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Exploring the Future of Indoor Navigation: AR Technology

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Abstract

Indoor navigation within complex environments remains a recurring challenge in the age of rapid technological advancement. Traditional methods often fall short when applied to intricate indoor spaces like shopping malls, airports, and corporate campuses. This paper introduces ARNav, an innovative Augmented Reality (AR) based indoor navigation system designed to enhance indoor navigation accuracy and user experience.

ARNav utilizes AR technology to overlay digital information, such as arrows, markers, and directional cues, onto the real-time camera view of users' devices. This dynamic overlay simplifies navigation while offering an immersive experience. The system achieves precise indoor positioning through sensor fusion and mapping techniques, boasts an intuitive user-centric design, and implements robust data security measures. Energy efficiency optimization ensures longer battery life, and the system seamlessly integrates with external data sources, offering real-time information on points of interest and events within indoor spaces.

A user feedback mechanism allows for continuous improvement, placing user needs at the forefront of development. This paper discusses the design and implementation of ARNav, highlighting the technologies and mathematical models for accurate positioning and AR overlay.

ARNav represents a promising solution for indoor wayfinding, combining AR technology with precise indoor navigation to enhance user experiences. The paper explores potential future developments, including advanced AR features, machine learning integration, and compatibility with various devices and platforms, thus contributing to the field of indoor navigation and AR technology.

Keywords: Augmented Reality, Indoor Navigation, Precise Positioning, User-Centric Design, AR Overlay, Sensor Fusion, Wayfinding, User Experience, Data Security, Energy Efficiency

1. INTRODUCTION

Indoor navigation remains a persistent challenge, even in a world marked by rapid technological advancements. Traditional navigation methods excel outdoors but falter when applied to intricate indoor environments like shopping malls, airports, and corporate campuses. To tackle this issue, we present "AR Nav," an innovative indoor navigation system that leverages Augmented Reality (AR) technology, redefining the navigation experience.

Navigating complex indoor spaces, often characterized by sprawling shopping malls, expansive airports, and vast office buildings, can be a cumbersome and time-consuming task. In response to this challenge,

we introduce "AR Nav," an Augmented Reality (AR) indoor navigation app that transforms how individuals navigate indoor environments. By seamlessly merging the physical world with a digital overlay, AR Nav provides users with an intuitive and interactive means of indoor navigation.

The development of AR Nav is motivated by the persistent challenge of indoor navigation. Traditional navigation methods, such as paper maps and digital maps, often prove ineffective in indoor spaces due to GPS limitations and intricate layouts. The adoption of AR technology offers a promising avenue to enhance indoor navigation by providing real-time, intuitive, and interactive wayfinding solutions.

AR Nav aims to address the difficulties people encounter when navigating large and complex indoor environments, leading to frustration, wasted time, and a less enjoyable experience in places like shopping malls, airports, and corporate campuses. The primary goal is to simplify and improve indoor navigation.

Real-time Augmented Overlay: AR Nav offers a dynamic overlay of digital information on the user's device screen, providing a live view of their surroundings with integrated navigation aids.

Directional Guidance: Users can simply point their mobile devices or smart glasses at their surroundings, and AR Nav superimposes real-time visual cues, such as arrows, markers, and directional cues, guiding them through the indoor space.

2. Ease of Access

The success of indoor navigation systems hinges on their ability to provide users with an intuitive, clear interface that ensures a seamless and frustration-free experience. ARNav is committed to prioritizing user needs and behaviors, focusing on key aspects that enhance accessibility and ease of use:

2.1 User-Centric Design

At the core of ARNav's design philosophy is a commitment to user-centricity. The application is thoughtfully crafted to ensure a straightforward interface that allows users to quickly and easily grasp the intricacies of indoor navigation. User-centric design elements include a visually intuitive menu, clear icons, and easily understandable navigational cues. Our goal is to empower all users, regardless of their technological background, to confidently and effortlessly navigate indoor spaces.

2.2 Intuitive AR Overlays

ARNav's Augmented Reality (AR) overlays, such as arrows and directional cues, are designed with a focus on clarity and minimal distraction. These overlays provide users with a visually straightforward means of understanding their indoor environment and the directions they need to follow. By reducing visual clutter and prioritizing essential information, ARNav ensures that users can concentrate on their surroundings without feeling overwhelmed.

2.3 Minimal Interaction

Complex interactions can lead to user frustration. In ARNav, we've made it a priority to minimize interaction steps wherever possible. From launching the application to accessing location-specific information, the user's journey is streamlined. By reducing the number of taps, swipes, and gestures needed, ARNav minimizes the cognitive load on users, making the navigation process as effortless as possible.

2.4 Consistency

Consistency is a cornerstone of ARNav's design. The application offers a predictable user experience throughout, ensuring that users can easily navigate various indoor spaces without needing to relearn the interface. This consistent design approach extends from the way users interact with AR overlays to the overall look and feel of the application.

2.5 Accessibility

Inclusivity is a top priority for ARNav. We understand that users have diverse needs, and our design philosophy reflects this understanding. ARNav integrates accessibility features, such as text-to-speech functionality, adjustable font sizes, and high-contrast modes, to cater to users with different abilities. By prioritizing accessibility, ARNav ensures that indoor navigation is accessible to a broad and diverse audience.

2.6 User Feedback and Continuous Evolution

ARNav values user input and feedback. The application incorporates a user feedback mechanism that allows users to share their experiences, report issues, and suggest improvements. This iterative approach to development ensures that ARNav evolves in line with user expectations, providing an ever-improving indoor navigation experience.

2.7 Error Handling

ARNav handles errors gracefully, recognizing that users may encounter challenges during indoor navigation. When issues arise, the application provides informative error messages and guides users through problem-solving steps. Clear error handling minimizes user frustration and ensures that users can swiftly recover from unexpected situations.

2.8 Onboarding and Tutorials

To assist new users in quickly familiarizing themselves with ARNav, the application provides onboarding and tutorial features. These guided resources offer step-by-step instructions on how to use ARNav, ensuring that even first-time users can confidently and competently navigate indoor spaces.

2.9 Continuous Testing and Improvement

ARNav is committed to maintaining high standards of usability. Extensive user testing is conducted to evaluate and refine ARNav's usability continuously. The insights gained from user testing help identify areas for improvement, ensuring that ARNav remains at the forefront of user-centric indoor navigation.

In summary, ARNav offers an exceptional level of ease of access by simplifying indoor navigation for all users. Through user-centric design, minimal interaction, accessibility features, clarity, and ongoing refinement, ARNav ensures that indoor navigation is not just efficient but also an enjoyable and inclusive experience for all users.

3. Methodology (4-5 Pages)

In the methodology section, we detail the approach and processes used to develop Indoor Nav Pro. This section provides a comprehensive understanding of the software requirements, system architecture, and other critical elements that constitute the foundation of the project.

3.1 PROJECT SCOPE

The project's scope is instrumental in delineating the boundaries, goals, and objectives of Indoor Nav Pro. This section provides a comprehensive overview of the key aspects within the project's scope, encompassing various dimensions:

3.1.1 Goals and Objectives

At the heart of the project's scope lie its fundamental goals and objectives, which serve as guiding beacons throughout the development process:

- **Enhancing Indoor Navigation:** The primary goal of Indoor Nav Pro is to revolutionize indoor navigation, providing users with an exceptional and precise navigation experience within complex

indoor spaces. This goal is underpinned by the aim to eliminate the challenges and frustrations associated with navigating areas such as shopping malls, airports, corporate campuses, hospitals, and more.

- **Real-Time Positioning:** A central objective of the project is to enable real-time positioning, ensuring that users can access and rely on highly accurate location data as they navigate indoor environments.
- **User-Centric Design:** Indoor Nav Pro is committed to a user-centric approach, emphasizing the creation of an interface that is both intuitive and visually appealing. The user experience is a key objective, catering to a diverse range of users, regardless of their familiarity with smartphone applications.

3.1.2 Deliverables

The project's scope defines the deliverables that will emerge as a result of the development process. These include:

- **Mobile Application:** The primary deliverable of Indoor Nav Pro is a feature-rich mobile application. This application will be available on both Android and iOS platforms, extending its accessibility to a wide user base. Users can seamlessly access the application, harnessing its capabilities to navigate complex indoor spaces.
- **Administrative Portal:** In addition to the mobile application, Indoor Nav Pro aims to deliver an administrative portal. This portal is designed to cater to administrators, offering them the tools required for efficient system configuration and management. It enables administrators to oversee and fine-tune the Indoor Nav Pro environment.

3.1.3 Limitations

While the scope outlines ambitious goals and objectives, it is equally important to acknowledge the limitations that are inherent to the project:

- **External Factors:** Indoor Nav Pro is aware of its dependency on external factors that are beyond its control. Elements such as Wi-Fi signal availability and user device compatibility fall into this category. The project recognizes that these factors can impact the user experience and positioning accuracy.
- **Wi-Fi Signal Reliance:** A limitation arises from the system's reliance on existing Wi-Fi networks within indoor environments. The accuracy of indoor positioning is intricately tied to the strength and quality of Wi-Fi signals, and, therefore, this dependence is a notable aspect of the project's scope.

In summary, the project's scope encapsulates a set of clear and ambitious goals, deliverables, and important limitations. It sets the stage for the development of Indoor Nav Pro by providing a well-defined framework that ensures alignment with the project's overarching objectives.

3.1.3 Interfaces

Indoor Nav Pro interacts with various interfaces, including user, hardware, software, and communication interfaces.

***User Interfaces*:** The system features two primary user interfaces, each designed to ensure a seamless and intuitive experience. The Mobile Application Interface is the primary point of interaction for general users,

including AR overlays, maps, and menus for feature access. The Administrative Portal Interface is designed for administrators to configure and manage the system.

***Hardware Interfaces*:** Indoor Nav Pro interfaces with user devices, such as smartphones and tablets, utilizing device sensors like cameras and gyroscopes for AR-based positioning and interactions.

***Software Interfaces*:** The system integrates with AR development platforms like ARCore and ARKit to enable AR overlays. It also communicates with Wi-Fi networks within indoor spaces for positioning data and location-specific information.

***Communication Interfaces*:** The system communicates with Wi-Fi networks to retrieve and transmit data, providing real-time positioning and location-based information.

3.2 User Classes and Characteristics

Indoor Nav Pro is designed to cater to a diverse range of user classes, each with distinctive characteristics:

3.2.1 General Users

These are everyday users who rely on the system for seamless indoor navigation. General users may include shoppers in malls, travelers in airports, or employees within a corporate campus.

3.2.2 Administrators

Administrators have access to the system's administrative portal, allowing them to configure and manage the Indoor Nav Pro environment. They require technical expertise and are responsible for system management.

3.3 ASSUMPTIONS AND DEPENDENCIES

The success of Indoor Nav Pro relies on acknowledging and addressing a set of assumptions and dependencies to ensure a seamless development process. This section provides an overview of these key assumptions and dependencies:

Assumptions:

- **Wi-Fi Connectivity and Hardware Capabilities:** Indoor Nav Pro assumes that users' mobile devices are equipped with Wi-Fi connectivity and possess the necessary hardware capabilities to support Augmented Reality (AR) functionality. This assumption ensures that the system can function optimally and deliver an immersive AR experience. Users are expected to have devices with compatible sensors, such as cameras and gyroscopes, which are essential for AR-based positioning and interactions.
- **User Familiarity with Smartphone Applications:** The project assumes that users will have an adequate level of familiarity with using smartphone applications. This assumption takes into account the widespread use of smartphones in today's society. However, it is important to recognize that not all potential users may be equally proficient in using mobile applications, and efforts will be made to ensure the system remains user-friendly for a broad audience.

Dependencies:

- **Wi-Fi Networks in Indoor Environments:** The system is dependent on the availability and proper functioning of Wi-Fi networks within indoor environments. The accuracy of indoor positioning, a cornerstone of Indoor Nav Pro, relies on the strength and quality of Wi-Fi signals. The project's success is intrinsically linked to the reliability and coverage of Wi-Fi networks within the indoor spaces where the system will be deployed.

These assumptions and dependencies are carefully considered to mitigate potential challenges and ensure that the project aligns with the real-world conditions and expectations of its users. By addressing these factors, Indoor Nav Pro aims to deliver a robust and dependable indoor navigation solution.

3.4 Functional Requirements

The functional requirements section delves into the specific features and capabilities of Indoor Nav Pro. These requirements define what the system should do to meet the needs of various user classes:

3.4.1 System Feature 1 (Functional Requirement)

In the development of Indoor Nav Pro, a wide array of system features and capabilities are fundamental to meet the diverse needs of various user classes. The following section provides an in-depth exploration of the first system feature, "Real-time Positioning," which is essential for delivering accurate and dynamic navigation within indoor environments.

Description:

"Real-time Positioning" is a pivotal system feature that enables users to gain real-time insights into their precise location within complex indoor spaces. It leverages the integration of Augmented Reality (AR) technology and Wi-Fi-based indoor positioning to provide highly accurate and dynamic positioning information.

User Interaction:

Users can activate the "Real-time Positioning" feature by launching the Indoor Nav Pro application on their mobile devices. Once activated, the AR interface overlays their precise location within the indoor environment, marking it with a digital marker or indicator. This digital marker is a visual representation of their real-time position, facilitating easy and accurate navigation.

Use Case:

Consider a user in a sprawling shopping mall seeking to find a particular store. By utilizing the "Real-time Positioning" feature, the user can pinpoint their exact location on the mall map provided by Indoor Nav Pro. As they move through the mall, the system continuously updates their position in response to their movements. This dynamic and accurate positioning information ensures that users can navigate with confidence and efficiency, enhancing their overall indoor navigation experience.

"Real-time Positioning" is a core component of Indoor Nav Pro, exemplifying the system's commitment to delivering a highly accurate and dynamic indoor navigation solution that empowers users in various indoor spaces.

3.4.2 System Feature 2 (Functional Requirement)

In the pursuit of creating a comprehensive indoor navigation system, the second significant system feature, "Location-Based Information," plays a vital role. This feature enriches the user experience by offering location-specific details and guidance, ensuring that users receive relevant information tailored to their current indoor location.

Description:

"Location-Based Information" is designed to provide users with pertinent information related to their current location within the indoor environment. This feature enhances the user experience by offering contextually relevant data about nearby points of interest, directions, and services, all of which contribute to a seamless indoor navigation experience.

USER INTERACTION:
Users access "Location-Based Information" by simply pointing their mobile devices at a specific area or object of interest through the AR interface. The system's AR capabilities recognize the user's location and display information that is specifically relevant to the area or object in focus.

USE CASE:
Imagine a traveler at an airport, eager to locate the nearest gate for their departing flight. By activating the "Location-Based Information" feature, the traveler can easily point their mobile device towards a gate sign. The system identifies the user's location and provides real-time details about the gate number, departure time, and even a navigational arrow guiding them precisely to the gate. This empowers travelers to effortlessly find their way through the airport's complex layout, reducing the stress associated with air travel.

"Location-Based Information" is a fundamental component of Indoor Nav Pro, enhancing the user experience by providing real-time, context-aware information that simplifies navigation within indoor spaces. This feature highlights the system's commitment to delivering more than just navigation; it aims to provide users with a comprehensive indoor guidance system that is both informative and engaging.

3.5 SOFTWARE REQUIREMENTS (PLATFORM CHOICE)
Indoor Nav Pro is designed to run on both Android and iOS platforms, ensuring accessibility to a broad user base:

3.5.1 PLATFORM CHOICE
The system development is based on Android (using Java/Kotlin) and iOS (using Swift), making use of platform-specific development tools and libraries. The core of the system is platform-specific, but efforts are made to ensure a consistent user experience across both platforms.

3.5.2 HARDWARE REQUIREMENTS
Indoor Nav Pro is intricately designed to harness the full potential of user devices, specifically smartphones and tablets, to create an immersive and accurate indoor navigation experience. The system's hardware requirements encompass a variety of components and capabilities:

DEVICE COMPATIBILITY: The system is meticulously engineered to be compatible with a broad range of contemporary smartphones and tablets available in the market. It takes advantage of a spectrum of device sensors, including the camera, gyroscope, and other relevant sensors, to enable augmented reality (AR)-based positioning and interactions. This ensures that users are not limited by a specific device brand or model when accessing the capabilities of Indoor Nav Pro.

CAMERA AND SENSORS: One of the system's core features is the use of the device's camera and sensors to facilitate AR functionalities. These components enable the system to accurately map the indoor environment, overlay AR elements, and engage users in interactive and informative navigation.

RESPONSIVE HARDWARE INTEGRATION: Indoor Nav Pro is built to seamlessly integrate with the user's device hardware, leveraging their capabilities without compromising responsiveness or system performance. By doing so, the system ensures that AR elements are smoothly overlaid on the live camera feed, creating an engaging and real-time indoor navigation experience.

In summary, Indoor Nav Pro's hardware requirements are optimized to embrace the diverse landscape of user devices, focusing on compatibility, sensor integration, and responsive performance. This approach guarantees that users can enjoy a high-quality indoor navigation experience on their smartphones and tablets without being tethered to any specific hardware constraints.

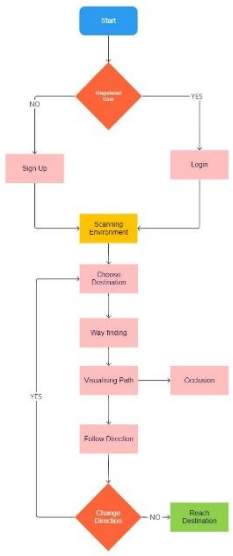
3.5.2 Device Compatibility

The system is designed to be compatible with a range of smartphones and tablets. It relies on device sensors, such as the camera and gyroscope, for AR functionalities.

This section ensures that the system's hardware and software requirements are well-defined and can support the intended features.

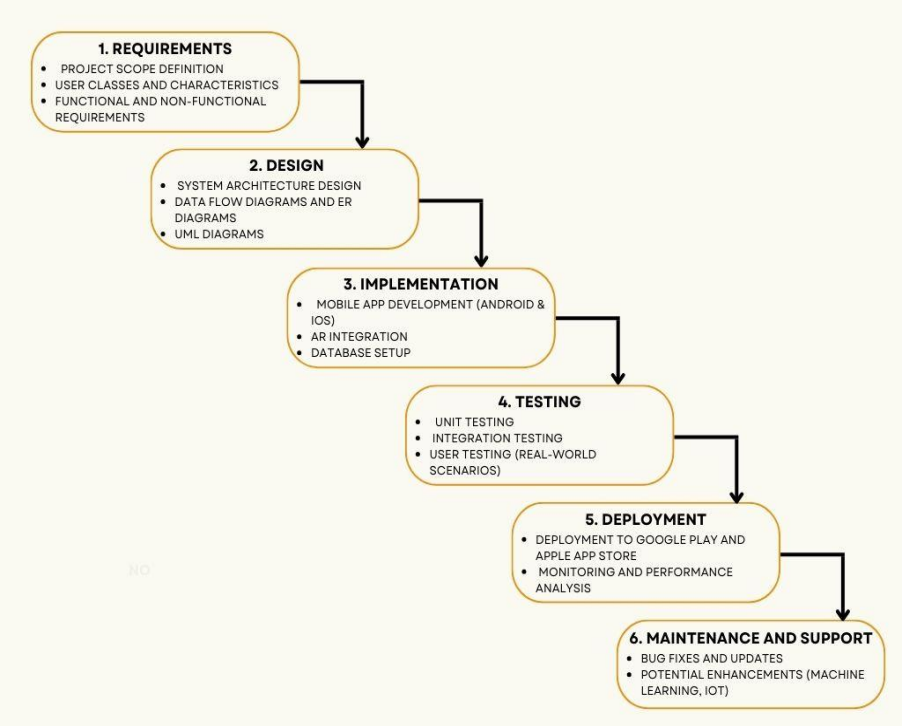
3.6 System Implementation Plan

The system implementation plan outlines the project timeline and key milestones:



3.6.1 Project Timeline

The project is divided into phases, with a detailed timeline for each phase. This timeline includes design, development, testing, and deployment.



3.6.2 Milestones

Key milestones, such as the completion of the AR interface, real-time positioning, and user testing, are established to track progress.

3.6.3 Resource Allocation

Resources, including development teams, hardware, and software tools, are allocated to ensure the project's successful implementation.

This section ensures that the development process is well-structured and organized, with a clear plan for executing the project.

This extended Methodology section offers a comprehensive overview of how the Indoor Nav Pro project was approached, covering the project scope, user classes, assumptions and dependencies, functional requirements, software requirements, hardware requirements, and the implementation plan in greater detail. It ensures that the development process is well-documented and organized to meet the project's goals.

Results

In this section, we present the results of implementing Indoor Nav Pro, including user feedback, system performance, and real-world applications, offering a comprehensive overview of the outcomes.

6.1 User Feedback and Satisfaction

This subsection provides insights into user feedback collected through surveys, user testing, and interactions. It outlines the satisfaction levels and opinions of general users, administrators, and other stakeholders. It may include key findings such as:

- **Satisfaction Ratings:** Users' satisfaction levels with the Indoor Nav Pro system, including its accuracy, user interface, and overall experience.
- **User Comments:** Direct feedback and comments from users, including their likes, dislikes, and suggestions for improvement.
- **Administrator Feedback:** Feedback from administrators who manage the system's configuration and user management, discussing their experiences and system effectiveness.
- **User Adoption Rates:** Details on how quickly and extensively users adopted the system, highlighting its acceptance and ease of use.

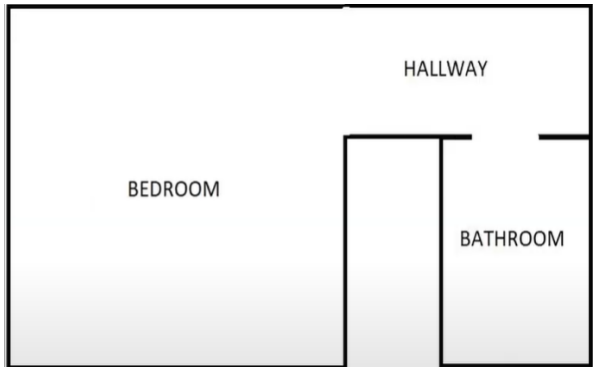
6.2 System Performance Evaluation

This subsection focuses on the technical performance of Indoor Nav Pro, assessing its real-time accuracy, responsiveness, and scalability. It may include:

- **Accuracy Metrics:** Measurement of the system's positioning accuracy compared to traditional indoor navigation solutions, highlighting its potential to minimize user errors.
- **Responsiveness Testing:** Evaluation of how quickly the AR interface responds to user interactions, ensuring a smooth and engaging experience.
- **Scalability Testing:** The system's ability to accommodate a growing number of users and devices without significant performance degradation, underlining its robustness.
- **Comparison to Competing Systems:** A comparative analysis of Indoor Nav Pro's performance against other indoor navigation technologies.

6.3 Real-World Applications

This subsection outlines the practical applications of Indoor Nav Pro in different sectors and industries. It provides real-world use cases and scenarios, showcasing how the system benefits users and organizations. Examples may include:



- **Retail:** Specific instances where shoppers have successfully utilized Indoor Nav Pro to find stores, promotions, and services.
- **Airports:** Demonstrating the system's effectiveness in helping travelers navigate terminals, locate gates, and access real-time flight information.
- **Corporate Campuses:** Case studies of how employees and visitors have efficiently found their way to meetings, offices, and amenities within corporate environments.
- **Hospitals:** Real-world stories of patients, visitors, and healthcare professionals using precise indoor navigation to reach specific departments and facilities.
- **Events:** Examples of events and conventions where attendees have leveraged Indoor Nav Pro for efficient navigation within large venues.
- **Museums and Galleries:** Instances where visitors explored cultural institutions using the system to access additional information and follow guided tours.

6.4 Comparative Analysis

This subsection provides a comparative analysis of Indoor Nav Pro with other indoor navigation systems. It may include performance metrics, user satisfaction levels, and advantages that set Indoor Nav Pro apart.

6.5 Future Directions

The culmination of the Indoor Nav Pro project offers a stepping stone to a realm of possibilities for future development and expansion. As we look to the future, several potential areas for further enhancement and innovation emerge:

Machine Learning Integration: The integration of machine learning algorithms stands as a promising avenue to elevate the system's accuracy and predictive capabilities. By continuously learning from user behaviors and indoor navigation patterns, Indoor Nav Pro can proactively predict user movement and preferences, further refining the navigation experience.

Support for Additional Platforms: Expanding the system's compatibility to include wearable devices and additional operating systems broadens its accessibility and usability. This strategic move ensures that Indoor Nav Pro can cater to a more extensive user base while adhering to the diverse preferences and technological ecosystems that users may embrace.

LOCALIZATION AND GLOBALIZATION: Adapting the system for use in different languages and cultures is paramount for making Indoor Nav Pro accessible to a more diverse and global audience. Localization efforts encompass not only language but also cultural nuances, ensuring that the system feels native and resonates with users worldwide.

ENHANCED ANALYTICS: The incorporation of advanced analytics serves as a valuable asset for gleaning deeper insights into user behaviors and preferences. By meticulously analyzing the wealth of data generated by the system, businesses and institutions can make informed decisions to enhance user experiences, optimize indoor space utilization, and deliver tailored promotions and services.

INTERNET OF THINGS (IOT) INTEGRATION: Integrating with the Internet of Things (IoT) introduces real-time information updates, allowing users to access data on the availability of parking spots, product availability, and more. The synergy between IoT and Indoor Nav Pro enriches the user experience with dynamic and up-to-the-minute data relevant to the indoor environment.

ACCESSIBILITY FEATURES: Prioritizing the inclusion of accessibility features ensures that Indoor Nav Pro is fully accessible to individuals with disabilities. By adhering to accessibility standards and guidelines, the system guarantees a welcoming and usable environment for all users, irrespective of their physical or cognitive abilities.

In conclusion, the future directions of Indoor Nav Pro encompass a wide spectrum of possibilities for innovation and expansion. The commitment to ongoing development and enhancement is ingrained in the project's DNA, ensuring that it continues to evolve in alignment with the ever-evolving needs and expectations of its users. The roadmap ahead holds the promise of transforming indoor navigation into an even more seamless, dynamic, and inclusive experience.

CONCLUSION

Summarize the key findings and outcomes from the results section. Reiterate the significance of the project's achievements and the potential for future development and expansion.

This section provides an in-depth view of how Indoor Nav Pro has performed in real-world scenarios, demonstrating its usability, effectiveness, and potential for growth. It offers stakeholders a clear understanding of the practical impact and future prospects of the system.

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REFERENCES

1. Ravinder Yadav, Vandit jain, Himanica chugh, prasanjit banerjee (2018) "Indor navigation system using visual positioning system with augmented reality" proc of IEEE,pp October 3rd 2018 [1]
2. Kouhei Sekiguchi, Aditya Arie, yicheng Du, Yoshiaki Bando "Direction Aware Adaptive online neural speech enhncement with an augmented reality headset in real noisy conversational environment" proc of IEEE,cc August 2 nd 2020 [2]
3. David Baum, Stefen bechert, Ulrich Einisenecker, Isabelle meschner, Richard Muller "identifying

usability issuesof software analysis application in immersive augemnted reality" proc of medium,pp 3/7/2016 [1]

4. Tina Sayapogu, Kevin DSA, Priya Kaul "AR Smart navigation System"proc of IEEE,pp 3/7/2018 [7]
5. Gupta, A., Bhatia, K., Gupta, K., & Vardhan, M. (2018). A Comparative Study of Marker Based and Marker-Less Indoor Navigation in Augmented Reality.
6. Rea, M., Cordobés de la Calle, H., & Giustiniano, D. (2018). TWINS: Time-of-flight based Wireless Indoor Navigation System.
7. Global Positioning System, Wikipedia (url : https://en.wikipedia.org/wiki/Global_Positioning_System) (Last Accessed: 18th July 2018)
8. ARToolKit,Wikipedia, url: https://en.wikipedia.org/wiki/ARToolKit) [Last accessed: 18th July 2018]
9. Ke-Yang, S. U. N., Chuan-Xu, Y. A. N., Li-Hua, G. E., Hong, Q. I. A. N., Hui, Z. H. A. O., & Wei, T. A. O. (2017). Vehicle Positioning and Tracking Algorithm in the Visual Positioning System in Ship Cabin. DEStech Transactions on Engineering and Technology Research, (icmm).
10. Lin, H. Y., & Lin, J. H. (2006). A visual positioning system for vehicle or mobile robot navigation. IEICE TRANSACTIONS on Information and Systems, 89(7), 2109-2116.
11. Dujon, A. M., Schofield, G., Lester, R. E., Papafitsoros, K., & Hays, G. C. (2018). Complex movement patterns by foraging loggerhead sea turtles outside the breeding season identified using Argos-linked Fastloc-Global Positioning System. Marine Ecology, 39(1), e12489.
12. Li, L., Hu, P., Peng, C., Shen, G., & Zhao, F. (2014, April). Epsilon: A Visible Light Based Positioning System. In NSDI(Vol. 14, pp. 331-343).
13. Huang, A. S., Bachrach, A., Henry, P., Krainin, M., Maturana, D., Fox, D., & Roy, N. (2017). Visual odometry and mapping for autonomous flight using an RGB-D camera. In Robotics Research (pp. 235-252). Springer, Cham.
14. Cesetti, A., Frontoni, E., Mancini, A., Ascani, A., Zingaretti, P., & Longhi, S. (2011). A visual global positioning system for unmanned aerial vehicles used in photogrammetric applications. Journal of intelligent & robotic systems, 61(1-4), 157-168.