

Seat Allocation for Blind People in Public Transport

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ABSTRACT

This work proposes an end-to-end assistive system that uses computer vision (CV) and natural language processing (NLP) to locate, reserve, and guide blind or low-vision users to appropriate seats in public places (buses, trains, waiting rooms, theatres, lecture halls). The system combines real-time visual seat/occupancy detection, OCR of signage, spatial mapping (depth/pose), speech-based user interaction (intent recognition + dialog), and audio/haptic guidance. Key goals are high reliability in crowded, variable lighting conditions; low-latency on-device inference; privacy-preserving operation; and compliance with accessibility regulations. We describe related work, datasets, models, system architecture, implementation details, evaluation metrics, deployment options, ethical/privacy considerations, limitations, and a roadmap for validation.

INTRODUCTION

Access to reserved or accessible seating is a critical mobility and dignity issue for blind and low-vision people. Current solutions (priority labels, human assistance, signage) often fail in busy environments, are inconsistent across venues, or rely on sighted intermediaries. A robust technical solution can:

- Automatically detect seating availability and reserved-seat signage.
- Understand a blind user's natural speech request (e.g., “find the nearest priority seat”).
- Guide the user safely to an allocated seat with audio/haptic feedback.
- Respect privacy, run on-device when required, and integrate into public infrastructure.

This proposal details a hybrid CV + NLP pipeline to achieve these goals in real-world public settings.

REVIEWS

In [1]: Liu, Li, and Li (2019) proposed a natural language processing (NLP) framework to evaluate passenger satisfaction and service quality in public transportation by mining large volumes of user-generated comments from the Dazhong-Dianping platform in Shanghai. The study collected nearly 26,000 reviews related to buses, metro systems, railway stations, and airports, replacing traditional, labor-intensive surveys with automated text analysis. Using sentiment analysis through the SnowNLP library, keyword extraction via TF-IDF, and co-occurrence network analysis with Gephi, the researchers identified common themes and service perceptions across different transport modes. Results revealed that

passengers expressed higher satisfaction with transport hubs like airports and railway stations, while buses received the lowest satisfaction ratings due to issues such as crowding, air conditioning, and driver behavior. The case study of Bus No. 49 highlighted how sentiment-based keyword analysis could pinpoint specific operational strengths and weaknesses. The paper demonstrates that NLP techniques can serve as a scalable, cost-effective alternative for understanding passenger feedback and improving service quality. It also emphasizes the potential of integrating text-based opinion mining with real-world operational data to enhance transportation management and policy-making.[1]

In [2]: The paper “Natural Language Processing: Transforming How Machines Understand Human Language” (Rayhan, Kinzler, & Rayhan, 2023) provides a comprehensive overview of how Natural Language Processing (NLP) has revolutionized communication between humans and machines. It explains the foundational principles, historical development, and core techniques of NLP, including tokenization, part-of-speech tagging, sentiment analysis, word embeddings, and neural network-based models such as transformers and deep learning architectures. The paper highlights practical applications of NLP in diverse domains like chatbots, machine translation, healthcare text analysis, social media sentiment mining, legal document summarization, and speech recognition systems. It also discusses major challenges such as bias, contextual ambiguity, data scarcity, and ethical concerns in model deployment. Moreover, it explores emerging trends such as multimodal NLP, integration with knowledge graphs, and quantum computing’s potential role in advancing the

field. Concluding, the paper emphasizes NLP’s transformative impact on human-machine interaction, its role in breaking language barriers, and its growing importance in fields like education, communication, and artificial intelligence ethics.[2]

In [3]: The paper “An Automated Navigation System for Blind People” presents an Internet of Things (IoT)-based intelligent navigation system designed to help visually impaired individuals move safely and independently in both indoor and outdoor environments. The proposed model integrates ultrasonic sensors, a stereo camera, and GPS for real-time object detection, obstacle avoidance, and location tracking. It employs deep learning algorithms, particularly the YOLOv4 framework, for object and currency recognition, while optical character recognition (OCR) enables text reading from the environment. The system also incorporates face recognition for identifying familiar individuals and speech processing modules for user interaction through natural language commands. All collected data, including location and user activity, are synchronized to the cloud, allowing guardians to monitor the blind user’s movement via web and Android applications.

Experimental results demonstrated high accuracy (up to 98.9%) in object detection and recognition tasks, confirming the system’s reliability and user-friendliness. Overall, this study contributes a comprehensive assistive technology that combines computer vision, speech recognition, and IoT connectivity to enhance

mobility, safety, and environmental awareness for blind individuals.[3]

In [4]: The paper “Blind Assistance System Using Machine Learning” (K. Naveen Kumar et al., Hindustan Institute of Technology and Science, 2022) presents a smart assistive system designed to aid visually impaired individuals through real-time object detection, distance estimation, and voice feedback. The system employs TensorFlow with the Single Shot Detector (SSD) algorithm and the COCO dataset to identify and classify objects captured by a camera. Once an object is detected, it is processed and converted into speech using the pyttsx3 library, enabling blind users to recognize and understand their surroundings. The system also calculates the depth or distance between the user and nearby objects to provide safety alerts, ensuring better navigation and obstacle avoidance. Compared to traditional buzzer-based systems, this model is more interactive and efficient, giving precise voice guidance rather than simple alerts. The paper highlights the model’s high accuracy, cost-effectiveness, and ease of implementation, making it a practical tool for visually challenged users. Future enhancements suggested include adding GPS functionality, developing a wearable version, and integrating chatbot-based communication for better user interaction and independence.[4]

In [5]: The paper “Assisting Visually Impaired People in the Public Transport System through RF-Communication and Embedded Systems” (Yessica Sáez et al., Sensors, 2019) introduces an innovative assistive system called MOVIDIS (Mobility

for Visually Disabled People) designed to enhance the mobility and independence of visually impaired individuals using public transportation. The system relies on radio frequency (RF) communication to establish interaction between the user, the bus stop, and the bus itself. It consists of three core modules: MOVI-ETA (a handheld device for the user), MOVI-STOP (installed at bus stops), and MOVI-BUS (mounted in buses). Through these modules, a visually impaired person can select a destination, transmit it to nearby bus stops, and receive vibration or buzzer feedback when the correct bus approaches. Experimental tests demonstrated that the RF communication between modules remained stable up to 224 meters in stationary conditions and effective at bus speeds up to 100 km/h. The system proved reliable, low-cost, and efficient even in noisy environments, overcoming limitations of GPS-based and audio-reliant systems. The study concludes that MOVIDIS significantly improves accessibility and autonomy for blind passengers, with future enhancements focusing on multi-user support, improved communication stability, and large-scale implementation in urban transport networks.[5]

In [6]: The paper “IoT-Based Full Duplex Smart Braille System for Blind and Deaf” (G. V. Sravan Kumar, Ch. S. S. Abhijit, and B. Lakshmi Sirisha, JETIR, 2020) presents an innovative communication and assistance system aimed at improving interaction and accessibility for people who are both visually and hearing impaired. The proposed system replaces traditional, slow, and costly piezoelectric Braille displays with a Smart Braille keyboard integrated with IoT and embedded components such as NodeMCU, Arduino Uno, Raspberry Pi, and APR voice

modules. It features two main modules: a communication module, which enables text messaging between users and converts SMS messages into Braille characters through NodeMCU and a lookup table, and an assistance module, which uses Optical Character Recognition (OCR) via a Raspberry Pi camera to read printed text aloud for the user. Micro-vibration motors and switches are incorporated to provide tactile feedback, ensuring effective communication without relying on sound. The system successfully enables two-way communication—sending and receiving messages through Braille input and voice playback—making it suitable for classroom and outdoor environments. The results show efficient functioning of both modules with accurate Braille translation and text-to-speech conversion. Overall, the paper demonstrates a low-cost, efficient, and user-friendly assistive technology that bridges communication barriers for the blind and deaf community by combining Braille literacy with modern IoT and embedded system design.[6]

In [7]: The paper “A Review on Disability-Inclusive Public Transportation: Current Barriers and Prospects” (Meshal Almoshaogeh et al., IEEE Access, 2025) provides a comprehensive global review of accessibility challenges faced by people with disabilities in public transportation systems. Drawing from over 1,100 studies, of which 35 met inclusion criteria, the paper categorizes key barriers into five areas — physical infrastructure, information and communication, attitudinal, economic, and safety and security. It highlights that despite advancements in accessibility laws and policies following the UN Convention on the Rights of Persons with Disabilities

(UNCRPD), most transport systems still fail to meet inclusive design standards. Using case studies from both developed and developing nations, the paper reveals persistent issues such as inaccessible bus stops, lack of tactile and audio aids, poor communication interfaces, and limited affordability. Furthermore, it explores emerging technological solutions, including AI, machine learning, LiDAR mapping, and computer vision, for identifying and mitigating accessibility barriers in real time. The authors propose integrating universal design principles and AI-driven infrastructure analysis into future transportation planning to ensure equitable access. Overall, the study emphasizes that achieving disability-inclusive mobility requires a multi-dimensional approach combining policy enforcement, infrastructure redesign, and technological innovation to improve independence and social inclusion for people with disabilities.[7]

In [8]: The paper “Analysis of Navigation Assistants for Blind and Visually Impaired People: A Systematic Review” (Sulaiman Khan, Shah Nazir, and Habib Ullah Khan, IEEE Access, 2021) provides a comprehensive systematic literature review of technological navigation systems developed for blind and visually impaired people (BVIPs). Covering 191 studies published between 2011 and 2020, the review evaluates diverse assistive navigation approaches, including infrared and ultrasonic canes, laser-based walkers, GPS- and RFID-based systems, robotic assistants, and computer vision-based navigation tools. The study categorizes these systems based on their hardware components, algorithms, obstacle avoidance mechanisms, and usability parameters such as accuracy,

response time, and cost-effectiveness. It highlights major challenges like limited detection range, power consumption, environmental adaptability, and lack of real-time path optimization. The review identifies that while many systems achieve high accuracy in controlled settings, few are scalable or user-friendly in real-world environments. The authors emphasize the need for IoT integration, AI-driven path planning, and low-power smart devices to improve safety and independence for visually impaired users. Ultimately, the paper serves as a valuable roadmap for researchers and developers to identify current gaps and design more efficient, intelligent, and reliable navigation aids for blind individuals.[8]

In [9]: The paper “Bus Detection System for Blind People Using RFID” (Jalila Al Kalbani et al., IEEE GCC Conference, 2015) presents a low-cost, efficient assistive system designed to enhance the independence and safety of visually impaired individuals using public transportation. The proposed model utilizes Radio Frequency Identification (RFID) technology to establish communication between buses, bus stations, and blind passengers. The system is divided into two main subsystems — the bus subsystem and the station subsystem — both linked to a centralized database. Each blind user is issued an RFID-based ticket containing their travel details, while buses and stations are equipped with RFID readers and tags to detect nearby entities. When a bus approaches a station, the system automatically announces the bus number and route for passengers at the station, while inside the bus, the driver is notified about blind passengers waiting at upcoming stops and their destinations. A website interface manages ticketing, database updates, and

route information. The prototype demonstrated reliable functionality, generating clear voice announcements and accurate detections within safe RF frequency ranges. Overall, the study concludes that the RFID-based bus detection system offers a safe, scalable, and practical transportation aid for blind users, improving their mobility, independence, and overall accessibility in public transport networks.[9]

In [10]: The paper “An Outdoor Navigation Assistance System for Visually Impaired People in Public Transportation” (Martínez-Cruz et al., IEEE Access, 2021) presents a highly efficient navigation aid designed to assist blind and visually impaired individuals in using public transport systems independently. The study introduces SUBE, a mobile application integrated with Bluetooth Low Energy (BLE) technology, which enables real-time communication between smartphones, buses, and bus stops. BLE beacons are installed on public vehicles and stations, allowing the application to identify the correct bus, announce approaching stops, and provide continuous voice guidance without requiring constant internet or GPS connectivity. This overcomes the limitations of GPS-based systems that often fail in indoor or low-signal environments. Experimental tests conducted in both controlled and real urban scenarios with visually impaired participants showed an impressive 97.6% effectiveness rate, ensuring accurate detection of vehicles and destination stops. Participants reported increased confidence, comfort, and independence compared to traditional systems. Overall, this research demonstrates a low-cost, non-intrusive, and reliable assistive technology that enhances public transport accessibility for visually impaired

users and contributes to the development of smarter, more inclusive urban mobility solutions.[10]

In [11]: The paper “Review on GPS Navigation System for Blind People” (Vidya Bhoge and S. Y. Chinchulikar, International Journal of Engineering Sciences & Research Technology, 2016) provides an overview of various navigation technologies developed to assist visually impaired individuals in moving safely and independently. The review classifies navigation systems into indoor, outdoor, and hybrid types, discussing their design principles, components, and limitations. It highlights that Global Positioning System (GPS) is the most widely used method for outdoor navigation, while ultrasonic sensors, infrared sensors, and RFID are commonly applied for indoor localization where GPS signals are unavailable. The paper examines several prototype systems that integrate GPS with voice recognition, text-to-speech modules, Arduino controllers, and ultrasonic sensors to provide real-time audio guidance and obstacle detection. It emphasizes the importance of combining obstacle detection with location tracking for effective mobility and discusses the evolution of hybrid systems that function both indoors and outdoors. The review concludes that developing affordable, accurate, and user-friendly hybrid navigation systems remains crucial for improving the autonomy and safety of visually impaired individuals, suggesting further research in sensor fusion and real-time data processing to enhance system reliability.[11]

In [12]: The paper “Smart Bus Alert System for Easy Navigation of Blind” (Adarsh Holikatti and Dr. S. Mohan Kumar,

International Journal of Advanced Networking & Applications, 2016) introduces a wireless sensor network-based assistive system designed to help visually impaired individuals navigate public transportation safely and independently. The proposed model employs ZigBee wireless communication, GPS, and voice modules (APR9600) to automate the process of bus identification, destination announcement, and travel assistance. The system consists of two main units—the blind module and the bus module. The blind module detects approaching buses within a 30-meter range through ZigBee transceivers, while users provide their desired destination via voice input. The bus module, equipped with a microcontroller, compares the received destination with its database to confirm if it matches the bus route and sends back a confirmation signal. The system then generates audio and vibration alerts to notify the user of the bus’s arrival and prompts them when their destination stop is reached using GPS data. Developed using ARM7 and 8051 microcontrollers and programmed in embedded C, the prototype successfully demonstrated automatic bus detection and reliable communication between modules. The authors conclude that the system provides a low-cost, energy-efficient, and user-friendly solution that enhances mobility and independence for visually impaired passengers, with potential for future integration of GSM modules for real-time emergency communication and location tracking.[12]

PROPOSED STATEMENT

Develop a multimodal, privacy-preserving assistive system that uses on-device computer vision (seat detection + occupancy + signage OCR + depth) and speech-based NLP (ASR + NLU + dialog + TTS) to allocate and guide blind users to suitable seats in public spaces, validated by a staged pilot program with blind users and venue partners.

CONCLUSION

This integrated CV + NLP system can materially improve independence and dignity for blind people navigating public places by automatically finding, reserving, and guiding them to appropriate seats. Key success factors are robust perception in crowded, varied conditions; fast, noise-robust speech understanding; privacy-first deployment; and extensive user-centered design and testing with the blind community.

LIMITATIONS

Despite the promise of the proposed CV + NLP-based seat allocation system, several limitations remain:

- **Hardware dependency:** The system requires cameras, microphones, and haptic devices, which may not be universally available in public transport.
- **Environmental variability:** Performance may degrade in low-light, noisy, or crowded conditions,

reducing accuracy of seat detection and speech recognition.

- **Latency and computation:** On-device inference can be resource-intensive, leading to delays in real-time guidance.
- **Privacy concerns:** Continuous video and audio processing may raise ethical concerns if not properly regulated.
- **Limited validation:** Current evaluation is conceptual; large-scale pilot testing with diverse blind users is still pending.
- **Infrastructure integration:** Deployment requires cooperation from transport authorities, which may be slow or inconsistent.

FUTURE WORK

- **Pilot studies:** Conducting staged trials with blind participants in buses, trains, and auditoriums to validate usability and safety.
- **Sensor fusion:** Integrating LiDAR, RFID, or BLE beacons to improve robustness in challenging environments.
- **Wearable integration:** Exploring smart glasses, haptic wristbands, or cane-mounted sensors for personalized guidance.
- **Adaptive NLP models:** Enhancing speech understanding with multilingual, noise-robust, and context-aware models.

- Scalability: Developing lightweight versions for low-cost devices to ensure affordability and widespread adoption.
- Policy alignment: Collaborating with accessibility regulators to ensure compliance with standards like UNCRPD and WCAG.
- Community feedback: Iteratively refining the system based on blind users' feedback to improve comfort, independence, and trust.

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