purpose of each component and the correct method of installation.

Visual highlights and placement indicators are displayed to assist the user in identifying the correct installation slots. This algorithm improves the learning experience by providing continuous assistance and ensuring that the assembly process follows correct hardware configuration practices.

VII. IMPLEMENTATION

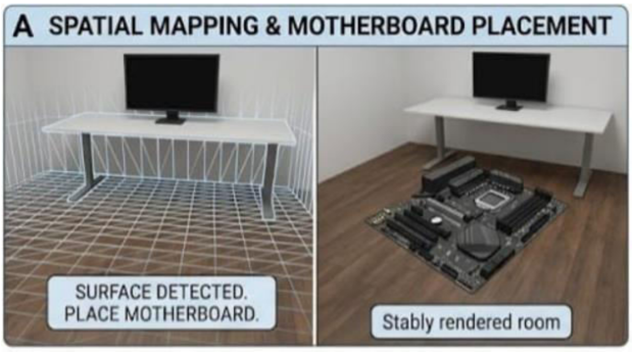
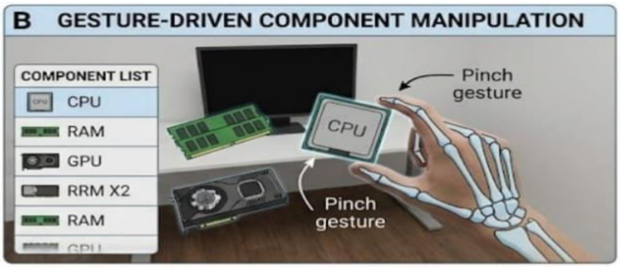
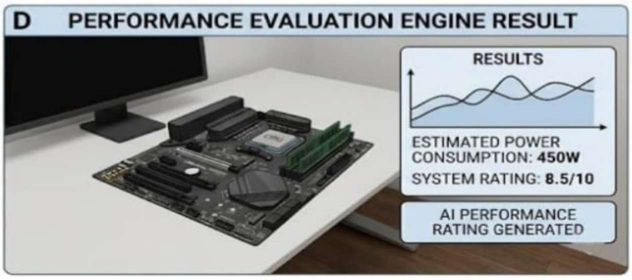
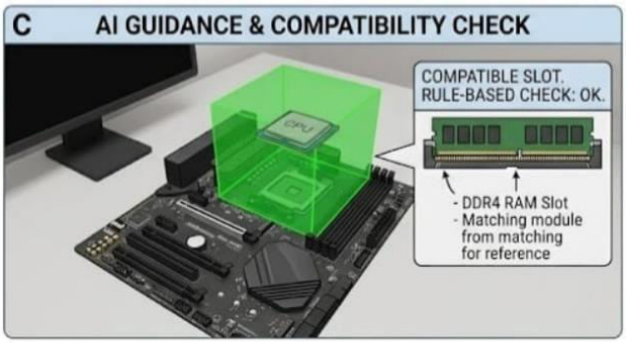


Figure 2:Implementation Screenshots







© 2026 IJMRSET | Volume 9, Issue 4, April 2026 | DOI:10.15680/IJMRSET.2026.0904391

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The proposed Mobile AR PC Assembly Simulator with AI Guidance and Hand Interaction is implemented using a mobile augmented reality development framework that integrates real-time visualization, interactive hardware simulation, and intelligent guidance mechanisms. The system is developed using the Unity game engine combined with AR Foundation to provide a stable augmented reality environment for mobile devices. The application interface allows users to initialize the AR environment, detect surfaces, select hardware components, and assemble them within the real-world scene while receiving step-by-step guidance.

The frontend of the system is designed using the Unity user interface framework, which provides interactive controls for component selection, assembly instructions, and performance visualization. The interface includes panels for selecting PC components, real-time AR visualization windows, and guidance displays that explain the installation procedure of each hardware element. User interactions such as dragging, rotating, and positioning components are processed through gesture-based controls, allowing intuitive manipulation of virtual objects within the AR environment. The application provides immediate feedback when components are correctly placed or when compatibility issues are detected.

The backend logic of the system is implemented using C# scripts within the Unity environment. These scripts manage AR surface detection, object placement, interaction processing, and compatibility validation between hardware components. A structured component dataset is integrated into the system to store hardware specifications such as processor architecture, RAM type, power requirements, and motherboard interface compatibility. Three-dimensional models of hardware components including the motherboard, CPU, RAM modules, graphics cards, and storage devices are stored in the local project repository and optimized for mobile rendering performance.

Artificial intelligence guidance is implemented as a rule-based decision module that analyzes the selected components and provides contextual instructions during the assembly process.

The guidance engine verifies compatibility between hardware components and generates step-by-step explanations for installation. When incorrect components are selected or placed in incompatible slots, the system automatically provides corrective suggestions to assist the user.

Performance evaluation functionality is integrated into the system to analyze the final hardware configuration after the assembly process is completed. The performance module calculates system capability based on parameters such as processor performance, graphics processing capability, and memory capacity. The results are presented through visual performance indicators and system ratings within the application interface.

VIII. EXPERIMENTAL RESULTS

Experimental evaluation was conducted to assess the performance of the Gesture-Controlled Mobile AR PC Building Guide using AI Intelligencein terms of AR environment stability, component interaction accuracy, assembly validation reliability, and overall system performance estimation capability. The system was tested using multiple hardware component configurations, different AR surface environments, and various user interaction scenarios to evaluate the effectiveness of each integrated module. Performance testing focused on AR surface detection stability, object placement accuracy, interaction responsiveness, and the reliability of the compatibility validation mechanism during the assembly process.

The AR assembly engine was evaluated by measuring the accuracy of component placement and the responsiveness of the gesture-based interaction module. Augmented reality visualization enabled users to place and manipulate virtual hardware components within real-world environments with high positional stability. Surface detection algorithms successfully identified flat environments and maintained stable placement of the virtual motherboard. Interaction tests demonstrated smooth dragging, rotation, and placement of components such as processors, memory modules, and graphics cards, allowing users to simulate realistic hardware installation steps.

Compatibility validation was evaluated by testing multiple hardware configurations with both compatible and incompatible component combinations. The validation module accurately detected mismatched components and generated corrective guidance to assist the user in selecting appropriate hardware elements. Performance evaluation tests showed that the system could successfully estimate overall system capability based on the selected hardware configuration. The analysis module calculated performance scores by considering parameters such as processor capability, memory capacity, and graphics performance.

The AI guidance module was evaluated through interactive user testing scenarios. The guidance system consistently provided step-by-step assembly instructions and highlighted correct component placement positions within the AR environment. Although performance may vary slightly depending on device hardware capability and environmental lighting conditions, the AR tracking system maintained stable operation during extended interaction sessions. Overall system testing confirmed reliable Unity-based AR functionality, efficient hardware compatibility validation, and smooth integration of the intelligent guidance module.

IX. DISCUSSION

The Experimental evaluation was conducted to assess the performance of the proposed Mobile AR PC Assembly Simulator with AI Guidance and Hand Interaction in terms of AR environment stability, component interaction accuracy, assembly validation reliability, and overall system performance estimation capability. The system was tested using multiple hardware component configurations, various AR surface environments, and different user interaction scenarios to evaluate the effectiveness of each integrated module. Performance testing primarily focused on AR surface detection stability, object placement precision, interaction responsiveness, and the reliability of the compatibility validation mechanism during the assembly process.

The AR assembly engine was evaluated by measuring the accuracy of component placement and the responsiveness of the gesture-based interaction module. Augmented reality visualization enabled users to place and manipulate virtual hardware components within real-world environments while maintaining high positional stability. Surface detection algorithms successfully identified flat environments and ensured stable placement of the virtual motherboard. Interaction testing demonstrated smooth dragging, rotation, and placement of components such as processors, memory modules, and graphics cards, allowing users to simulate realistic hardware installation procedures.

Compatibility validation was evaluated by testing several hardware configurations that included both compatible and incompatible component combinations. The validation module accurately detected mismatched components and generated corrective guidance to assist users in selecting appropriate hardware elements. Performance evaluation tests indicated that the system was capable of estimating overall system capability based on the selected hardware configuration. The analysis module calculated performance scores by considering factors such as processor capability, memory capacity, and graphics performance.

ADVANTAGES

The proposed system system offers several important advantages:

- Provides an interactive learning environment for understanding computer hardware assembly through augmented realityvisualization.
- Allows users to simulate PC assembly without requiring physical hardware components, reducing cost and risk of hardwaredamage.
- Supports real time visualization of computer components such as CPU, RAM, GPU, and storage devices in a realistic threedimensionalenvironment.
- Integrates intelligent AI guidance to provide step by step instructions during the hardware installation process.
- Enables gesture based interaction that allows users to drag, rotate, and place hardware components naturally within the ARenvironment.
- Performs automatic compatibility validation to ensure correct configuration between hardware components.
- Includes performance evaluation functionality that estimates overall system capability based on the selected hardware configuration.
- Maintains a modular system architecture that supports easy integration of new hardware components and additional learningmodules.
- Provides an immersive educational platform that improves conceptual understanding of computer hardware architecture.
- Reduces dependency on traditional laboratory setups by enabling hardware training through a mobile application.

• Enhances practical learning by allowing students and beginners to explore PC assembly procedures in a safe simulated environment.

Overall, the proposed framework provides an interactive, scalable, and educational AR-based simulation platform that enhances computer hardware learning while minimizing the need for physical equipment.

X. LIMITATIONS

Despite its effectiveness, the proposed system has certain limitations:

• System performance depends on the processing capability of the mobile device used for running the AR application.
• AR surface detection accuracy may vary depending on environmental lighting conditions and camera quality.
• Gesture interaction accuracy may be affected by device sensor limitations and user interaction patterns.
• The current simulation focuses mainly on common hardware components and may not include all specialized PC hardware configurations.
• Performance estimation is based on predefined parameters and may not perfectly reflect real world hardware performance.
• Three dimensional component models must be optimized for mobile devices, which may reduce graphical detail in certain cases.
• Complex hardware configurations may require additional compatibility rules to ensure accurate validation.
• Continuous AR tracking may consume higher battery power during extendedusage sessions.
• The system currently supports single user interaction and does not include collaborative multi user learning environments.
• Additional datasets and component libraries are required to support future hardware technologies and advanced PC configurations.

XI. FUTURE ENHANCEMENT

The following enhancements are proposed to improve system capability, scalability, and real-world applicability.

• **Advanced Gesture Recognition:** The current system supports basic touch and gesture interaction for component placement. Future versions can integrate advanced hand tracking technologies using computer vision frameworks such as MediaPipe or depth-based sensors to enable more natural and precise interaction with virtual hardware components.
• **Expanded Hardware Component Library:** The system currently includes a limited set of common PC components. Future updates can introduce a larger component database including modern processors, graphics cards, storage technologies, and specialized hardware configurations to simulate real-world computer building scenarios more accurately.
• **AI-Based Hardware Recommendation System:** An intelligent recommendation engine can be developed to suggest optimal PC configurations based on user requirements such as gaming, video editing, or software development. The AI module can analyze component compatibility and performance balance to recommend suitable hardware combinations.
• **Multilingual Learning Support:** To make the application accessible to a broader audience, multilingual guidance systems can be integrated. The application could provide assembly instructions and hardware explanations in regional languages such as Tamil, Hindi, or other international languages while maintaining clear technical communication.
• **Voice-Assisted Assembly Guidance:** Future versions of the system can include voice-based assistance using speech recognition technology. Users would be able to ask questions such as "Where should the RAM module be installed?" and receive real-time audio guidance during the assembly process.
• **Collaborative AR Learning Environment:** The platform can be extended to support multi-user AR environments where multiple learners can participate in the same virtual assembly session. This feature would allow collaborative learning experiences for classrooms and training laboratories.
• **Hardware Performance Simulation:** Future implementations can incorporate more advanced performance modeling techniques to simulate real-time hardware benchmarks and power consumption analysis. This enhancement would provide users with deeper insights into system efficiency and performance optimization.
• **Cloud-Based Component Database Updates:** The system can be connected to an online component database to automatically update hardware specifications and compatibility rules. This would allow the simulator to support newly

© 2026 IJMRSET | Volume 9, Issue 4, April 2026 | DOI:10.15680/IJMRSET.2026.0904391

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released PC components without requiring manual updates.Overall, these future enhancements aim to transform the AR PC Assembly Simulator into a comprehensive interactive training platform capable of supporting advanced learning features, intelligent hardware recommendations, and collaborative augmented reality environments. By integrating improved interaction technologies, expanded hardware datasets, and intelligent guidance systems, the application can evolve into a powerful educational tool for computer hardware training and simulation.

XII. CONCLUSION

This research This research presents the design and implementation of a Mobile AR PC Assembly Simulator with AI Guidance and Hand Interaction that integrates augmented reality visualization with intelligent instructional support for computer hardware learning. The proposed system extends beyond traditional instructional methods by providing an interactive platform where users can explore and assemble virtual computer components within a real-world environment. By combining AR-based surface detection, three-dimensional hardware visualization, gesture-driven interaction, and AI-guided assembly validation within a layered system architecture, the platform demonstrates how immersive technologies can improve practical understanding of PC hardware assembly and configuration.

The experimental implementation confirms the feasibility of integrating augmented reality interaction, hardware compatibility validation, and performance estimation within a unified mobile learning framework. The modular architecture ensures scalability, maintainability, and flexibility for future development, including expanded hardware component libraries, advanced gesture recognition techniques, and collaborative AR learning environments. Although system

performance may depend on device hardware capabilities, environmental conditions, and the accuracy of predefined compatibility datasets, the proposed simulator establishes a strong foundation for interactive computer hardware education. Overall, the system contributes to the advancement of AR-based educational technologies by bridging immersive visualization, intelligent guidance, and hands-on simulation within a practical and accessible learning platform.

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ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

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