

## Navigate U: A Smart Navigation System for Disabled People Based on ML

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<p><b>Type:</b> Article <b>Received:</b> 8 February 2026 <b>Revised:</b> 9 March 2026 <b>Accepted:</b> 10 April 2026 <b>Published:</b> 21 May 2026</p>	<p>Accessibility remains a major challenge for individuals with disabilities while navigating public spaces, mainly due to the lack of reliable and up-to-date information about accessible infrastructure. In this work, we present Navigate, a web-based accessible location discovery system developed using React.js, Firebase Firestore, Google Maps Platform, and Geolocation APIs. The system helps users identify nearby places that provide essential accessibility features such as ramps, lifts, wheelchair access, and accessible toilets. The application displays these locations on an interactive map and allows users to filter them based on their specific needs. Users can either use their current location or manually enter a place name, which helps address inaccuracies sometimes observed in network-based location detection. In addition, a voice-based filtering feature is included to make interaction easier for users with limited mobility. All location data is stored in Firebase Firestore, enabling Realtime updates and allowing users to contribute new accessibility information. A lightweight recommendation approach is also implemented to suggest the most suitable location by considering both distance and available accessibility features. The system was tested in real-world scenarios and was able to effectively assist users in identifying accessible places. Overall, the results indicate that web-based technologies can be used to build practical and user-friendly solutions for inclusive navigation.</p>
	<p><b>Keywords:</b> Accessible Navigation; Location-Based Services; React.js; Firebase Firestore; Leaflet Maps.</p>

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## Introduction

Navigation and accessibility have become important research areas due to the growing need to support individuals with mobility challenges, including physically disabled, visually impaired, and elderly users. Moving safely in public spaces is still difficult for many people because information about accessible infrastructure is often incomplete or not easily available. As a result, there has been continuous effort to develop systems that improve independence, safety, and usability in both indoor and outdoor environments. Early work by Thangadurai and Kartheeka [1] focused on indoor navigation systems using sensor-based control mechanisms. Their approach showed that assistive technologies can help users move safely inside buildings and reduce dependence on caregivers. However, such systems were mainly limited to controlled indoor environments. With the advancement of digital mapping technologies, researchers started focusing on accessibility in web-based maps. Biggs, Coughlan, and Walker [2] evaluated existing mapping platforms using Web Content Accessibility Guidelines (WCAG) and found that many tools still lack essential features such as screen reader support and simple navigation interfaces. This highlights the need for more inclusive and user-friendly map designs.

Further developments have explored the use of advanced technologies for navigation assistance. Casanova, Guffanti, and Hidalgo [3] reviewed systems that use artificial intelligence, computer vision, and wearable devices. Their findings suggest that combining multiple feedback methods such as audio, haptic, and visual cues can improve navigation accuracy and user confidence. Augmented Reality (AR) has also been introduced as a modern approach to navigation. Kim and Atiq [4] proposed the ARbility Map, which provides real-time visual guidance and hazard detection. While this improves user experience, such systems often require advanced hardware, which may limit their practical use. Research on web-based mapping has also emphasized inclusive design. Manu [5] highlighted the importance of simplifying map interfaces and providing alternative representations such as text descriptions and adaptive layouts. This makes digital maps more accessible to users with different needs. Urban environments continue to pose challenges for accessibility. Allahbakhshi and Ardüser [6] pointed out issues such as uneven pathways and lack of proper infrastructure. Their work shows that spatial data and mapping systems can play a key role in improving accessibility in cities.

Other studies have focused on optimizing navigation based on user preferences. Alharbi et al. [7] proposed a model that considers accessibility constraints along with environmental factors to suggest better routes. This approach improves user satisfaction compared to traditional shortest-path navigation. Physical infrastructure also remains a major concern. Santoso [8] discussed real-world barriers such as poorly designed ramps and inaccessible facilities, highlighting the need for better planning and implementation of accessibility standards. More interactive systems have also been explored. Rajakumaran et al. [9] developed an eye-tracking-based navigation system, showing how human-computer interaction can be used for assistive navigation. Similarly, Supekar and Patil [10] proposed a portable system combining image processing and audio guidance to help users detect obstacles and navigate effectively. Despite these advancements, most existing systems focus on specific aspects of navigation and often lack a simple, cost-effective, and integrated solution. To address this gap, the present work proposes a web-based accessible navigation system that combines map-based visualization, accessibility filtering, and lightweight recommendation techniques to support users in real-world environments.

## Literature Review

Assistive navigation technologies have received increasing attention in recent years as researchers aim to improve mobility and independence for individuals with disabilities. Different approaches have been explored, ranging from sensor-based systems to web mapping platforms and advanced technologies such as artificial intelligence and augmented reality. While these systems have shown promising results, many challenges still remain in terms of usability, cost, and real-world applicability. Early work by Thangadurai and Kartheeka [1] focused on indoor navigation using sensor-based control systems. Their approach demonstrated that automated assistance can help users move safely within buildings and reduce dependence on caregivers. However, the system was limited to indoor environments and did not address outdoor navigation or real-time environmental changes.

In the area of digital mapping, Biggs, Coughlan, and Walker [2] evaluated existing map platforms using WCAG guidelines. Their findings revealed that many platforms still lack basic accessibility features, such as proper screen reader support and simple navigation interfaces. This suggests that accessibility is often not considered during the initial design of mapping tools.

Casanova, Guffanti, and Hidalgo [3] provided a broader view by reviewing modern navigation technologies for visually impaired users. Their work covered artificial intelligence, computer vision, and wearable systems. One important observation from their study is that combining multiple feedback methods—such as audio, vibration, and visual cues—can significantly improve user confidence. At the same time, the cost and complexity of these systems remain a concern.

Augmented reality has emerged as an interactive solution for assistive navigation. Kim and Atiq [4] developed the ARbility Map, which supports real-time visual navigation and hazard detection, improving user experience; however, its dependence on advanced hardware limits

practical adoption in low-resource environments. Manu [5] emphasized accessibility in web-based mapping and highlighted the importance of inclusive design principles such as simplified layouts, alternative text descriptions, and customizable interfaces. Allahbakhshi and Arduser [6] explored urban accessibility challenges, identifying issues including uneven pathways and inadequate infrastructure that continue to affect usability. To enhance route planning, Alharbi et al. [7] proposed a model incorporating user preferences and accessibility constraints to improve comfort and safety. Santoso [8] further examined physical barriers such as narrow pathways and poorly designed ramps. Additionally, Rajakumaran et al. [9] and Supekar and Patil [10] introduced interactive systems using eye tracking, image processing, and audio guidance, highlighting the need for integrated and affordable navigation solutions.

## Proposed System Design

In this work, we developed a web-based accessible navigation system called NavigateU to assist individuals with mobility challenges, including physically disabled and elderly users. The system focuses on combining digital maps, real-time location tracking, accessibility filtering, and a simple recommendation mechanism to help users make better navigation decisions. Unlike many existing solutions that depend on specialized hardware such as sensors or wearable devices, our approach uses widely available web technologies. This makes the system more affordable, easier to use, and scalable for realworld deployment. While designing the system, we considered several limitations observed in earlier studies, such as the lack of accessibility-based filtering, limited personalization, and complex user interfaces. To address these issues, we integrated filtering options, voice interaction, and lightweight navigation support into a single platform.

## System Architecture

The system is divided into four main modules:

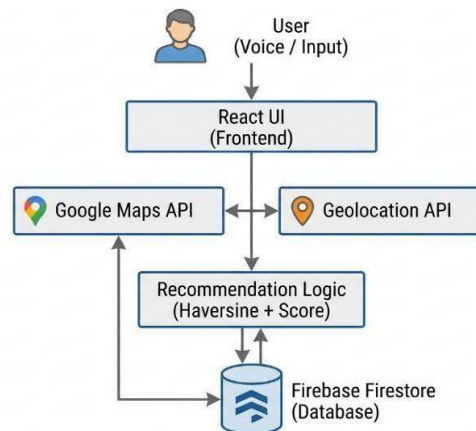
### 1) User Interface Module

The user interface is built using React.js and is designed to be simple and easy to use. It allows users to interact with the system through both manual input and voice commands.

Key features include:

- Voice-based interaction using the Web Speech API
- Selection of accessibility filters (ramp, lift, etc.)
- Interactive map visualization
- Manual location input using place names

The interface is kept minimal to ensure that users can operate it without confusion.



*Fig 1: System Architecture of NavigateU*

### 2) Navigation and Mapping Module

This module uses the Google Maps Platform to display maps and handle location-based operations. It shows accessible locations using markers and allows users to select them directly from the map.

It also tracks the user's current position in real time using the Geolocation API.

### 3) Location and Distance Calculation Module

To find nearby places, the system calculates the distance between the user and stored locations using the Haversine formula. This helps in identifying the closest and most relevant accessible places.

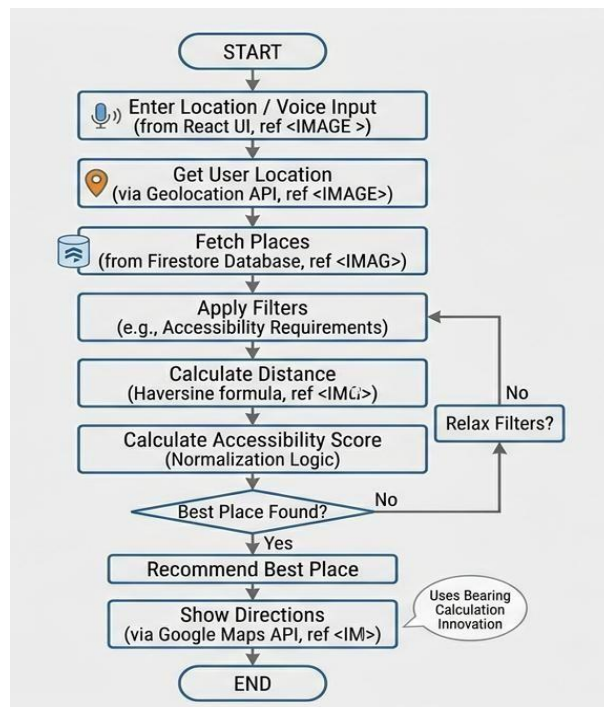
### 4) Accessibility Recommendation Module

A simple scoring-based method is used to recommend suitable locations. Each place is evaluated based on the availability of features such as ramps, lifts, wheelchair access, and accessible toilets.

A normalized score between 0 and 1 is calculated to represent how accessible a location is. The final recommendation considers both distance and this accessibility score, rather than just proximity.

#### Working Methodology

- The system works in the following steps:
- The user enters a location manually or through voice input
- The system detects the current location using the
- Geolocation API
- Nearby accessible places are displayed on the map
- The user applies filters based on required features
- Distance is calculated using the Haversine formula
- Accessibility scores are computed for each location
- The most suitable location is identified
- Navigation instructions such as “Go Straight,”
- “Turn Left,” and “Turn Right” are displayed in real time



**Fig 2: Workflow of Accessible Navigation System**

#### Technology Components

The system is built using the following technologies:

Frontend: React.js, Database: Firebase Firestore, Maps: Google Maps Platform, Location Tracking: Browser Geolocation API, Voice Interaction: Web Speech API.

### System Advantages

The proposed system offers several practical advantages:

1. Allows users to filter locations based on accessibility needs
2. Provides real-time navigation using lightweight logic
3. Supports voice-based interaction for ease of use
4. Recommends locations based on both distance and accessibility
5. Uses cost-effective and scalable web technologies

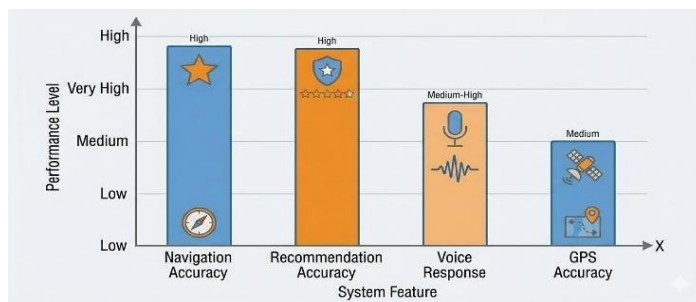
### Objective of the Study

The main objective of this work is to design and develop a web-based accessible navigation system that can support individuals with mobility challenges, including elderly users and physically disabled individuals. The focus is on improving ease of movement, usability, and independent decision-making by providing accessibility-aware location information along with simple navigation support. To achieve this, the study aims to meet the following objectives:

1. Develop a web-based platform that allows users to find nearby places equipped with accessibility features such as ramps, lifts, wheelchair access, and accessible toilets.
2. Design a simple and intuitive user interface using React.js so that users can interact with the system without difficulty.
3. Provide filtering options based on accessibility features to help users choose locations according to their specific needs.
4. Enable real-time location detection using the browser-based Geolocation API to identify the user’s current position.
5. Implement a lightweight navigation method that provides clear directions such as “Go Straight,” “Turn Left,” and “Turn Right”.

### Proposed Output and Discussion

The proposed accessibility navigation system, NavigateU, was evaluated to analyze its effectiveness in assisting users in locating and navigating to accessible places. The evaluation was conducted under real-world outdoor conditions using web-based interaction, real-time location tracking, and accessibility filtering mechanisms.



**Fig. 3: System Performance Metrics of NavigateU**

### Navigation Accuracy

The system demonstrated reliable real-time navigation performance during testing. This was achieved through continuous user location tracking and dynamic direction estimation. By integrating the Google Maps Platform with the browser-based Geolocation API, the system was able to detect the user's position with acceptable accuracy under outdoor conditions. Navigation instructions such as “Go Straight,” “Turn Left,” and “Turn Right” were generated using bearing angle calculations. These instructions were updated dynamically as the user moved, enabling smooth and responsive navigation. Additionally, the distance between the user and available locations was computed using the Haversine Formula, which improved the precision of both nearest location detection and navigation guidance. Accessibility-Based Recommendation Performance Unlike conventional navigation systems that prioritize only distance, the proposed system focuses on recommending the most suitable location based on accessibility features. Each location is evaluated using a weighted scoring mechanism that considers key accessibility attributes such as ramps, lifts, toilets, and wheelchair access. Experimental observations showed that the system often selected locations with higher accessibility scores even when they were slightly farther away. This demonstrates that the proposed approach enhances decision-making by prioritizing usability over mere proximity.

### User Interface and Accessibility Evaluation

The user interface, developed using React.js, provides an intuitive and user-friendly experience. The design ensures that users can access important features quickly and efficiently. Key functionalities include: Voice-based interaction Map-based visualization using markers Easy

accessibility filter selection Real-time display of navigation directions and AI-based accessibility scores User testing indicated that the interface is simple to use and requires minimal effort for interaction. The inclusion of voice-based commands further enhances usability by reducing dependence on manual input.

### *Voice Interaction Effectiveness*

The voice interaction feature, implemented using the Web Speech API, significantly improved system usability. Users were able to Apply accessibility filters through voice commands Set location inputs verbally This feature reduced interaction effort and made the system more accessible, especially for individuals with mobility challenges or limited manual interaction capabilities. Comparative Analysis with Existing Systems Compared to traditional navigation systems, the proposed solution offers several accessibility-focused enhancements:

Filtering of locations based on accessibility features Recommendation based on accessibility rather than just distance Voice-enabled interaction Real-time navigation update Most existing systems primarily focus on shortest path routing. In contrast, NavigateU emphasizes accessibility and user convenience, making it more suitable for individuals with special needs.

### **Discussion**

The overall evaluation indicates that integrating modern web technologies with real-time tracking and accessibility-aware logic significantly improves navigation support for users with mobility challenges. The system effectively addresses limitations of traditional navigation tools, particularly: Lack of accessibility filtering Absence of personalized recommendations However, certain limitations were observed: Dependence on stable internet connectivity Variability in GPS accuracy, especially on non-mobile devices Reliance on manually entered accessibility data Future improvements may include: Development of a mobile application to enhance GPS accuracy Integration of advanced machine learning models for improved recommendation accuracy Incorporation of real-time user feedback to maintain up-to-date accessibility data Overall, the system contributes to improving accessibility awareness and provides a practical solution for locating and navigating to accessible places efficiently. The proposed accessibility navigation system (NavigateU) offers several improvements over traditional navigation tools by focusing on accessibility, real-time support, and ease of use. By combining these features into a single web-based platform, the system aims to provide a more practical and user-friendly solution for individuals with mobility challenges. One of the major strengths of the system is its ability to help users find locations based on specific accessibility features such as ramps, lifts, wheelchair access, and accessible toilets. With the addition of filtering options and voice-based interaction, users can easily search for places that match their needs. This makes the system more inclusive compared to conventional navigation tools, which often do not focus on accessibility requirements. The system provides real-time navigation by continuously tracking the user's location and updating directions accordingly.

### **Future Scope**

The proposed system provides a good starting point for further improvements and feature expansion. There are several directions in which the system can be enhanced in the future. One possible improvement is the integration of advanced machine learning techniques. By using methods such as clustering or user behavior analysis, the system can provide more personalized and accurate recommendations. Developing a mobile application version of the system can also improve performance. Using frameworks like React Native would allow better GPS accuracy and a smoother user experience. Another useful enhancement would be the inclusion of realtime crowd-sourced updates. Users could share information about accessibility conditions, such as broken ramps, nonfunctional lifts, or temporary obstacles. This would help keep the data more accurate and up to date. Offline navigation support is another important area for improvement. Adding offline map capabilities would allow the system to function even in areas with limited or no internet connectivity. The voice assistant can also be made more advanced by integrating natural language processing techniques. This would enable users to give more complex commands, such as finding specific types of accessible places or requesting navigation assistance in a more natural way. Introducing user authentication features could further improve personalization. Users would be able to save preferences, mark favorite locations, and receive recommendations tailored to their needs. In the future, the system could also be connected with smart city infrastructure. This would allow access to real-time public data, making accessibility information more accurate and reliable. Finally, the recommendation model itself can be improved by using more advanced algorithms such as K-Nearest Neighbors (KNN) or Decision Trees. These methods can help make the system more intelligent and adaptive to user requirements.

### **Conclusion**

The growing need for accessible navigation solutions highlights the limitations of traditional systems, which mainly focus on finding the shortest path rather than considering accessibility requirements. To address this issue, the proposed system (NavigateU) introduces a web-based platform that helps users easily find and navigate to locations with suitable accessibility features. The system makes use of modern web technologies such as React.js, Google Maps Platform, and Firebase Firestore to support real-time location tracking, map visualization,

and efficient data management. Features like accessibility-based filtering, voice interaction, and simple navigation guidance make the system easier to use, especially for individuals with mobility challenges. A key strength of the system is its ability to recommend locations based on both distance and accessibility. By combining the Haversine Formula with a weighted scoring method, the system identifies places that are not only nearby but also more suitable for the user's needs. The results obtained during testing indicate that the system can improve decision-making and help users independently locate accessible places. The use of voice commands further enhances usability by reducing the need for manual interaction. However, certain limitations still exist, including dependence on internet connectivity, variations in GPS accuracy, and reliance on manually added data. These factors may affect performance in some situations. Despite these challenges, the system provides a strong base for future development. With the addition of advanced machine learning techniques, mobile application support, and real-time data updates, it can be further improved into a more intelligent and scalable solution. Overall, the proposed system demonstrates that a simple, web-based approach can significantly improve accessibility and support independent mobility, ultimately contributing to a more inclusive navigation experience.

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