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A Review of CNN-Based Object Recognition and Tracking Systems forVisually Impaired People

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Abstract: Visually impaired persons (VIPs) face significant challenges in navigating their environments, impacting their independence and quality of life. This paper reviews recent advancements in assistive technologies aimed at enhancing mobility and safety for VIPs. It explores various systems, including wearable devices, object detection technologies, and navigation aids, highlighting their functionalities, limitations, and potential future develop- ment. The integration of machine learning and sensor technologies has led to innovative solutions that provide realtime feedback and improved spatial awareness for users. VIPs need assistance in performing daily tasks such as object detection, obstacle recognition, and navigation, particularly in indoor and outdoor environments. The paper emphasizes the importance of protecting and ensuring the safety of VIPs. Devices typically use sensors like infrared, ultrasonic, and imagery to gather environmental data, which is then processed by machine learning techniques. Users receive feedback via auditory or vibratory means. The paper provides a comprehensive comparative analysis of assistive devices, discussing their key attributes, challenges, and limitations, along with a score-based evaluation to help select appropriate devices for specific needs.

Keywords: Assistive technology, visually impaired, object detection, distance estimation, wearable devices, real-time feedback

I. INTRODUCTION

The World Health Organization (WHO) estimates that 285 million people worldwide are visually impaired, with 39 million classified as blind [2]. Traditional aids such as white canes and guide dogs have limitations in range, functionality, and practicality, making it crucial to develop advanced assistive technologies. Modern solutions leverage advancements in machinelearning, computer vision, and sensor integration technology for the visually impaired, object detection, distance estimation, wearable devices, and real-time feedback. There is a global need for assistive technologies for the visually impaired, with WHO estimating around 2.2 billion people worldwide experiencing some form of visual impairment. Traditional aids such as canes and guide dogs are limited, hence the need for advanced technological solutions.

The devices assist VIPs with object detection, navigation, and daily activities, often using sensors like infrared, ultrasonic, or cameras to gather environmental data. The paper intro- duces essential attributes required for these devices, such as reliability and efficient feedback mechanisms. A score-based analysis evaluates each device's performance based on real-time processing, accuracy, and adaptability to indoor and outdoor environments. The analysis reveals that while many devices perform well in specific areas, no single device meets allthe ideal requirements, suggesting a need for future development.

A. Problem Statement

Visually impaired individuals face significant challenges in navigating their environment safely and independently. Traditional assistive tools provide limited real- time feedback and lack comprehensive features for object recognition and location tracking.

B. Objectives

- 1) Object Detection Accuracy: Improve the accuracy of object detection for visuallyimpaired individuals.
- 2) Real-Time Navigation Assistance: Provide real-time navigation feedback to help usersmove safely and independently.
- 3) Safety and Tracking Features: Include safety and tracking features to enhance user confidence in navigating various environments.



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II. LITERATURE SURVEY

A. Wearable Devices

Recent advancements have led to the development of wearable devices that integrate object detection and distance estimation capabilities. These devices often use lightweight, portable technologies like the Raspberry Pi and camera modules to identify objects and provide auditory or haptic feedback about their proximity [4]. For example, smart glasses equipped with these modules can alert users to obstacles in real-time, enhancing their spatial awarenessand autonomy without requiring hands-on interaction.

B. Object Detection Systems

Object detection remains a cornerstone of assistive technologies for VIPs, enabling the recognition of obstacles and landmarks in their environment. Convolutional neural networks (CNN) have proven to be highly effective in this domain, allowing real-time visual analysis with high accuracy [5]. Systems like Mobile-Net have been optimized for low-power devices, making them suitable for portable applications. However, while CNN-based systems excel at object identification, they often struggle with precise distance estimation, which is essential for safe navigation [6].

C. Navigation Aids

Navigation aids have evolved from simple obstacle detectors to sophisticated systems that utilize multisensory fusion techniques. By combining data from ultrasonic sensors, LiDAR, cameras, and GPS modules, these systems can create detailed maps of the user's surroundings, facilitating smooth navigation through complex environments [7], [8]. Integrating artificial intelligence (AI) into these devices has allowed for adaptive learning, enabling the system oimprove its obstacle-detection capabilities and decision-making processes over time [9]. This evolution in technology significantly enhances the user's ability to move safely and independently.

D. Hybrid Devices

These devices combine object detection and navigation functionalities, offering more com-prehensive assistance. They use both vision and non-vision-based sensors, and some even incorporate GPS [7]. For instance, the project integrates a stereoscopic camera and GPS to offer both navigation and obstacle detection.

E. ADL (Activities of Daily Life) Devices

Devices supporting daily tasks like currency recognition, reading text, or identifying objects in the user's immediate surroundings [7]. Technologies in this category often utilize portable, wearable designs, making them more accessible for everyday use.

Sr. No	Title	Author	Publication and	Pros	
			Year		
1	CNN-Based	F. Ashiq et al.	IEEE Access,	• Efficient on low-power	
	Object Recognition and		2022	devices	
	Tracking Systemto Assist			• Provides auditoryfeedback	
	VisuallyImpaired People				
2	Real-Time	M. Asif	Journal of	• Focuses on real-time	
	Image and Video		Computer Science,	processing	
	ProcessingTechniques		2016	 Addresses adaptation 	
	in Assistive			to	
	Technology			lighting and	
				occlusions	
3	Integrating Web-	S. Zafar	Web Engineering	• Enables remote	
	Engineering		Journal, 2020	monitoring	
	with Assistive Technologies			• Enhances usersafety	
	forImproved UserExperience				

Table I: Literature Survey



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4	Towards	K.C. Shakira, A.	IEEE Access,	• Provides an in- depth
	Assisting Visually Impaired:	Lijiya	2021	survey of techniques for vi-
	А			sual data decoding
	Review on			
	Techniques for Decoding			
	the			
	Visual Data			
	From ChartImages			
5	Obstruction	Usman Masud et	IEEE Access,	• Leverages state-of-the-art
	Avoidance Through	al.	2022	machine learning
	Object			techniques forobstruction
	Detection and			avoidance
	Classification			 Provides real-time feedback
				through auditory/vibratory
				means
6	Assistant	Pratik	Journal of	• Uses computervision
	for Visually Impaired using	Vyavahare, Syed	Computer Vision,	techniquesfor
	Computer Vision	Habeeb	2019	assistingvisually impaired
				individualsinunderstanding
				their surroundings
7	Wearable Vision	Bin Jiang et al.	2019	• Innovative use of
	Assistance System			binocular sensors for real-
	Basedon			time assistance, providing
	BinocularSensors			depth perception and
	forVisually			obstacle detection
	Impaired User			
8	Be My Eyes:	Rucha Doiphode	2017	• Provides user- friendly
	Android App for Visually	et al.		assistance through an app
	Impaired People			that connects visually
				impaired people with
				volunteers for real-time
				help
9	Depth Detection	A. Kumar	Journal of	• Real-time depthdetection to
	for Assistance		Computer	help in navigation
	in Navigation		Engineering, 2020	• Uses efficient sen-sors for
	for VisuallyImpaired			low la- tency

III.PROPOSED SYSTEM OVERVIEW

The primary objective of CNN-based assistive systems is to recognize objects and pro-vide audio feedback to VIPs in real time. Many of these systems use Mobile-Net, a CNN architecture designed for mobile and embedded devices. The system architecture typically consists of a camera for input, a CNN for object recognition, and a text-to-speech engine for delivering audio feedback to users. This section elaborates on the technical components of such systems. The application helps blind people to walk alone, and they can move anywhere without anyone's help. Normal people can register the images in their minds, but blind people are not able to identify with their vision. As we have mentioned in the existing system, many applications are there that are not in sequence and cannot be used easily by blind people. So, we have developed an application that manages the handling of difficulties faced by blind people in identifying reading, directing the location, object detection, setting reminders, and identifying trusted people by connecting with each individual. To solve those difficulties, thismodel provides a good and efficient solution.



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Fig. 1. Proposed System Architecture for Assistive Technology

IV.EVALUATION AND ANALYSIS

Performance evaluation in these systems is typically based on accuracy, processing time, and ease of use. For example, Ashiq et al.[1] achieved 83.3% accuracy in object detection with their proposed system. The evaluation also considers user feedback and realworld testing in various indoor and outdoor environments. In comparison to previous systems, newer models using advanced CNN techniques have shown significant improvements in both accuracy and processing speed. Integrating Dialog flow API The Dialog flow API is integrated to recognize the voices of visually challenged people, which is the basis of this project. Dialog Flow isa human-computer interaction technology based on natural language conversations that is a Google-owned developer. Object Detection The spy camera is connected to an Oculus to detect objects and indicate to the user by voice commands that an object is present on itsway. This may indicate him to either wait or move in some other direction to proceed further. Thus, it helps the user to walk on the roads safely.

V. CHALLENGES AND FUTURE DIRECTIONS

Despite the significant advancements in assistive technologies, several challenges remainto be addressed for these devices to become more effective and accessible.

PERFORMANCE COMPARISON OF ASSISTIVE DEVICES					
Device Type Performance Score		Key Features			
Optical Sensor-Based Aids	62%	Speed and lightweight design, but limited			
		functionality			
AI-Based Aids	44%	Comprehensive scene understanding but			
		resource-intensive			
Multi-sensor Fusion Aids	51%	Robust functionality with essential assistive			
		features			
Hybrid-Based	30%	Smartphone-based with wearable camera; pro-			
		vides audio feedback for both navigation and			
		detection			
Arduino Based	24%	Uses ultrasonic and RGB sensors to assist with			
		navigation and object recognition tasks			

TABLE II

- 1) Complexity and Cost: Many state-of-the-art devices require expensive hardware compo- nents and sophisticated algorithms, which can limit their availability and affordabilityfor users [10].
- Real-Time Performance: Ensuring that devices process data and provide real-time feed- back is crucial for navigation safety. 2) Optimization of computational efficiency remains a key development area to improve response times[11].



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- *3)* User Acceptance: The success of assistive technologies largely depends on their accep- tance by VIPs. Engaging with end-users throughout the development process is essential to address their specific needs, preferences, and usability concerns[12].
- 4) Integration with AI and Machine Learning: There is potential to enhance these tech- nologies through AI-driven personalization, allowing devices to learn and adapt to a user's specific navigation patterns and behaviors over time[13].
- 5) Limited Functionality: Many existing assistive devices are constrained in their capabil- ities, often excelling in one area (like object detection) while lacking in others (such as accurate distance measurement or navigation [14].
- 6) Cost and Accessibility: Advanced assistive devices often come with high costs due to sophisticated hardware and software requirements, limiting their availability to userswho need them [15].

VI.CONCLUSION

The review of CNN-based object recognition and tracking systems for visually impaired people underscores the significant advancements in assistive technologies designed to enhance mobility and independence. While many systems, including wearable devices and navigation aids, offer promising functionalities, no device fully meets all the needs of visually impaired individuals. Challenges such as high costs, complexity, and user acceptance remain barriers to widespread adoption. Engaging users in the development process is crucial to creating so- lutions that cater to their specific requirements. Furthermore, integrating artificial intelligencecould lead to personalized devices that adapt to users over time, improving their overall expe-rience. Continued research and collaboration among developers, researchers, and the visually impaired community are essential for refining these technologies. Ultimately, the future of assistive technology holds great potential, aiming to empower visually impaired individuals with the tools they need to navigate their environments confidently and independently.

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