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Smart Local Navigation System using AI and Machine Learning Techniques

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***Abstract*— Nowadays structures of hospitals, colleges, railway stations, malls, other privately and government owned enterprises are getting complex due to this people get confused. People who are visiting these infrastructures for the first time and are not aware of these complex structures get confused and stuck. The existing approaches don't provide exact information indoors using GPS, visual Simultaneous Localization and Mapping (SLAM) and inertial sensors. Our approach is to minimize the complexity of the indoor infrastructures and their surroundings and deliver a fast and user-friendly path using AIML our approach suggests shortest and accurate path. As the user uses the system ML model learns the user behaviour and improves its navigation accuracy. In our approach user can enter his current location and destination then our system gives navigation instructions using 2D and 3D view using Augmented Reality (AR), therefore it is easy to understand the directions given through AR. AI can detect the crowds and obstacles therefore it reduces congestion, time and increases safety thus providing an intelligent and reliable solution to the user. This approach is useful to initiate smart cities and a digital nation.**

***Keywords*— Indoor Navigation, Augmented Reality, SLAM, Localization, Path-Planning, Sensor Fusion, Crowd Analytics, Context Awareness.**

I. INTRODUCTION

The Structure of Modern cities involve complex, dense and multi-functional indoor areas. Railway stations, malls, hospitals, universities and airports are designed with multiple floors and contain multiple entries and exits. For outdoor navigation GPS works accurately as we enter indoor GPS doesn't provide accurate information and static maps, signboards are not very useful at every situation. To resolve this problem, we recommend Smart Local Navigation System using AIML, this approach aims to reduce complexity, confusion and without repeatedly asking anyone for the directions the individual can reach their desired destination. Our system is a mobile based solution which is specially designed for indoor environments this system doesn't depend on GPS but finds real time location using sensors, camera and AI algorithms it uses the concept of SLAM in which the system designs the digital map of building and track the user position. In simple words, the system itself understands what is the current location of the user after this the user selects its destination like platform number, doctor's room. Shop and exit, system calculates the shortest and safest path and provide the step-by-step path to user. AI can analyse crowds for example if the area is crowded the system won't suggest that path, it will suggest an alternate path.

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Machine learning learns the behaviour from the user which results in accuracy in path finding. It can be very helpful for elderly people, disabled user and first-time visitors. This project tries to make indoor navigation simple, smart, and stress-free. Nowadays buildings are not only large but also complex. Multiple floors, confusing layouts, connecting blocks, long corridors are very common for outdoors tools like google map are very helpful as we enter inside the building, GPS stops working. To solve this real-life problem, we develop an idea of Smart Local System Using Artificial Intelligence and Machine Learning. Voice based Guidance is one of the important and helpful user-centric features which allows efficient and accessible navigation, thus our proposed system is very easy for the user to use. In traditional approaches we have to continuously look into the screen of floor map this results lot of inconvenience in crowded areas. The proposed Solution provides eye free and hand free navigation guidance. Users can select multiple languages in Voice based Guidance feature. The idea behind this approach is to develop the Smart and Intelligent Local Navigation Framework which can improve the user experience, reduce travel time and easily accessible local facilities. It can also enhance the real time responsiveness and safety. In this approach AR is very helpful for Smart Local Navigation System because it shows the digital direction over the real-world view, when users open their camera, the system shows the surroundings to their screen and overlays the arrows, direction indicators and path lines so the user doesn't need to think about the map, user can easily reach to their destination by following those arrows. This approach reduces confusion, wrong turns and makes navigation process fast and user-friendly.

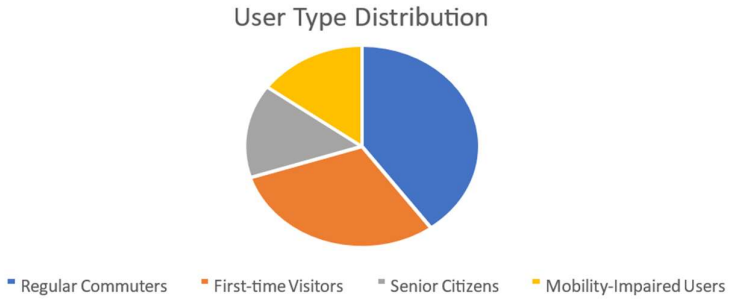

Fig 1. Parameter Comparison chart

II. Literature Review

A. Smart Local Navigation System

In present time, the need of navigation system is one of the essential part of our daily life and most of the people uses GPS which work very effective for the outdoor environment. [1] It was clearly mentioned that GPS doesn't work accurately for indoor environments such as campuses, malls, hospitals, airports, etc. [3][4] There's a need of smart Local navigation system which can learn the local environment and works well in the for the indoors. Due to this the researchers have concluded that using AR, AI and ML based navigation system which can provide the accurate routes and context-aware guidance to the user.

B. Indoor navigation and Localization techniques

The major challenge in indoor navigation is to know the accurate localization, means the exact location of the user. [3] Wi-Fi fingerprinting, Bluetooth, RFID, magnetic sensors and inertial sensors are used for the indoor navigation. The comparison of different indoor positioning techniques is mentioned below.

Table I: Comparison of Positioning Techniques

Positioning Techniques	Range
Wi-fi	<40m
GPS	>40m
BLE beacon	<20m
Magnetic field	<6m
Visible markers	Unreliable

[5] These methods can be more accurate but the major drawback is the infrastructure dependency. Extra hardware is needed to be installed which results in high cost and extra maintenance, thus mobile camera and sensors are used to give an infrastructure-free solution.

C. Augmented Reality (AR) Based Navigation System

Augmented reality-based navigation system provides virtual arrows, labels and direction over the real-world results in better understanding for the user. [2][3] AR is being used to guide the users to reach buildings and rooms. AR navigation is more intuitive and user-friendly in the comparison of 2D maps, there is no need to look map again and again for the direction because directions are aligned with the real environment. Most of the AR based navigation system are static and do not have capability of intelligent decision making.

Fig 2 Augmented Reality (AR) Based Navigation System

D. Vision-Based aur Marker-Based Navigation Approaches

[1] [5] Vision-based navigation system uses camera input, QR codes and visual markers for the indoor navigation and its advantages are:-

- Low Cost
- Easy deployment
- Suitable for the indoor navigation

[1] These systems require large image databases that cause delay in processing, thus real-time navigation system require intelligent decision making with the help of AI and ML techniques.

E. Artificial Intelligence (AI) in Navigation Systems

[3] The user is only able to see direction with the help of AR but internally AI is used for path planning and optimization. Ant Colony Optimization and path planning algorithms are used to find the most shortest and best route for the user. [5] AI navigation makes the system smart but in existed system the use of AI is very limited and rule based thus not capable to learn from the user behaviour.

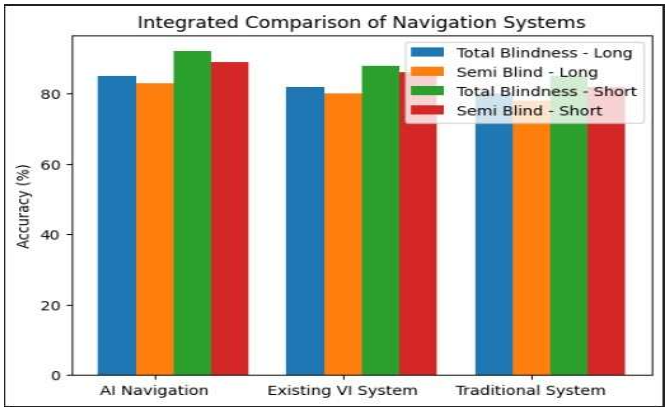

Fig 3. Integrated Comparison of Navigation System

F. Machine Learning (ML) for Smart Navigation

Integration of Machine Learning with navigation system makes it more adaptive and personalized. [2] Deep learning techniques are used to recognize the internal structure of the building; object identification this helps AR navigation to be more accurate. [5] ML models are designed in such a way that they can learn routes from the past user experiences which helps in improving the accuracy in the navigation system and ultimately it results in betterment of the system with the time.

G. Research Gap

AR improves visual navigation while AI and ML enhance decision making and adaptability. The existing systems doesn't able to combine these three technologies effectively although individually these technologies are very powerful, but no effective united framework is built. Therefore, it shows a clear research gap in the development of Smart Local Navigation system with the combination of AR, AI and ML, which leads to the development of smart campuses, hospitals, malls, airport and smart cities.

III. PROPOSED METHODOLOGY

The proposed approached provides smart indoor navigation for crowded places like railway stations, malls, hospitals, and campuses. It integrates Artificial Intelligence for recommendation, Machine Learning for prediction, and Augmented Reality (AR) for visualization to guide users from their location in the simplest and efficient way.

Step 1: Indoor Environment Mapping

- The indoor space (station/mall/hospital) is digitally mapped using Floor plans, POIs (Platforms, exits, toilets, lifts, counters), Corridors, stairs, elevators.
- A semantic indoor map is created where every location has meaning (example: Platform 3, Lift A).

Step 2: User Detection & Classification

- When a user opens the application then, System detects location using Wi-Fi, Bluetooth beacons, IMU sensors.

Step 3: Real-Time Data Integration

- System fetches live data such as Platform changes, Train delays, Entry/exit congestion, Lift/escalator availability.
- Real-time updates ensure accuracy and reliability.

Step 4: Intelligent Route Generation (AI + ML)

- Machine Learning algorithms calculate Ant Colony Optimization, path planning, least crowded route, Accessibility-friendly path.

Step 5: Navigation & Multi-Sensory Guidance

- Navigation is provided using 2D maps, 3D AR-based path overlays, Visual arrows, Audio instructions.

Step 6: Continuous Tracking & Re-routing

- User position is continuously tracked. If the user deviates or conditions change, System automatically recalculates the route and Updated guidance is shown in real time.

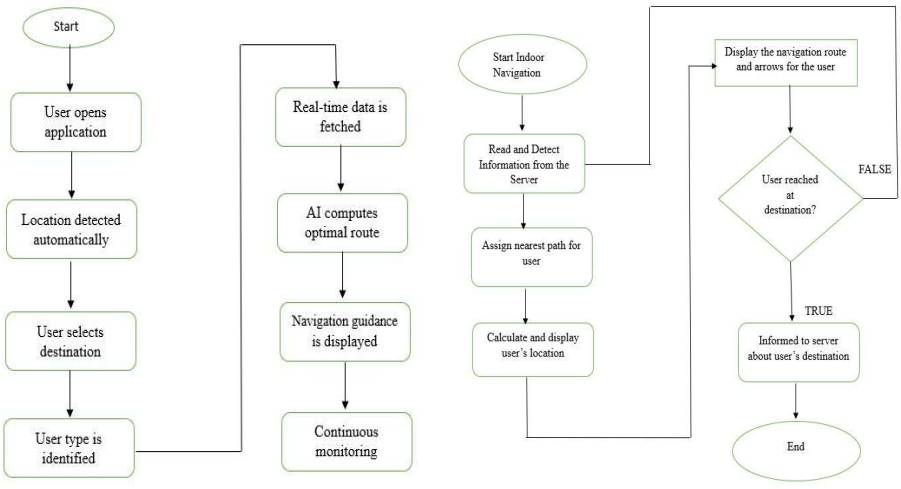

Fig 4. System work flow diagram

IV. RESULT ANALYSIS

The idea behind of this system not to provide only a navigation system but to provide simplicity, smart, and a stress-free environment to the user who visits complex places like railway stations, malls, hospitals, and

campuses. When the user opens the application, the system automatically detects his location, and on the basis of real-time data, it will provide an optimal and safest route. This can be very efficient to save time, reduce confusion, and is not required to ask anyone. It is observed from studies and practical observations that using these intelligent systems can reduce the time by 35–45% to reach the destination and minimize confusion by 50–60%. The impact of this project is not limited to only users but would be very helpful to management and authorities. AI-based analysis provides clear data on crowd density and peak hours; this reduces congestion by 25–30%, and response time will be improved during emergency time. With the help of personalized routing and continuous monitoring, the improved navigation accuracy rate is around 90%, which is far better than traditional signage systems.

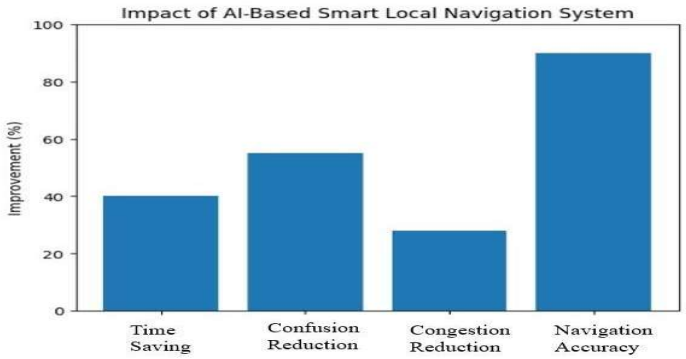

Fig 5

REFERENCES

[1] P. Pande, G. Gagal, R. Pagdhune, K. Gangakhedkar, and N. Kokate, "Augmented Reality Based Navigation Interface System," Apr. 2024.

[2] A. Tamboli, A. Mitta, D. Jamdade, L. Pujari, K. Chakote, and Y. R. Kalshetty, "Navigation System for Railway Platform," May 2025.

[3] V. Dosaya, S. Tak S. V., V. K. P., and A. Beniwal, "A Low Cost Augmented Reality System for Wide Area Indoor Navigation" 2020.

[4] F. Curtsson, "Designing an AR Navigation Interface for Large Indoor Spaces," 2021.

[5] A. Sharma, R. Verma, and S. Gupta, "Indoor Navigation Using Augmented Reality," 2023.

[6] GG., "Guiding People in Complex Indoor Environments Using AR," Dec. 2018.

[7] M. K. Sharma, S. Chachaundiya, and V. Sharma, "Augmented Reality Navigation,", 2020.

[8] V. Jyoshika Reddy, V. Tejaswini, P. Pallavi, S. Keerthi, and P. Feridoz Khan, "Enhancing Navigation for Railway Station Facilities and Locations," Apr. 2025.

[9] OJ., Y. Kim, and J.K, "IoT for Smart Railway: Feasibility and Applications," Apr. 2018.

[10] D.H., V. Behzadan and A. Munir "Security, Privacy Issues in Intelligent Transportation Systems: Classification and Challenges," Apr. 2019.

[11] I.A.C, A.K, , A. S. Yuksel, and T. Yigit "Mobile Indoor Navigation System for iOS Platform Using AR," 2018.

[12] D. R. Rajesh, D. R. Bolla, S.S, M. Abhiram, and B. Mithun Kumar, "An Innovative Smart Railway Platform Assist in Domestic Railway Stations," May 2018.

[13] A.A, R. Abdu Kayumbek, H. Jeon, and R. Oh, "Real-Time Railway Monitoring System Based on Sensor Stream Data TrackingNov. 2020.