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RELIX: A Lightweight Augmented Reality Heritage Guide using Image Recognition

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Abstract

Cultural heritage sites often struggle to communicate historical knowledge to visitors due to static information boards, limited signage, and language barriers. This creates a disconnected experience, especially for tourists, children, and visually impaired individuals. To address these gaps, this paper proposes RELIX, a lightweight mobile-based Augmented Reality (AR) system designed to deliver accessible cultural information in real time. RELIX integrates a MobileNetV2-based image recognition pipeline with a Flutter-based frontend and FastAPI backend to identify monuments, statues, and temple features through live camera input. Instead of computationally expensive 3D rendering, the system overlays lightweight 2D visual, textual, and audio explanations to improve accessibility and user engagement. Experimental testing demonstrates efficient inference time ranging between 400–700 ms, smooth AR overlay performance on mid-range smartphones, and positive user feedback regarding engagement, educational value, and accessibility. The findings suggest that combining AR with optimized machine learning provides an effective solution for enhancing cultural learning in heritage environments. Future improvements include multilingual support, dataset expansion, and offline inference using TensorFlow Lite.

Keywords

Augmented Reality, Cultural Heritage, MobileNetV2, Image Recognition, Accessibility, Mobile Computing, FastAPI, Flutter

Introduction

Cultural monuments, temples, and heritage sites encapsulate centuries of history, tradition, and architectural knowledge. Despite their significance, visitors frequently struggle to interpret their symbolic or historical value due to insufficient signage, non-interactive displays, and lack of multilingual support. Traditional approaches such as printed boards or guided tours cannot scale to diverse audiences and provide limited accessibility for children or differently abled individuals. As a result, cultural learning remains passive and fragmented.

In recent years, advancements in mobile computing and computer vision have enabled interactive modes of learning through Augmented Reality (AR). AR technology enhances real-world environments by overlaying digital elements such as text, images, and animations on the user's view, thus enabling immersive cultural and educational experiences. Simultaneously, lightweight deep learning models, such as MobileNetV2, have improved real-time inference on smartphones, eliminating the need for high-performance computing hardware.

The proposed system, named RELIX, leverages mobile AR and optimized machine learning to bridge the educational gap at heritage sites. By identifying monuments and statues through live camera input and displaying historical explanations through 2D overlays, RELIX transforms cultural exploration into an engaging and accessible experience suitable for tourists, children, and differently abled users.

Problem Statement

Visitors at heritage sites often lack contextual understanding of monuments due to issues such as limited signage, language barriers, and absence of interactive guides. Traditional guided tours are not scalable and do not support accessibility features such as text-to-speech narration. Therefore, there is a need for a scalable, mobile-based system capable of identifying heritage elements and presenting educational content in an interactive and inclusive manner.

Objectives

The main objectives of this study are:

1. To develop a lightweight AR application capable of identifying statues and monuments using image recognition.

2. To integrate 2D AR overlays including text, animations, and audio explanations for educational support.

3. To design a culturally accessible system with child-friendly modes and narration support.

4. To ensure compatibility with mid-range smartphones through computationally efficient model selection.

5. To evaluate the system based on performance, accuracy, usability, and accessibility.

Motivation

India possesses thousands of temples, monuments, and historic statues that represent deep cultural relevance. However, accessibility to structured information is limited, especially for younger audiences and international visitors unfamiliar with local languages. With the rapid penetration of affordable smartphones, mobile AR offers a practical medium for modernizing heritage learning.

Methodology

The RELIX system follows a modular design consisting of four core components:

• Mobile Frontend (Flutter + Dart)

• Backend Server (FastAPI + TensorFlow)

• Metadata Repository

• Augmented Reality Display Layer

Dataset Preparation: A custom dataset of statues and temple structures was collected, annotated, and categorized. Data augmentation techniques such as rotation, cropping, scaling, and brightness adjustment were applied to improve robustness.

Model Architecture: MobileNetV2 was selected due to its inverted residual bottleneck design and low computational complexity. Transfer learning using ImageNet weights accelerated convergence and improved accuracy.

Backend Design: The backend was implemented using FastAPI to handle image reception, inference execution, and metadata retrieval. Responses were returned in structured JSON format.

Frontend and AR Overlay: The Flutter frontend integrates camera modules, text-to-speech support, mascot-based child mode, and 2D overlay widgets to display educational content without heavy 3D rendering.

Results and Discussion

Performance Evaluation: The system was tested on mid-range smartphones, and backend inference time ranged between 400–700 ms per prediction, demonstrating near real-time performance.

Usability Evaluation: User evaluation sessions showed increased engagement, improved cultural understanding, and better accessibility compared to static museum boards. Children benefited from mascot explanations, and visually impaired users benefited from TTS.

Comparative Discussion:

Compared to existing AR museum applications, RELIX offers advantages such as lightweight 2D rendering, markerless recognition, child-friendly interactions, and accessibility support.

Limitations: The system experiences reduced accuracy in low-light conditions and currently supports a limited number of monument classes.

Conclusion

RELIX demonstrates that combining lightweight AR with optimized image recognition can enhance cultural learning at heritage sites. The system enables interactive, inclusive, and engaging educational experiences for tourists, children, and differently abled users. Future work includes dataset expansion, multilingual narration, location-based recommendations, and offline TensorFlow Lite support.

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