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Augmented Reality Navigation on Android: Challenges and Solutions

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Abstract

This research focuses on the development of an advanced augmented reality (AR) navigation system, specifically designed to enhance traditional navigation methods and significantly improve overall user satisfaction. By utilizing the latest technological advancements in AR, this system aims to create a more engaging and user-friendly navigational experience. The developed system is based on an Android application that allows users to select their desired routes and navigate to their destination by following virtual direction displayed on their devices. These overlays provide real-time, personalized directions, making it easier for users interact with navigational tools. Unlike traditional map-based navigation, which often requires users to interpret 2D information and imagine how it is related to the real world, this AR system directly shows navigational cues into the real world, making the process more user-friendly. The primary objective of this research is to address the limitations of conventional navigation systems, such as difficulty in understanding map data and getting lost in new places.

Keywords: Augmented Reality, Android, Extended Reality, Navigation System

1. Introduction

In the rapidly evolving field of augmented reality (AR), navigation systems are a promising application that can significantly enhance user experience. Traditional navigation tools, such as 2D maps, often fall short in providing intuitive and immersive guidance, particularly in complex environments. This research aims to bridge that gap by developing an

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augmented reality navigation system for Android devices that utilizes cutting-edge technologies like ARCore and the Mapbox API.

1.1 Objectives

The main objectives of this research are:

- Provide an overview of AR technology and its use in existing research.
- To develop augmented reality application for android which can be used for navigation to available destinations.
- Identify the technical and practical challenges in AR-based navigation applications.
- Present strategies and methodologies to overcome challenges in AR navigation application development.

2. Literature Review

The integration of augmented reality (AR) into navigation systems has significantly advanced across various domains, including pedestrian, automotive, and indoor navigation. In pedestrian navigation, AR technologies have revolutionized how users interact with their environment. Modern AR navigation apps overlay directional cues, street names, and other useful information onto the real-world view captured by a smartphone camera. This approach enhances user orientation and reduces navigation errors by providing more intuitive and contextually relevant guidance compared to traditional 2D maps as introduced in [1,2,3,7]. Munesh Kumar Sharma [4] discussed about an augmented reality navigation that can be employed in different sectors like car navigation and pedestrian navigation. AR has been employed to enhance the driving experience through technologies like head-up displays (HUDs) that show navigational information directly onto the windshield as mentioned in [4,7]. Y. Kaizu and J. Choi [5] discussed about an augmented reality system for tractor navigation system.

Indoor navigation systems also benefit from AR technology, particularly in complex environments such as shopping malls, airports, and large office buildings. AR-based indoor navigation solutions overlay virtual pathways and point-of-interest markers onto physical spaces, making it easier for users to find their way within large and often confusing indoor environments as mentioned in [6,8].

Recent advancements in augmented reality have been comprehensively surveyed by Azuma et al. [9], highlighting key developments and applications, particularly in enhancing user interaction with real-world environments. Yovcheva et al. [10] empirically evaluated smartphone AR browsers within an urban tourism context, emphasizing their effectiveness in enriching the tourist experience. McKercher and du Cros [11] tested a cultural tourism typology, which underscores the potential of AR in providing immersive cultural experiences for tourists. Hyun et al. [12] discussed mobile-mediated virtual experiences in tourism, outlining how AR can create engaging and personalized vacation experiences. Bhaskara and Sugiarti [13] explored the use of AR technology to enhance cultural heritage tourism in Bali, demonstrating its value in preserving and promoting local culture. Cranmer et al. [14] further examined the benefits of AR in tourism, noting its capacity to offer unique and interactive experiences for travelers. Finally, Vlahakis et al. [15] presented Archeoguide, an AR application for archaeological sites, showcasing how AR can transform the way tourists engage with historical sites.

3. Methodology

The research aims to develop an AR application for Android using ARCore and Mapbox API. Additionally, the system uses the sensors and the cloud services to provide an engaging augmented reality experience.

3.1 System Architecture

The system architecture defines how the components interact with each other to deliver the intended functionality. The user interface is responsible for presenting the application's user interface to the user. It includes the layout of the app's screens, buttons, and other interactive elements. This application logic is responsible for implementing the core key functions of the application. It includes algorithms for object recognition, location tracking, and other essential functionalities. This database is responsible for storing and managing the application's data. It includes user data, location data, and other relevant information. Moreover, the application programming interfaces (APIs) provide a standardized way for the application to communicate with other systems or services. The application uses the Map box API to retrieve location data. The augmented reality engine is responsible for rendering virtual objects in the real world. ARCore engine is used to detect and track real-world objects and anchor virtual objects to them. The device sensors provide data to the application, such as the device's location, orientation, and camera data. The application uses this data to deliver an immersive augmented reality experience. Finally, cloud services can be used to provide additional functionality to the application, such as user authentication, data backup and synchronization, and analytics. Figure 1 illustrates the system architecture diagram.

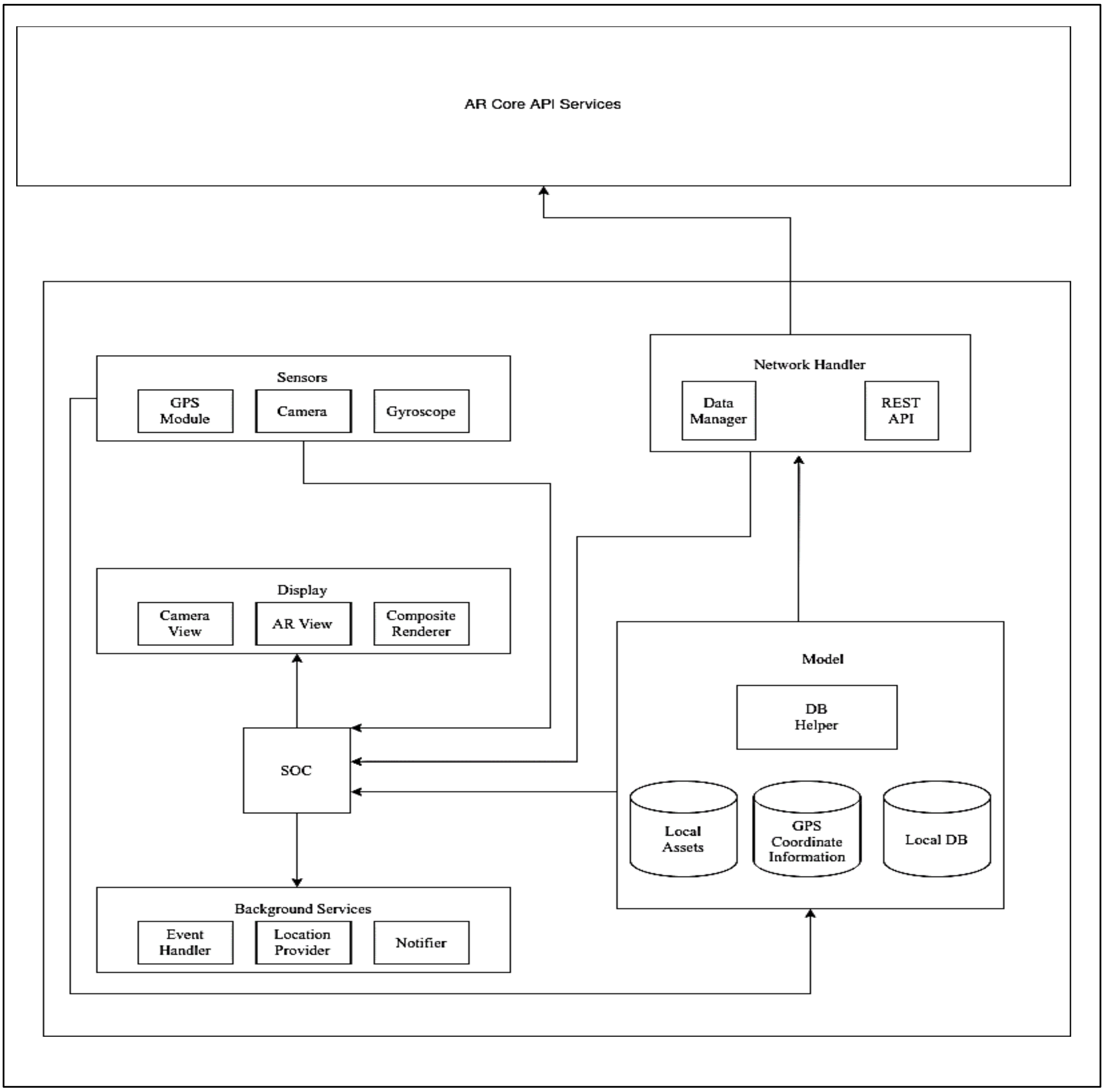

Figure1. System Architecture Diagram

3.2 System Components

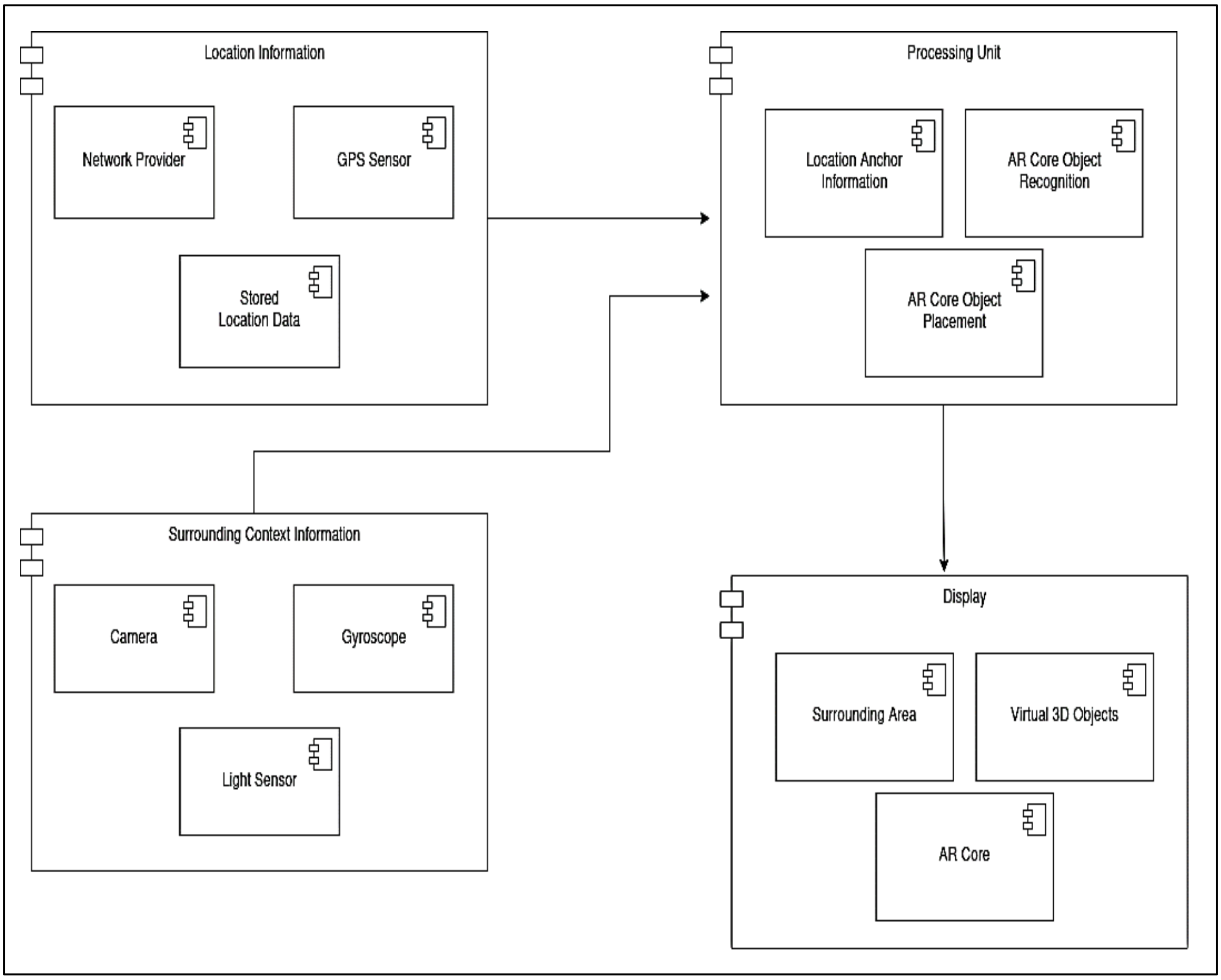

Figure 2. System Component Diagram

Figure 2 illustrates the system component diagram. The first component is the location information, which includes the network provider, GPS sensor, and stored user data. The network provider provides the device's location information, while the GPS sensor provides precise location data. The processing unit is the second component and includes location anchor information, ARCore object recognition, and ARCore object placement. The third component is the surrounding context information, which includes the camera, light sensor, and gyroscope. The camera is used to capture the user's environment and track their movements. The light sensor is used to adjust the virtual objects' lighting to match the environment's lighting conditions. The gyroscope is used to track the device's orientation and adjust the virtual objects' position accordingly. Finally, the display component includes the surrounding area, virtual 3D objects, and ARCore. The surrounding area is the real-world environment captured by the camera. Virtual 3D objects are the digital objects overlaid on the real-world environment. Together, these components work to create an immersive AR experience for the user.

3.3 Work Flow

The navigation system for the augmented reality application begins when the user opens the app. First, the system checks if location permissions are granted. If granted, the app fetches the user's current location using the Mapbox API; otherwise, the app closes. The user then selects a destination on the screen, triggering the system to fetch route information from Mapbox API. As the user moves, the system continuously calculates the user's facing direction and updates the route information in real-time. Once the destination is reached, a message indicating "You have reached destination" is displayed on the screen. The Figure 3 illustrates the workflow of developed navigation system.

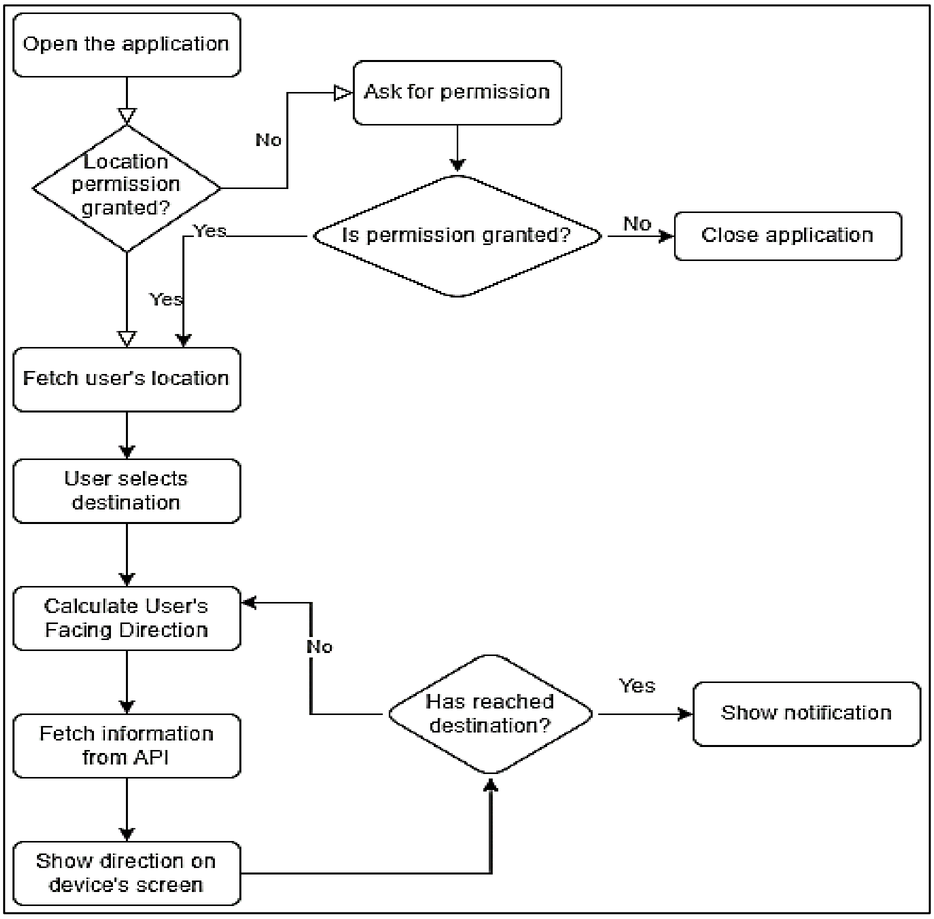

Figure 3. Workflow Diagram of Navigation System

The Table. 1 below shows the Tools used in the development

Table1. Tools Used

Description	Tools Used
Development Machine	A standard desktop computer was used. The device had 16GB of RAM and a 512 GB SSD.
Third Party APIs	Mapbox API
Development Tools	Android Studio, Unity, Java, Kotlin, ARCore
Database	SQLite Database

3.4 Algorithms

The augmented system is supported by several key algorithms and technologies that ensure accurate object recognition, precise location tracking, and real-time updates of route information.

- **Object Recognition**

The system leverages ARCore, a powerful platform by Google, for object recognition. ARCore provides robust environmental understanding by detecting and tracking key features in the user's surroundings. This allows the application to accurately place virtual objects in real-time and recognize relevant landmarks that are essential for navigation.

- **Location Tracking**

For location tracking, the system employs a combination of GPS and the Mapbox API. GPS provides the foundational location data, while the Mapbox API enhances this data by offering detailed mapping and route information. This combination ensures continuous and precise location tracking, enabling the application to provide accurate real-time navigation guidance.

- **User's Facing Direction and Real-time Route Updates**

The user's facing direction is determined by ARCore, which uses the device's sensors to track orientation and alignment in real-time. This data is crucial for accurately aligning AR overlays with the physical world. Real-time route updates are managed through the Mapbox API. As the user moves, the system recalculates the route based on the current GPS location and facing direction, ensuring that the navigational guidance remains accurate and up-to-date throughout the journey.

4. Results and Discussion

The result of this system provides a thoroughly developed augmented reality application for android which can be used for navigation to available destinations. Users don't need to log in to our application. They can just open the application and get started. A screen shows available destinations for users as depicted by Figure 4 after getting started.

Figure 4. Available Destination Screen

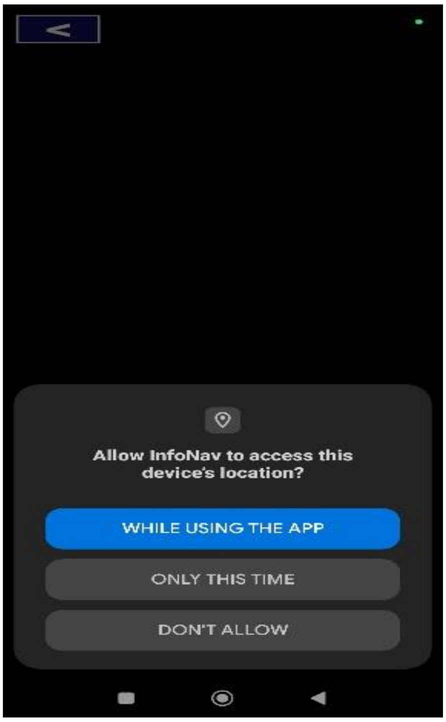

Figure 5. Location Permission Popup

Users must provide location access to the application after clicking one of the available destinations choosing any one of the options shown in Figure 5.

Figure 6. Information Overlay on Screen

Users are provided with navigation information overlayed on the screen as shown in Figure 6.

5. Challenges and Solutions

5.1 Challenges

A few difficulties in creating an augmented reality application are compatibility issues with hardware and software, performance issues, user experience issues, object tracking, content creation, and testing. A smooth and immersive experience depends on compatibility with a variety of devices and operating systems. A user-friendly interface must focus on the user experience. For a smooth experience, accurate object tracking is essential, but it can be difficult in situations with changing light exposure and camera angles. While testing is difficult because of the intricate relationships between hardware, software, and the outside environment, content development is costly and time-consuming.

5.2 Solutions

To optimize AR navigation applications, background services or WorkManager can be used for location tracking and battery efficiency. Testing and profiling on various devices with different hardware capabilities is crucial for identifying performance bottlenecks. Device-specific optimizations, such as using Vulkan instead of OpenGL ES, can enhance performance and lower CPU usage. Local caching of frequently accessed data can reduce the need for constant network requests. Adaptive rendering techniques, such as dynamic resolution scaling, can adjust AR content resolution based on the device's performance. Efficient resource management can improve graphics performance by using simplified 3D models, reducing polygon count, and employing techniques like Level of Detail. Effective garbage collection can be done sparingly and tested thoroughly. Optimized asset management can reduce memory consumption by loading assets only when needed and unloading them when no longer needed.

6. Conclusion

It can be concluded from this research that utilizing augmented reality (AR) in navigation applications offers significant potential to enhance user experience by providing more intuitive, immersive, and contextually relevant guidance. The integration of AR can transform how users interact with navigation systems despite the inherent challenges. The future work aims to enhance the accuracy of the GPS system by exploring other options, such as using Wi-Fi positioning or BLE beacons, and improve the routing system through the implementation of machine learning algorithms to automatically generate routes based on user preferences and traffic data.

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