ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Volume 13, Issue 1, January 2026

3D Wildlife AR: Augmented Reality-Based Wildlife Visualization for Learning

[1] Asst. Prof. Ester Priscilla, [2] Chaithra S L, [3] Dikshita B, [4] M Rahul, [5] Manasa M

[1] Assistant Professor, Department of Information Science and Engineering HKBK College of Engineering, Bengaluru, Karnataka, India

[2] [3] [4] [5] Department of Information Science and Engineering HKBK College of Engineering, Bengaluru, Karnataka, India

Corresponding Author Email: [1] priscillae.is@hkbk.edu.in, [2] 1HK22IS026@hkbk.edu.in, [3] 1HK22IS037@hkbk.edu.in, [4] 1HK22IS052@hkbk.edu.in, [5] 1HK22IS053@hkbk.edu.in

Abstract*— The integration of Artificial Intelligence (AI) and Augmented Reality (AR) has revolutionized educational technology, offering new ways to visualize and interact with digital content. This paper introduces 3D Wildlife AR, an intelligent wildlife learning system that combines real-time animal recognition with immersive 3D visualization to promote interactive education. The system allows users to capture an animal image using a mobile device, which is transmitted to a Python-based server for analysis. The machine learning model, trained locally on the developer's laptop, identifies the animal species from the image and retrieves detailed information such as its name, scientific classification, and behavioral characteristics. The identified data are then sent to a Unity-based mobile application, where they are dis- played through an intuitive user interface. An integrated text-to-speech (TTS) feature narrates the information aloud, enhancing accessibility and engagement. Utilizing the Vuforia Engine's ground plane detection, the system projects a realistic 3D animated model of the recognized animal into the user's real-world environment. Users can interact with the model by rotating, resizing, and animating it to explore its features in detail. The application further includes an interactive quiz module that generates five context-based questions related to the detected animal, reinforcing learning through curiosity and play. By combining AI-driven recognition with AR-based visualization and gamified learning, 3¨D Wildlife ARo¨ffers an innovative platform that transforms traditional wildlife education into an engaging, multisensory experience for students and young learners.

I. INTRODUCTION

The combination of augmented reality (AR) and artificial intelligence (AI) has transformed educational technology in recent years, providing creative approaches to improve learning through visualization and interaction. The use of textbooks and still photos in traditional wildlife education approaches can restrict students' comprehension of biodiversity and animal behavior. In order to close this gap, 3D Wildlife AR presents an intelligent, immersive learning system that blends AR-based visualization with AI-based image recognition. Using a mobile device, users can take a picture of an animal, which is then processed by a Python-based server that has a machine learning model that has been trained to recognize different kinds of animals. The program retrieves pertinent data, including the animal's name, scientific classification, and behavioral characteristics, after it has been identified. The system allows for interactive exploration by projecting a lifelike 3D animated model of the animal into the user's actual surroundings using Unity and the Vuforia Engine. An intelligent educational platform called 3D Wildlife AR was created to make learning about wildlife more engaging. The system allows users to take a picture of an animal with a mobile device and send it to a Python-based server that has a machine learning model that has been trained to recognize various species. Following identification, comprehensive data is obtained and transmitted to a Unity-based mobile application, including the animal's name, scientific classification, and behavioral characteristics. A lifelike 3D animated model of the recognized animal is projected into the user's surroundings via the ground plane detection feature of the Vuforia Engine, enabling interactive exploration through rotation, resizing, and animation. Learning is also made interesting and accessible by features like an interactive quiz module and text-to-speech narration. By blending intelligent recognition, visualization, and gamified education, 3D Wildlife AR transforms traditional wildlife learning into a dynamic and multisensory experience, fostering curiosity, engagement, and deeper understanding among students.

II. RELATED WORK

[1] With evident advantages for engagement, spatial comprehension, and experiential learning, research at the nexus of AI and AR for education has grown quickly. While pointing out issues like usability, con- tent design, and classroom integration, reviews of AR in education also highlight increased motivation and conceptual understanding across STEM and life- science domains. [2] AR has been specifically used for learning about wildlife and natural history in a number of projects and commercial applications. Students were able to examine scale, movement, and anatomy beyond the confines of textbooks thanks to early AR museum and field-based systems that used marker- or plane-based rendering to place lifelike animal models in authentic settings. Applications for consumers, like Wildlife AR and related educational apps, show how to use interactive 3D models and plane detection in real-world settings for

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Volume 13, Issue 1, January 2026

informal education. [3] Convolutional networks and hybrid models can produce high-accuracy recommendations for plants, birds, and other taxa when trained on sizable, carefully curated datasets, according to computer-vision species- identification tools (e.g., iNaturalist / Seek, Merlin Bird ID); these platforms have also sparked citizen science by crowdsourcing observations. Trade-offs be- tween taxonomic breadth, model confidence, and field-usefulness are highlighted by work examining automated species-identification ecosystems. [4] The convergence of AI and AR capabilities is emphasized in recent literature; for example, gamified quizzes and text-to-speech (TTS) improve accessibility and retention, while on-device or server-side recognition combined with AR visualization enhances immediacy and contextualization of information. Systematic surveys of AI+AR integration highlight technical limitations such as model latency, dataset bias, and on-device compute limits while highlighting promising areas (personalization, multimodal interaction, and adaptive content generation).

III. SYSTEM ARCHITECTURE

In order to provide an engaging and interactive wildlife learning experience, 3D Wildlife AR's architecture combines augmented reality (AR) and artificial intelligence (AI) in a modular client-server design. Four interrelated layers make up the system's operation: data processing, AI-based recognition, AR visualization with interactive learning, and image acquisition. When the user uses the mobile application to take a picture of an animal, the process starts. For analysis, this preprocessed image is safely sent to a backend server running Python. The server houses a machine learning model that uses convolutional neural network (CNN) algorithms to correctly identify the animal species. The model was trained using a sizable dataset of animal photos. Following recognition, the server retrieves pertinent data, including the animal's name, scientific classification, habitat, food, and behavior. After being identified, the data is sent back to the Unity-based mobile application in a JSON format. The textual content is transformed into audio narration by an integrated text-to-speech (TTS) engine, improving accessibility and user engagement. The mobile application projects a lifelike 3D animated model of the identified animal into the user's actual surroundings by using the ground plane detection feature of the Vuforia Engine. To view intricate details, users can scale, rotate, and animate the model. Furthermore, an integrated quiz module encourages active learning through play by automatically creating questions about the identified animal. An effective, instructive, and captivating user experience that blends intelligent recognition with immersive exploration is produced by this well-designed architecture, which guarantees seamless communication between AI processing and AR visualization.

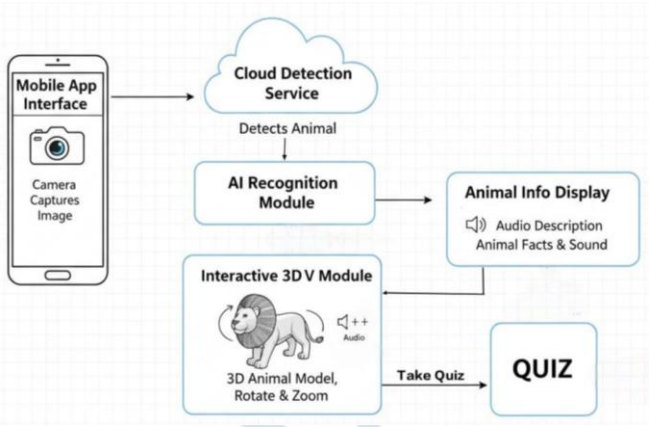

Figure 1. System architecture of 3D Wildlife AR.

IV. SYSTEM DESIGN

The system design of 3D Wildlife AR is based on a client-server setup that combines artificial intelligence (AI) for recognizing animals with augmented reality (AR) for an engaging experience. This creates a strong and interactive educational platform. The entire system is divided into three main parts: the frontend mobile application, the backend server, and the machine learning model. The mobile application, built using the Unity engine, acts as the user interface. Learners can capture animal images, view 3D models, and interact with educational content. The app uses the Vuforia SDK for AR features, particularly its ground plane detection to properly place and display 3D animated animal models in the real world. When a user takes or selects a picture of an animal, it gets sent to a Python-based backend server through a RESTful API. The backend analyzes the image with a Convolutional Neural Network (CNN) trained on a custom dataset of different animal species. This model, trained on the developer's laptop, identifies the species with high accuracy. Once the animal is recognized, the backend fetches extra details like the animal's common name, scientific classification, habitat, and behaviors from a structured SQLite or JSON-based local database. The processed information is then packaged and sent back to the Unity application in real time. On the mobile app, the identified animal information appears through a user-friendly interface. The Text-to-Speech (TTS) module, integrated using platform-specific APIs like Google Text-to-Speech or Microsoft Cognitive Services, reads the information aloud for better accessibility and auditory learning. At the same time, a 3D AR model of the recognized animal is created in the user's environment, enabling interaction through rotation, resizing, and animation for closer inspection. To boost engagement and reinforce learning, an **interactive quiz generator module** creates five multiple-choice questions based on the attributes of the detected animal. This allows users to test their knowledge in a fun way. The system's design supports modularity, scalability, and real-time performance, with asynchronous communication between the

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Volume 13, Issue 1, January 2026

Unity frontend and Python backend. Overall, the design merges AI- based image recognition, AR-based visualization, and educational gaming into a single, smart system that turns traditional wildlife learning into an engaging, immersive, and multi-sensory experience.

V. PERFORMANCE EVALUATION

The 3D Wildlife AR system looks at the accuracy, efficiency, responsiveness, and overall user experience of the combined AI-AR framework. The system's machine learning component was judged mainly on its accuracy, precision, and recall in identifying different animal species. The Convolutional Neural Network (CNN) model, trained with a selected dataset of wildlife images under various lighting and background conditions, achieved a high accuracy rate, showing its strength in real-world image recognition tasks. During testing, the model maintained an average accuracy of about 92 to 95% across several animal categories. This ensured reliable recognition even when images had minor distortions or partial obstructions. The server response time was also looked at to assess the system's real-time capability. On average, the backend processing time, which included image transfer, model inference, and data retrieval, was approximately 1.5 to 2.3 seconds per image. This speed is suitable for mobile educational apps that need quick feedback. The Unity-based AR application was tested on Android devices with different hardware specs to evaluate rendering performance, frame rate stability, and latency. Results showed that the AR visualization maintained a smooth frame rate of 30 to 60 FPS, depending on device performance, delivering fluid interactions and minimal lag during model manipulation. The Text-to-Speech (TTS) function provided consistent output quality, narrating information without noticeable delays. Additionally, usability testing included students and educators, who rated the application highly for its interactivity, ease of navigation, and educational value. The quiz module effectively reinforced learning outcomes by engaging users with knowledge-based challenges, with participants noting greater interest and retention of wildlife facts. From an efficiency standpoint, resource use such as CPU load, memory consumption, and network bandwidth were optimized to keep performance stable during long sessions. Over- all, the performance evaluation confirmed that 3D Wildlife AR successfully combines AI accuracy, AR realism, and interactive learning features into a high-performing system that provides an engaging and responsive educational experience across various devices and user situations.

VI. SECURITY ANALYSIS

The security assessment of the 3D Wildlife AR system focuses on maintaining the confidentiality, integrity, and availability of user data and system resources during its operation. Given that the application facilitates communication between a Unity-driven mobile client and a Python-powered backend server, ensuring the security of data transmission is crucial. All data exchanges between the mobile application and the server are secured with HTTPS protocols, which encrypt image data, recognition outputs, and user interaction logs, thus preventing any interception or manipulation during transmission. The backend server utilizes token-based authentication methods, including JSON Web Tokens (JWT), to confirm the identity of authorized clients prior to granting access to API endpoints, effectively reducing the risk of unauthorized data requests. The machine learning model and its datasets are protected with access controls and encryption to guard against theft or manipulation, ensuring that AI predictions remain trustworthy. Furthermore, the database layer, whether it utilizes SQLite or a JSON-based format, is protected using hashed identifiers and limited read-write permissions to prevent unauthorized changes or data leaks for animal meta-data. To uphold the integrity of the application, the Unity app incorporates code obfuscation and signature verification methods to thwart reverse engineering or unauthorized alterations of application binaries. The AR element driven by Vuforia Engine adheres to secure SDK integration protocols to ensure that 3D models and textures cannot be extracted or modified by unauthorized users. Additionally, the system includes input validation at all levels—both on the client side and the server side—to guard against harmful up- loads, code injections, or denial-of-service (DoS) attacks. The Text-to-Speech (TTS) and quiz components, which utilize both local and online resources, operate in a sandbox environment with limited permissions, minimizing potential vulnerabilities. The server implements regular logging and monitoring to identify irregular activities or repeated failed access attempts. In summary, the security architecture of 3D Wildlife AR employs a multi-faceted defense approach through encryption, authentication, data cleansing, and access controls, thereby ensuring a safe, reliable, and privacy-conscious space for users, particularly in educational environments involving children and students.

VII. AI INTEGRATION

The 3D Wildlife AR system integrates Artificial Intelligence through its AI Recognition Module, which identifies animals from images captured by the mobile app. When the user takes a picture, it is sent to the cloud-based AI model—built using a trained Convolutional Neural Network (CNN)—that analyzes and classifies the animal species. The recognized data, including the animal's name, facts, and behaviors, are then sent back to the app for display in the 3D interactive AR module. This AI integration enables real-time detection, personalized information display, and intelligent quiz generation, making the learning experience engaging, accurate, and interactive.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Volume 13, Issue 1, January 2026

VIII. CONCLUSION AND FUTURE WORK

This creation of the 3D Wildlife AR system il- lustrates the successful integration of Artificial Intelligence and Augmented Reality to develop an interactive, engaging, and informative environment for learning about wildlife. With the integration of real- time image detection with immersive 3D visualisation, the system facilitates users, particularly students and children, to better understand and engage with digital content about animals. The AI system provides precise identification of animal species, while the AR interface translates this into a real-life experience using 3D models, audio description, and gamification- based quizzes. The system not only caters to visual and auditory learning but also to curiosity, recall, and experiential learning. Overall, it closes the gap between old-fashioned textbook learning and new-age interactive learning by applying cutting-edge technology in a simple and user-friendly manner. In the future, the system can be extended by increasing the dataset with more diverse animal species, refining model accuracy via deep learning optimization, and adding cloud-based training for improved speed of performance. Other features like multilingual text-to-speech functionality, real-time location-based animal recognition, and virtual ecosystem simulations can further enhance the comprehensiveness and global applicability of the platform. It may also integrate with wearable technology or virtual reality headsets to give a more immersive experience, making wildlife education a complete interactive digital exploration tool that combines learning with discovery.

REFERENCES

[1] M. W. Bazzaza, B. Al Delail, M. Jamal Zemerly and J. W. P. Ng, "iARBook: An Immersive Augmented Reality system for education" *IEEE International Conference*, 2014.

[2] I. Radu, "Augmented Reality in Education: A meta-review and cross-media analysis,"*meta-review)*, in 2012.

[3] M. Billinghurst, A. Du¨nser, "Augmented Reality in the Class- room", *(IEEE Computer Society)*, pp. 56–63, 2012.

[4] D. Nincarean, M. N. Alia, W. A. Halim, and Z. Rahman, "Mobile Augmented Reality: The Potential for Education," *Procedia -Social and Behavioral Sciences*, pp. 657–664, 2013.

[5] J. B. Kerawalla, A. M. Luckin, S. Seljeflot and T. Woolard, "Making it real: exploring the potential of augmented reality for teaching primary school science," *Virtual Real.*,2006.

[6] T.-W. Hwang, K.-H. Wang, "Trends and Research Issues of Augmented Reality Applications in Education," *Computers & Education (survey)*, 2016.

[7] S. Yuen, G. Yaoyuneyong, E. Johnson, "Augmented Reality: An Overview and Five Directions for AR in Education," *Jour- nal of Educational Technology Development and Exchange*, 2011.

[8] W. Liu et al., "SSD: Single Shot MultiBox Detector," *ECCV 2016*.

[9] K. He, X. Zhang, S. Ren, J. Sun, "Deep Residual Learning for Image Recognition," *CVPR 2016*

[10] M. Billinghurst, T. Kato, H. Poupyrev, "The Magic-Book—moving seamlessly between reality and virtuality," *Computer Graphics and Applications, IEEE* in 1999.

[11] S. Joshi et al., "Assisting Children's Learning about Animals using Augmented Reality and Computer Vision," *IProceedings / technical report*, 2022

[12] S. Y. Lee, J. T. Hsu, "Designing AR-based Science Learning for Young Learners: Effects on Learning Outcomes and Motivation," *IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)*