From Bystander to Rescuer: An AI Agent-Supported 360-Degree Scenario Simulation System for Web-Based CPR Training

Qi-Zhen Huang[1,*,†], Wan-Yu Li[1,†]

[1]*Department of Interaction Design, National Taipei University of Technology, Taipei, Taiwan*

Abstract

Cardiopulmonary resuscitation (CPR) is a critical emergency response skill; however, existing training methods still face limitations in contextual adaptability, continuous practice, and accessibility for public education. Although emerging technologies such as virtual reality (VR) and Augmented Reality (AR) have shown potential for immersive emergency training, equipment requirements, and usability barriers may limit their widespread adoption.

To improve CPR learning and situational response capabilities, this study proposes a web-based CPR training system that integrates an AI agent, a Teachable Machine, and a dynamic 360-degree scenario simulation. The system generates diverse emergency scenarios and combines interactive guidance with KPI-based feedback to support the review of CPR knowledge and situational practice for the general public.

The proposed system aims to retain the benefits of immersive learning while reducing equipment-related barriers, thereby enhancing emergency response capabilities and long-term skill retention in diverse scenarios. Future work will extend the proposed approach to other related training devices and applications.

Keywords

CPR Training, AI Agent, 360 Training, Gamified Learning, Emergency Response Education

1. Introduction

Cardiac arrest can occur anywhere and when a patient suddenly loses consciousness, the first person available to provide assistance is often not a healthcare professional, but an ordinary bystander. Timely and appropriate cardiopulmonary resuscitation (CPR) can significantly improve patient survival outcomes [1]. However, despite widespread recognition of the importance of CPR, many learners still struggle to translate procedural knowledge acquired in the classroom into effective responses in real-world emergency situations. Under stress, environmental pressure, or unexpected circumstances, individuals may hesitate, panic, or forget critical steps, resulting in a gap between procedural knowledge and practical emergency response capability.

Traditional CPR training primarily relies on instructor-led lectures, presentation slides, instructional videos, and mannequin-based practice. Although these approaches provide fundamental procedural knowledge, they tend to emphasize memorizing fixed procedures and offer limited opportunities for learners to experience situational variations and real-time decision-making [2]. Furthermore, knowledge and practical skills may gradually decline over time after training. In addition, real-world emergencies can occur in diverse settings such as homes, transportation environments, and public spaces, whereas fixed-scenario simulations often fail to fully capture the environmental pressures and unpredictability of actual emergencies. To address these limitations, recent studies have explored emerging training approaches, including augmented reality (AR), virtual reality (VR), and self-directed learning, to enhance learning effectiveness [3][4]. However, these methods often involve equipment-related constraints that limit their accessibility to the general public.

APMAR'26: The 18th Asia-Pacific Workshop on Mixed and Augmented Reality,Aug. 3–5, 2026,Taipei, Taiwan

*Corresponding author.
†These authors contributed equally to this work and share first authorship.
t114ac8012@ntut.org.tw (Q. Huang); t114ac8023@ntut.org.tw (W. Li)

In addition to immersive technologies, artificial intelligence has increasingly been applied in education and training to provide more adaptive and interactive learning experiences [5]. Generative AI has been utilized to automatically generate customized learning materials based on learning topics, difficulty levels, and instructional objectives, thereby improving the adaptability and scalability of educational content [6]. Through personalized learning guidance, adaptive content adjustment, and real-time feedback mechanisms, AI has the potential to enhance learners' knowledge comprehension, learning engagement, and problem-solving abilities [7].

Recent studies have further suggested that AI should not merely be regarded as a tool for task execution, but rather as a human-centered technology that guides and supports human decision-making and analytical capabilities. Through appropriate interaction mechanisms, AI can also foster users' critical thinking and judgment skills [8]. However, existing research has primarily focused on text-based content generation and learning content analysis, with relatively limited attention given to the application of generative AI in immersive scenario construction, situational decision guidance, and skill training. Therefore, in the field of medical education, exploring how generative AI, immersive scenario-based simulation, and skill-training mechanisms can be integrated to enhance learners' situational responsiveness and practical skills has become an important research direction.

To address this research gap, this study proposes a CPR emergency training system that integrates an AI Agent, dynamic 360° scenario simulation, KPI-based feedback, and posture recognition mechanisms. The proposed system aims to provide a learning experience that combines situational response training with hands-on skill practice while reducing the equipment barriers commonly associated with immersive training technologies. This integrated design enables learners to seamlessly transition from emergency decision-making to physical skill practice within a single web-based platform, providing a more comprehensive and scalable CPR training experience. The system is designed as a supplementary learning tool for CPR review and scenario-based practice, rather than a replacement for formal CPR certification courses or professional emergency response training.

2. Design Concept

2.1. Design Goals

This study adopts a Human-Centered AI perspective as its primary design approach. The AI Agent integrated into the system is not intended to replace human instructors or professional CPR training. Instead, it functions as a learning support mechanism that provides scenario-based prompts, procedural explanations, and corrective feedback during repeated practice sessions. To ensure educational reliability, the AI Agent operates within a predefined instructional framework rather than generating unrestricted CPR knowledge. The generated scenarios, guiding questions, and feedback are based on established CPR procedures and learning objectives. The AI is responsible for contextualizing emergency situations and supporting learner interaction, while the core CPR procedures remain aligned with standardized first-aid guidelines. Therefore, the proposed system is intended to supplement repeated learning and scenario-based practice rather than replace certified CPR instruction or professional medical judgment.

By helping users understand the rationale behind CPR procedures, reducing hesitation in simulated emergency situations, and supporting self-directed learning under lower equipment requirements, the system aims to facilitate more effective and accessible CPR training.

The proposed system is designed based on the following goals:

1. **Enhancing Situational Adaptability** The system generates diverse emergency scenarios through AI simulation, allowing users to practice CPR procedures in various environments and strengthen their emergency response and decision-making abilities under different situations.
2. **Enhancing Immersive Learning Experiences** By integrating dynamic 360° scenario simulation with AI-guided interactive workflows, the system provides a learning experience that more closely resembles real emergency situations, improving user engagement and contextual understanding.

3. **Improving Public Accessibility** Compared with VR-based training method that rely on head-mounted devices, the proposed web-based platform reduces equipment requirements and accessibility barriers, enabling the general public to more easily access CPR learning and practice.
4. **Increasing Sustained Learning Motivation**
   The system incorporates goal-oriented gamified learning processes and Teachable Machine-based motion correction, encouraging users to continuously review CPR knowledge and engage in scenario-based practice, thereby supporting long-term skill retention.

2.2. User Learning Framework

The learning workflow of the proposed system is illustrated in Figure 1.

First, users specify the training topic, environmental context, and difficulty level. Based on these inputs, the AI Scenario Generation Module generates a structured emergency scenario, including learning objectives, CPR procedures, decision-making questions, and feedback messages. Instead of generating the immersive environment itself, the AI outputs structured scenario data in JSON format, which is then matched with a corresponding pre-prepared 360° panoramic scene. In the current prototype, the 360° environments are pre-prepared static panoramic scenes. They are not generated by the AI model and are not fully reconstructed 3D environments. The role of the AI is to generate structured scenario content and task logic, while the system maps the generated scenario to the most relevant 360° scene according to environment type, such as home, public space, or transportation setting.

The selected 360° environment is presented through an A-Frame-based web interface, where interactive hotspots and scenario tasks are dynamically loaded according to the generated scenario. Users observe the surrounding environment, identify important emergency cues, and complete CPR-related tasks following the generated workflow. This design combines AI-driven scenario generation with immersive contextual interaction while maintaining consistency between the generated learning content and the visual training environment.

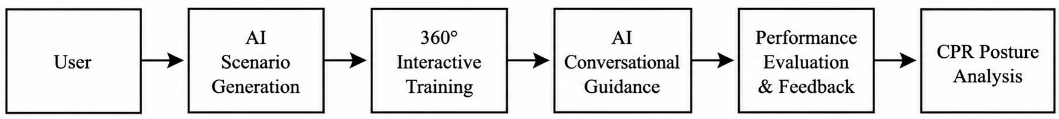

Figure 1: Learning workflow of the proposed 360° CPR training system.

2.3. Scenario Design

The emergency scenarios in the proposed system comprise several key elements, including environmental settings, patient conditions, emergency resources, and training objectives. By combining different contextual factors through AI-driven generation, the system creates diverse CPR training scenarios with varying levels of complexity. These scenarios may occur in residential environments, public facilities, or complex public spaces, with different patient locations, AED placements, and environmental distractions tailored to the characteristics of each setting. Through this structure, each generated scenario can present a different emergency context while still maintaining consistency with the core CPR training process.

To enhance training realism, the system further varies environmental conditions, including crowd density, ambient noise, spatial complexity, and the availability of bystander assistance. These variations require users to make decisions and perform emergency procedures under different circumstances, rather than simply following a fixed sequence of instructions. By dynamically generating and combining scenario elements, the proposed system provides a diverse and reusable training experience while reducing the cost and effort required for manual scenario development. This approach also allows the training content to be adapted more flexibly to different learning needs and emergency contexts.

2.4. Gamification Design

The gamification design of the proposed system is built upon three mechanisms: goal-oriented tasks, AI conversational guidance, and skill-based challenges. Users are required to complete tasks involving environmental observation, emergency decision-making, and CPR procedures as outlined in the scenario, while progressively achieving designated learning objectives throughout the training process.

In addition, after completing the scenario-based training, users can further practice CPR techniques through a Teachable Machine-based posture recognition module. This mechanism supports motion practice and posture correction, enabling users to strengthen both conceptual understanding and practical CPR skills.

3. Prototype Implementation

3.1. System Architecture

The proposed system adopts a web-based architecture with separated frontend and backend components. As Figure 2, the system is composed of five major modules: the AI Scenario Generation Module, the 360° Interactive Training Module, the AI Agent Module, the performance Evaluation Module, and the Teachable Machine Skill Training Module. These modules are interconnected through data exchange and process control mechanisms, enabling the generation of training scenarios, management of user interactions, performance evaluation, and CPR skill training. The integrated architecture supports the complete CPR learning workflow from scenario creation to practical skill development.

Regarding the data flow, users first specify the training topic, environment type, and difficulty level. These parameters are then sent to the AI Scenario Generation Module, which generates the corresponding learning objectives and CPR Standard Operating Procedures (SOPs). The generated scenario data are stored in JSON format and transmitted to the frontend system to load the corresponding 360° scene and training content. During training, users can interact with the AI Agent Module for learning assistance and guidance. User actions are validated according to the predefined SOP rules, and the corresponding records are simultaneously sent to the KPI Evaluation Module for analysis and assessment. After completing the scenario-based training, users can further practice CPR posture recognition and skills through the Teachable Machine Skill Training Module. The system then provides training feedback based on the posture recognition results.

3.2. Technical Implementation

The proposed system adopts a web-based architecture consisting of a React frontend, a lightweight Node.js backend, and multiple AI-supported training modules. The frontend was developed using React, Vite, and Tailwind CSS to provide a responsive user interface that supports AI scenario generation, immersive 360° training, performance review, and CPR posture correction. The immersive training environment was implemented using A-Frame, allowing users to explore 360° emergency scenes directly through a standard web browser without requiring dedicated VR hardware.

On the backend, the Node.js server communicates with the Gemini API to generate structured CPR training scenarios based on user-selected training topics, environmental contexts, and difficulty levels. Rather than generating unrestricted instructional content, the AI outputs are constrained to predefined

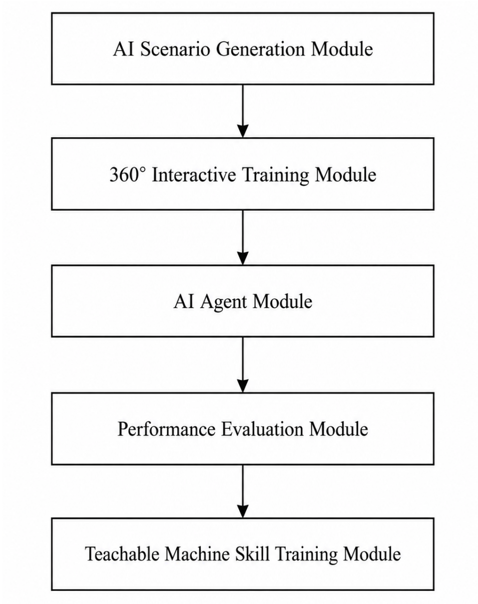

Figure 2: System architecture of the proposed 360° CPR training system.

scenario templates and instructional rules to ensure consistency with established CPR procedures. The current prototype follows a fixed CPR learning sequence derived from standard CPR/AED training procedures, including checking responsiveness, calling emergency services, requesting an AED, starting chest compressions, and following AED prompts. Therefore, the Gemini API is used to contextualize predefined CPR learning content into different emergency scenarios, rather than to independently generate medical instructions. The generated scenario data, including learning objectives, CPR procedures, decision-making questions, answer options, feedback messages, and task completion criteria, are organized in JSON format and transmitted to the frontend, where the corresponding 360° environment and interactive tasks are dynamically loaded.

The Skill Training Module integrates TensorFlow.js with a Teachable Machine model to provide camera-based CPR posture analysis and real-time corrective feedback. The module evaluates observable posture-related indicators, including hand placement, arm extension, shoulder alignment, and upper-body posture during chest compression practice. The posture recognition model classifies predefined CPR posture categories and provides visual guidance based on the recognition results to help users adjust their posture during self-directed practice.

Since a standard RGB camera cannot accurately measure compression depth, compression force, or compression rate, these critical CPR performance indicators are beyond the scope of the current module. Therefore, the posture recognition function is intended to provide preliminary movement guidance and reinforce correct body posture rather than replace professional CPR performance assessment.

3.3. Prototype Interface

The prototype interface consists of two complementary training stages: AI-generated emergency scenario training and CPR posture correction, as illustrated in Figure 3. Users begin from the home screen and may either start an immersive CPR scenario or directly access the posture correction module. This two-stage design connects emergency decision-making with practical skill training, allowing users to progress through the learning process in a clear and structured manner.

In Stage 1, users enter an AI-generated 360° emergency scenario and complete CPR-related tasks through contextual observation and interactive decision-making. The AI Agent provides scenario-specific guidance, procedural explanations, and corrective feedback throughout the training process. User actions are recorded and summarized using KPI-based performance indicators, including task completion, errors, and key learning points, enabling users to review their decision-making performance after training.

In Stage 2, users practice CPR posture using the Teachable Machine module. The system analyzes observable posture features, including hand placement, elbow extension, shoulder alignment, and upper-body posture, and provides real-time corrective feedback. This module focuses on reinforcing correct CPR posture during self-directed practice and complements the scenario-based decision training.

Overall, the prototype integrates immersive scenario simulation, AI-guided learning, performance evaluation, and posture correction into a continuous training workflow. By combining cognitive decision-making with practical posture guidance, the system provides a more comprehensive and accessible CPR learning experience.

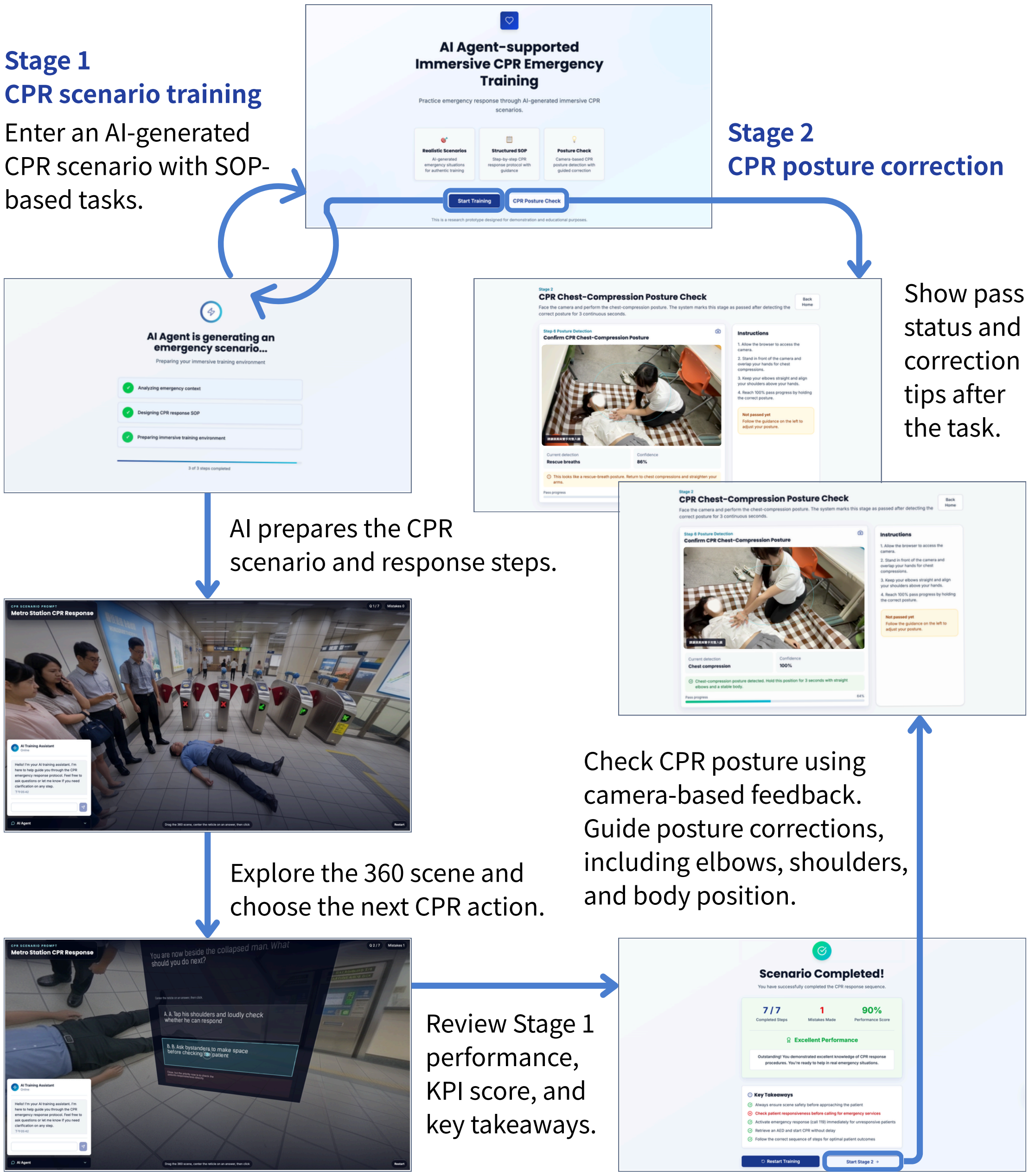

Figure 3: Overall interface flow of the AI-supported immersive CPR emergency training prototype, including CPR scenario training and posture correction.

4. Conclusion and Future Work

To verify the feasibility of the proposed system, functional testing was conducted on all major modules, including AI-based scenario generation, 360° scene loading, interactive task execution, AI Agent interaction, KPI analysis, and Teachable Machine-based pose recognition. The results demonstrated that all modules operated as intended and successfully completed their expected workflows. These results provide preliminary evidence of technical feasibility, but they do not yet demonstrate learning effectiveness or CPR performance improvement.

Compared with conventional VR-based CPR training systems, the proposed web-based architecture reduces hardware requirements by allowing users to access immersive scenario training through a standard web browser. New emergency scenarios can be incorporated by updating AI prompts and corresponding 360° scene resources without redesigning the entire system. Although AI services introduce API-related operational costs, the overall deployment and maintenance costs remain lower than those of dedicated VR equipment and instructor-intensive training environments, making the proposed approach more scalable for public CPR education.

Future work will involve conducting user studies to evaluate the effectiveness of the proposed system in improving CPR learning outcomes, situational response capabilities, and long-term skill retention. In addition, the system will be expanded to support a wider range of emergency scenarios and training content, including AED operation, the Heimlich maneuver, seizure first aid, and bleeding control procedures, thereby increasing its practical value and application potential in emergency response education.

As CPR is a life-critical emergency response skill, the proposed system is designed as a supplementary learning support tool rather than a replacement for certified CPR training or professional medical instruction. Its primary objective is to provide learners with opportunities for repeated scenario-based practice, knowledge reinforcement, and situational familiarization before or after formal CPR education. Future development will continue to emphasize the reliability and safety of AI-generated content by constraining scenario generation within established first-aid guidelines and predefined instructional frameworks. Future work will also involve collaboration with CPR instructors and domain experts to validate AI-generated scenarios and learning feedback, thereby further improving the educational reliability and practical applicability of the proposed system.

Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT for grammar and spelling check, paraphrase and reword. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

References

[1] A. L. Missel, C. J. Drucker, K. Kume, J. Shin, L. Hergert, R. W. Neumar, P. J. Kudenchuk, and T. Rea, "Association between bystander physical limitations, delays in chest compression during telecommunicator-assisted cardiopulmonary resuscitation, and outcome after out-of-hospital cardiac arrest," *Resuscitation*, vol. 188, p. 109816, 2023, doi: 10.1016/j.resuscitation.2023.109816.

[2] M. Marcus, A. A. Abdullah, J. Nor, T. H. T. Kamauzaman, and N. T. P. Pang, "Comparing the effectiveness of a group-directed video instruction versus instructor-led traditional classroom instruction for learning cardiopulmonary resuscitation skills among first-year medical students:

A prospective randomized controlled study," *GMS Journal for Medical Education*, vol. 39, no. 4, p. Doc45, 2022, doi: 10.3205/zma001566.
[3] F. Buttussi, L. Chittaro, and F. Valent, "A virtual reality methodology for cardiopulmonary resuscitation training with and without a physical mannequin," *Journal of Biomedical Informatics*, vol. 111, p. 103590, 2020, doi: 10.1016/j.jbi.2020.103590.
[4] A. Saidu, K. Lee, I. Ismail, O. Arulogun, and P. Y. Lim, "Effectiveness of video self-instruction training on cardiopulmonary resuscitation retention of knowledge and skills among nurses in north-western Nigeria," *Frontiers in Public Health*, vol. 11, p. 1124270, 2023, doi: 10.3389/fpubh.2023.1124270.
[5] Hariyanto, F. X. D. Kristianingsih, and R. Maharani, "Artificial intelligence in adaptive education: A systematic review of techniques for personalized learning," *Discover Education*, 2025, doi: 10.1007/s44217-025-00908-6.
[6] S. A. Salloum, R. O. Abukhait, Z. Alshawa, R. A. Aljanada, K. Alhumaid, *et al.*, "Generative AI in Education and Training: A Data-Driven Approach to Customized Learning Material," in *Studies in Computational Intelligence*. Cham, Switzerland: Springer, 2025, doi: 10.1007/978-3-031-89175-5/28.
[7] V. Kumaresan, M. Jeyakarthic, P. Manjula Devi, P. J. I. Rani, E. Mohan, *et al.*, "Personalized AI-Driven Online Education Technologies for Adaptive Learning and Cognitive Skill Enhancement," in *Proc. IEEE International Conference on Signal Processing, Computing and Control (ISPCC)*, 2025, doi: 10.1109/ISPCC66872.2025.11039410.
[8] N. Kökciyan, "Enabling Responsible AI with Humans," in *Frontiers in Artificial Intelligence and Applications*, vol. 391, 2025, doi: 10.3233/FAIA250785.