Technological Advancements to Assist Visually-Impaired People: A Survey

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ABSTRACT
It is possible to use technology to support individuals with visual impairments. This paper provides a brief overview of several approaches that have been employed over time to assist people with disabilities. It covers digital, deep learning, and sensor- based methods. The study also includes an in-depth discussion of deep learning techniques and their deployment on edge de- vices. Additionally, the role of accelerators in modern computing is briefly addressed. Researchers seeking to explore further advancements in this field may find this study a useful starting point.

General Terms
Object detection, visual impairement

Keywords
Visually impaired, navigation, mean average precision, deep learn- ing, computer vision

1. INTRODUCTION
An essential part of the human sensory system is vision. Loss of sight can be caused by accidents, aging, or other unforeseen cir- cumstances. This poses a significant challenge to routine tasks and other everyday activities. However, helping those with vision im- pairments has always been made possible in large part by technology. These tools and methods not only make difficulties easier, but they also give people a greater sense of confidence. This support could come in the form of communication devices, learning aids, or tools for movement or navigation. These days, digital technologies and techniques are very popular. Furthermore, advances in artificial intelligence, cloud computing, and the internet of things have created new opportunities for research and development in the field of helping the blind and visually impaired.

Recently, smartphone-based walkable road recognition has demonstrated significant promise in aiding VI navigation [1]. Using the data gathered and the model trained on those images, this work at- tempted to identify solutions on crowded roads. After road segmentation, well-optimized image segmentation models are used to help VI individuals. Deep learning (DL) approaches are used to solve nearly every problem that arises. To train a model, a specialized and specific dataset is required. A supervised DL problem requires well-annotated data with few defects. It is a serious challenge in this domain. However, researchers have addressed specific needs and provided cutting-edge solutions. In [2], pothole detection DL models are used. It is then mounted on smart canes to assist in iden- tifying potholes while navigating the roadways.Object detection is the process of determining the object of interest in the proposed scene. It is achieved in a variety of ways. However, deploying those models on edge devices is a hard task. In general, OD models are large and have restricted capabilities while providing real-time per- formance. There are ways for quantifying models, however they can have a negative impact on model behavior. A Raspberry Pi- based device that employed a DL model to OD limited objects has showed significant promise. However, the object images used in testing are seen in a controlled environment, and ambient noise can affect the performance in real time [3]. Figure 1 shows the major blocks of computer vision (CV)-based visual assistance systems. A camera sensor is chosen depending on the application specifica- tions, and images/videos are captured for the purpose of training a model or creating a rule based on image processing principles. Be- fore transferring images to the DL processing engine, they have to be pre processed. Resizing, denoising, normalization, and standard- ization are a few examples of general techniques used for pre pro- cessing. This helps to reduce the additional overhead imposed on the models during processing. A specific DL model is then trained, and the frozen graphs/models are exported to the format specified by the user. Inference outputs are then post processed to provide extra information such as voice/feedback. This helps the VI per- son receive the alert. Figure 2 displays an extra accelerator compo- nent. The majority of the data being processed by these pipelines are two-dimensional images. The best option for processing such data to reduce overall latency is a graphical processing unit (GPU). Other accelerators offered with certain processors, such as Tensor Processing Units (TPU) and Neural Processing Units (NPU), aid in shifting computational loads from the central processing unit (CPU) and improve system performance.

2. LITERATURE SURVEY
Table 1, has summarized few works in this domain.

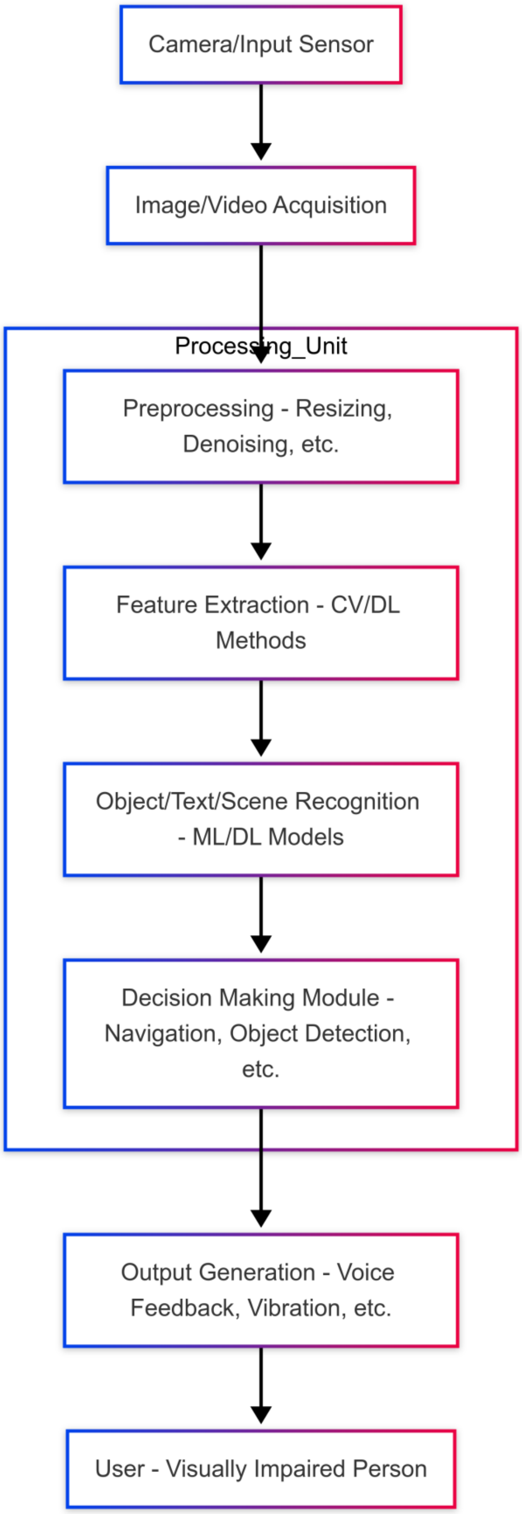

Fig. 1: Block diagram of assistance system to visually impaired people

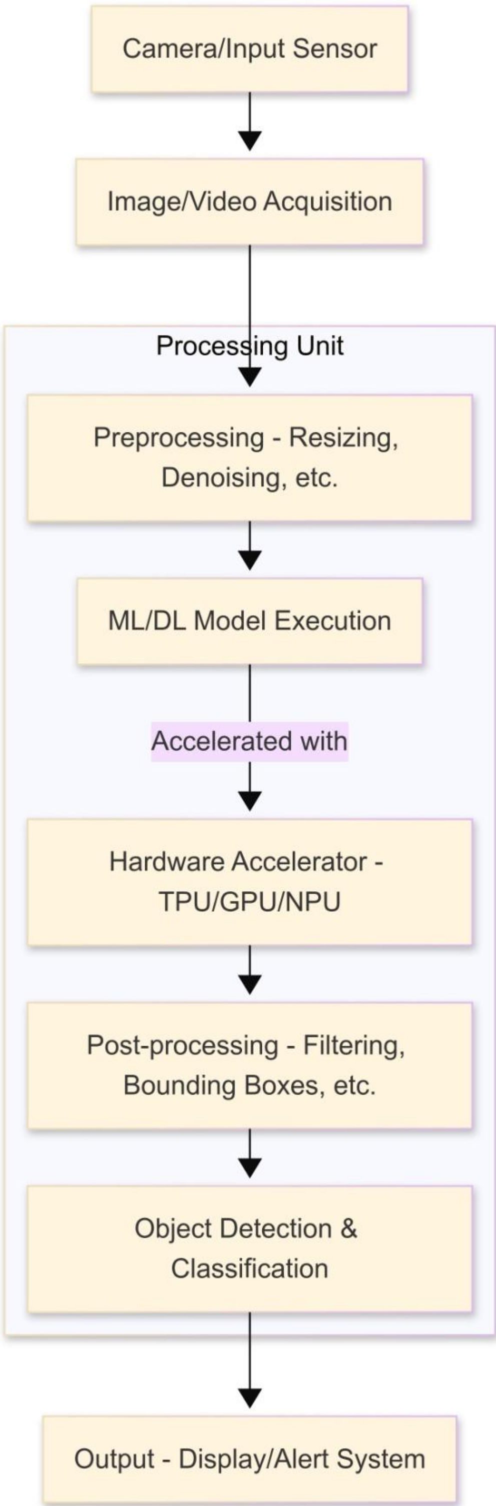

Fig. 2: A deep learning model on hardware platform-edge devices

Table 1. : Literature review

Ref.	Authors	Main Technology	Key findings	Research Gap
[4]	D. Lunney et.al	Microntroller based assistance	Used for Mathematical computations with voice feedback	Limited application

[5]	J. Brabyn et.al	Sensors & Touch pad based system	Handling computers	Better for computer usage
[6]	N. K. Lodge et.al	Television for blind	AUDETEL project - Audio description to blinds	Auditory perception, missing touch and sensory system
[7]	K. Thorn	Capacitance based system	Liquid measuring devices	Less generalized use case, Noise prone
[8]	J.L. Leopold et.al	Visual programming	voice, handwriting & gesture	Not a standalone system
[9]	A. Tomita et.al	Image Processing	Rule based image analysis for assistance	Limited real time performance
[10]	S. Ram et.al	Mobility aid to visually impaired (VI)	Pyroelectric and ultra sound sensors	Ambient noise degrades performance
[11]	K. Magatani et.al	Optical beacons	Navigation assistance	Problem of crossing pathway
[12]	Avizzano et.al	Multifinger haptic	modified kinematics for improved rendering	Noise amplification
[13]	W. C. Lee et.al	SINVI: Indoor navigation	Image features	Lightning conditions noises
[14]	Toledo et.al	FPGA based AR application	Helpful for people with tunnel vision	Impacted by surroundings
[15]	Tjan et.al	Way finding and navigation	digital sign system	Suitable for indoor environment
[16]	Roslak et.al	Navigation	RF environmental sensing	Obstacles and environmental disturbances
[17]	P. Manohar et.al	Braille system keyboard	based on logical switches	Less range of functionality
[18]	M. Ahmad et.al	MathVision	YOLOv7 + LSTM	Limited application
[19]	M.Kan et.al	eLabrodar	GPS + google maps	Internet connectivity
[20]	S. Ikram et.al	Navigation	Machine learning techniques	Low range
[21]	Makanyadevi et.al	Smart glasses	Object detection YOLOv8	difficulty in Small object detection
[22]	Sakib et.al	Road navigation	CNN + Laser	Data variations
[23]	Farooq et.al	Vision Assist	Smart phone application	deep learning framework
[24]	R. Shashanka et.al	VisioGuide	OCR, navigation and voice commands	Heavily relied on quality of image
[25]	Cho et.al	Piano learning system	Image processing	Model generalize well with train set
[26]	Mahalley et.al	Mobile application-Navigation	OpenCV + OCR	Robustness can be improved

[27] R. Jain et.al	Smart cap	Camera + Text to speech	Ambient light noise and latency

3. CONCLUSIONS

A detailed and focused overview of the techniques used to as- sist visually impaired individuals is presented in this paper. Key methodologies, major technologies, and existing research gaps are highlighted, with secondary details kept minimal. This approach enables researchers to efficiently identify and select relevant top- ics, thereby saving time. The paper also emphasizes the impact of hardware accelerators, which may encourage researchers to design systems that are more effective for real-time applications.

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