AR-Based First Aid and Emergency Training System

Ayesha Bashirul Haque Shaikh[1], Vaishnavi Balkrishna Phadtare[2], Tejal Shridhan Rokade[3], Kamlesh V. Patil[4]

[1,2,3,4]*Dept. of Information Technology, Bharati Vidyapeeth's College of Engineering for Women, Pune, India*

***Abstract*—The ability to provide immediate and correct first aid during emergency situations can significantly reduce the severity of injuries and improve survival outcomes. However, a lack of practical training and real-time guidance often limits the effectiveness of first aid performed by untrained individuals. This paper presents an AR-Based First Aid Emergency Training System that integrates interactive learning, simulation, and real-time guidance to enhance user preparedness.**

The proposed system is implemented as a web-based application and consists of three primary modes: Learning Mode for structured theoretical understanding, Dummy Mode for step-by-step 2D simulation, and Live Mode for real-time Augmented Reality (AR) guidance. The system utilizes browser-based APIs for camera access and incorporates computer vision techniques to detect body parts such as hands, face, and legs. Based on this detection, 3D models and visual overlays are dynamically rendered to guide users during emergency response.

In addition, the system includes user authentication and an admin module for managing training content and user access, ensuring scalability and adaptability. Experimental observations indicate that the system improves user understanding, procedural accuracy, and confidence in handling emergency situations. The integration of 2D simulations and 3D AR overlays provides a comprehensive learning experience that bridges the gap between theoretical knowledge and real-world application.

The proposed solution demonstrates the potential of AR technology in enhancing first aid training and can be extended to support a wider range of medical scenarios in the future.

***Index Terms*—Augmented Reality, First Aid Training, Emergency Response, Interactive Learning, Computer Vision, Health-care Technology, Real-Time Guidance**

I. INTRODUCTION

In critical emergency situations such as burns, heavy bleeding, or fainting, the first few minutes are crucial for saving lives. Despite widespread awareness programs, many individuals lack the practical skills and confidence required to perform first aid effectively. Traditional learning methods, including textbooks and videos, often fail to provide hands-on experience.

With advancements in Augmented Reality (AR), it is now possible to create immersive training environments that simulate real-life scenarios. AR overlays digital information onto the physical world, allowing users to visualize and interact with step-by-step guidance in real time.

This paper introduces an AR-Based First Aid Emergency Training System that combines theoretical learning, interactive simulations, and real-time AR assistance. The system is designed to make first aid training more accessible, engaging, and practical, especially for individuals without medical backgrounds.

The key contributions of this work include:

- Development of a multi-mode first aid training system integrating learning, simulation, and AR guidance.
- Implementation of real-time AR overlays for emergency assistance.
- Design of an interactive and user-friendly interface for effective skill acquisition.
- Evaluation of system usability and effectiveness in im-proving emergency response readiness.

II. RELATED WORK

Previous research in first aid training has primarily focused on traditional educational methods such as classroom sessions, instructional videos, and static simulations. While these methods provide theoretical knowledge, they often lack real-time interaction and practical engagement.

Recent advancements in AR and Virtual Reality (VR) have introduced immersive learning experiences in medical training. Studies have shown that AR-based systems improve retention

and understanding by allowing users to visualize procedures in a real-world context. Applications of AR in healthcare include surgical training, anatomy visualization, and rehabilitation.

However, most existing systems are either limited to professional medical training or require expensive hardware.

Additionally, few solutions integrate real-time guidance with interactive simulations for common emergency scenarios.

The proposed system addresses these limitations by offering:

- A cost-effective, web-based AR solution.
- Multi-mode learning (theory + simulation + real-time).
- Focus on common emergency scenarios for general users.

A. Novelty of the Proposed Work

The uniqueness of this system lies in combining three distinct training approaches into a single platform: Learning Mode for conceptual understanding, Dummy Mode for step-by-step practice, and Live AR Mode for real-time assistance. Unlike existing systems, this approach ensures a complete learning cycle from theory to real-world execution, making it highly effective for non-medical users.

III. SYSTEM ARCHITECTURE

The proposed AR-Based First Aid Emergency Training System follows a layered and modular architecture that integrates user interaction, application logic, content management, and real-time AR processing. The system is designed to provide a structured flow from user entry to final output while maintaining scalability and efficient control over training content and user management.

A. User Entry and Interface Layer

The system begins with the User, who interacts with the application through the Home Page. The Home Page serves as the entry point of the system and provides an overview of the platform along with login and signup functionality. Once authenticated, the user is directed to the Training Library, which contains the three primary modes of operation: Learning, Dummy, and Live. The system also includes an Admin Panel, which is responsible for managing both users and training modules.

B. Content Layer

The content layer consists of structured training resources, including images, videos, and step-based instructional data. This content is dynamically linked to the Training Library and is accessed based on the selected module and mode, allowing scalable delivery of instructional material without modifying core application logic.

C. Application Layer

The application layer manages the core functionality of the system and acts as a bridge between the user interface and processing components. It includes the Session Manager, Step Controller, and Mode Handler. The Session Manager handles user sessions and maintains the current training state. The Step Controller ensures sequential execution of steps, while the Mode Handler manages transitions between different training modes.

D. AR Processing Layer

The AR processing layer enables real-time interaction in Live Mode. Camera input is captured using browser-based APIs and processed through MediaPipe-based detection to identify body parts such as hands, face, and legs. The AR Renderer then generates visual overlays and 3D models aligned with detected regions. The Overlay and Feedback System controls step-based instruction display and ensures correct user progression.

E. Output Layer

The output layer delivers results based on the selected mode. In Learning Mode, users receive structured instructional content. In Dummy Mode, the system provides step-based 2D simulations using layered visuals. In Live Mode, real-time AR guidance is generated by overlaying 2D cues and 3D models onto detected body parts.

F. Data Flow and Control Mechanism

The system operates through a continuous flow of data and control signals across layers. User actions from the interface are processed by the application layer, which controls step progression and mode transitions. In Live Mode, the camera stream is processed through the AR layer to generate real-time visual feedback. The Admin Panel interacts with the authentication system and Training Library to manage users and content dynamically.

IV. IMPLEMENTATION AND RESULTS

A. Implementation Details

The AR-Based First Aid Emergency Training

System is implemented as a web-based application using React for component-based UI design and state management. Browser-based APIs such as the Media Devices API are used to access the device camera, while canvas-based rendering and lightweight AR libraries provide visual guidance overlays. MediaPipe is integrated for real-time detection of body parts including hands, face, and legs. Each emergency scenario (Burns, Bleeding, Fainting) is divided into structured steps ensuring sequential user guidance.

1) Learning Mode: The Learning Mode provides foundational knowledge in a structured format. Each first aid procedure is broken into step-by-step instructions displayed sequentially. React components represent individual steps containing explanatory text, images, or embedded videos. State management tracks the current step and allows controlled navigation.

2) Dummy Mode: The Dummy Mode provides an interactive 2D simulation for practicing first aid procedures. Each scenario is implemented as a sequential step process where the interface updates dynamically by layering relevant visual elements such as wounds, dressings, or bandages. The simulation is built using layered PNG images, with React state management controlling the current step and event handling managing user progression.

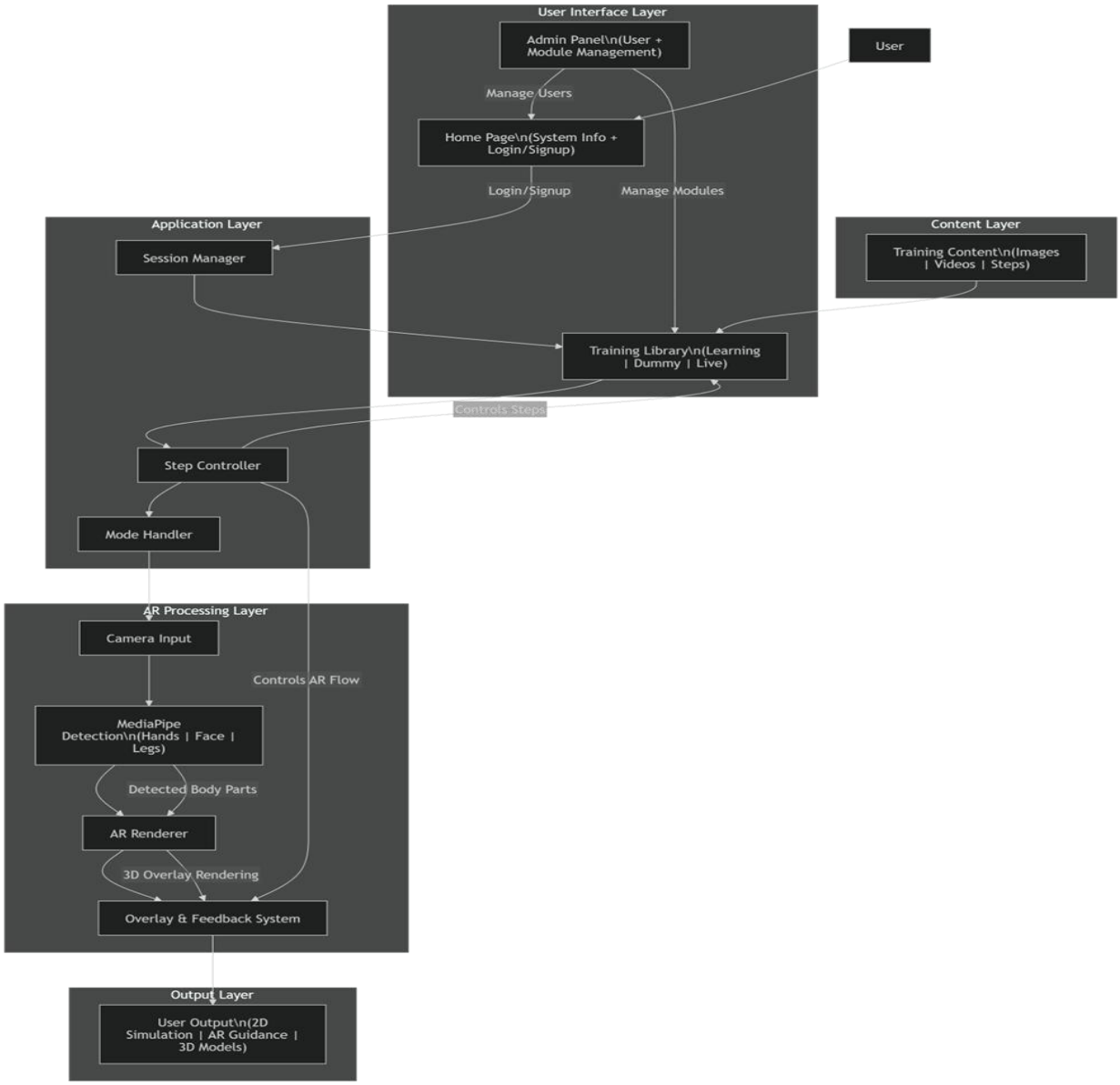

Fig. 1: System Architecture of the AR-Based First Aid Emergency Training System

3) Live Mode (AR-Based): The Live Mode is the core component providing real-time AR-based first aid guidance. On activation, the system accesses the camera via the Media Devices API, performs body region detection using MediaPipe, and overlays 3D models and visual guidance onto the detected region. A time-based interaction system gives users a fixed duration to perform each step, creating an active and immersive training experience.

4) Integration Across Modes: All three modes are integrated into a unified workflow. Users typically begin with Learning Mode, proceed to Dummy Mode for guided practice, and finally use Live Mode for real-time application. React-based state management ensures seamless transitions and continuity across modes.

B. Experimental Setup

To evaluate the system, testing was conducted with users having varied familiarity with first aid procedures. Participants interacted with all three modes across scenarios including bleeding, burns, and fainting, under normal indoor conditions using smartphones and laptops with camera access.

C. Performance Evaluation

Performance was evaluated across multiple parameters. Ease of use was assessed by observing navigation speed without external assistance. Response time was evaluated in Live Mode covering camera initialization, detection, and overlay rendering. Accuracy of guidance was analyzed by observing correct step sequencing. User confidence improvement was assessed qualitatively, with users reporting increased confidence after transitioning from Dummy Mode to Live Mode.

D. Discussion

Results indicate that integrating AR with step-based inter-active learning significantly enhances practical understanding of first aid procedures. The Live Mode contributed to a more immersive experience. Limitations include dependence on device capabilities, environmental lighting conditions, and an initial delay during camera setup. Despite these challenges, the system demonstrates strong potential as an accessible first aid training tool.

V. USER EXPERIENCE AND INTERFACE DESIGN

The interface adopts a task-driven design approach where users are guided step-by-step through each procedure. Large interactive buttons, minimal textual content, and clear visual indicators ensure accessibility across different age groups and technical backgrounds.

A. Overall Interface Design

The interface is organized into three stages: module selection, mode selection, and execution. Consistent layout through-out the application improves usability and reduces confusion.

B. User Interaction and Navigation

Navigation is designed to be simple and predictable, with smooth transitions between steps. Users always understand their current position within the workflow.

C. Visual Guidance and Feedback

The system uses highlights, markers, and progressive visual updates to indicate actions and areas of focus. Continuous feedback confirms completed actions and provides clear cues for the next step.

D. Consistency Across Modes

Consistent layout, navigation, and instruction style across all modes allows smooth transitions and reinforces user understanding.

E. Design Considerations

The interface minimizes cognitive load, allows step retry without restrictions, maintains responsiveness across devices, and uses clear visual cues for first-time users.

VI. ETHICAL CONSIDERATIONS

A. Medical Accuracy and Expert Validation

First aid procedures implemented in the system were validated through consultation with medical professionals and cross-referenced with established medical guidelines to ensure accuracy and safety.

B. User Safety and Responsibility Disclaimer

The system is designed as an assistive training tool and not a substitute for professional medical care. Users are clearly informed that in severe or life-threatening situations, immediate medical assistance should be sought.

C. Risk Minimization in Interaction Design

Step-by-step instructions, visual cues, and controlled progression minimize the chances of incorrect actions. Dummy Mode allows practice without real-world consequences.

D. Privacy and Data Protection

No video or image data is stored without explicit consent. All processing is performed locally whenever possible, and sensitive data is not transmitted to external servers.

E. Accessibility and Inclusivity

Simple navigation and visual guidance ensure usability for individuals with varying technical knowledge. Future improvements may include multilingual support and voice-based assistance.

VII. APPLICATIONS AND LIMITATIONS

A. Applications

The proposed system can be applied in the following areas:

1) Public first aid education to improve emergency response awareness among individuals without medical training.
2) School and college training programs to provide inter-active and practical first aid learning.
3) Healthcare awareness campaigns for demonstrating correct first aid procedures.
4) Disaster management training where rapid and accurate response is critical.

B. Limitations

The system has the following limitations:

1) Performance in Live Mode is dependent on device camera quality and environmental conditions such as lighting.
2) Detection is currently limited to specific body parts, including hands, face, and legs.
3) The web-based implementation may require stable internet connectivity for optimal performance.
4) Low-end devices may experience reduced responsive-ness and less accurate AR rendering.

VIII. REAL-WORLD DEPLOYMENT CHALLENGES

A. Device Compatibility

AR functionality depends on device hardware. Low-end devices may experience lag or inaccurate tracking.

B. Environmental Constraints

Lighting, background clutter, and camera quality impact AR detection and overlay accuracy.

C. Internet Dependency

Web-based implementation may require internet access, limiting usability in remote or emergency scenarios.

D. User Adaptability

Initial onboarding may be required for users unfamiliar with AR-based systems.

E. Reliability in Emergency Situations

System delays or crashes during real emergencies reduce trust. Performance optimization is therefore critical.

IX. FUTURE WORK

Future improvements include integration of advanced AI-based detection models, expansion to additional scenarios such as CPR, fractures, and choking, voice-guided instructions for improved accessibility, offline functionality for low-connectivity areas, and multilingual support for broader reach.

X. CONCLUSION

The AR-Based First Aid Emergency Training System presents an innovative approach to improving first aid education and emergency response readiness. By combining structured learning, interactive simulation, and real-time AR guidance, the system effectively bridges the gap between theoretical knowledge and practical application. The integration of Learning, Dummy, and Live modes enables users to progressively build understanding and confidence. Although limitations exist regarding device dependency and environ-mental constraints, the system demonstrates strong potential as an accessible and impactful solution, with scope for further development and real-world deployment.

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