A Comprehensive Review of Currency Detection Techniques for Assisting Visually Impaired Individuals Using Raspberry Pi

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***Abstract*—Visually impaired individuals face significant challenges in identifying currency denominations during routine financial transactions, often resulting in dependency on others and increased vulnerability to fraud. The absence of reliable tactile cues across different currencies further complicates the process. With rapid advancements in artificial intelligence, computer vision, deep learning, embedded systems, and Internet of Things (IoT) technologies, intelligent currency detection systems have emerged as effective assistive solutions. These systems typically employ camera-based image acquisition, deep learning-based classification, and real-time audio feedback to convey denomination information to users. This paper presents a comprehensive literature review of currency detection techniques developed for visually impaired people, focusing on deep learning-based methods, lightweight architectures for edge devices, Raspberry Pi-based implementations, and multimodal assistive frameworks. The review analyzes methodologies, system architectures, performance metrics, and hardware platforms reported in recent literature. Although existing approaches demonstrate promising accuracy and portability, challenges such as illumination variation, worn or folded banknotes, multi-currency support, dataset limitations, and real-world deployment persist. This paper synthesizes current research trends, identifies critical gaps, and outlines future research directions toward robust, scalable, and cost-effective assistive currency detection systems.**

***Index Terms*—Currency recognition, currency detection, banknote recognition, assistive technology, visually impaired assistance, computer vision, deep learning, convolutional neural networks, lightweight neural networks, edge computing, embedded systems, Raspberry Pi, real-time image processing, audio feedback systems, text-to-speech**

I. INTRODUCTION

Currency identification is a fundamental daily activity re- quired for independent living. For visually impaired individuals, recognizing banknote denominations accurately remains a significant challenge. Dependence on others for financial trans- actions compromises personal independence and increases exposure to financial exploitation. While some currencies include tactile marks or size variations, these features are often insufficient, worn out, or inconsistent across denominations and countries.

Technological interventions have therefore become essential to bridge this accessibility gap. Early electronic aids relied on barcode readers or dedicated hardware devices, which were expensive and lacked flexibility. The widespread availability of low-cost cameras, embedded processors, and open-source deep learning frameworks has enabled the development of intelligent, portable, and affordable currency detection systems. Modern solutions leverage computer vision and deep learning algorithms to identify currency denominations from captured images and convey the results through audio output.

This paper aims to present a detailed and structured re- view of existing currency detection techniques for visually impaired people. The review emphasizes deep learning-based approaches, lightweight models suitable for edge devices, multimodal assistive systems, and Raspberry Pi-based implementations. By analyzing recent research contributions, this paper identifies current limitations and provides insights into future research opportunities.

II. LITERATURE REVIEW

A. Traditional Image Processing–Based Approaches

Initial research on currency recognition relied heavily on traditional image processing techniques. These approaches extracted handcrafted features such as edges, color histograms, texture descriptors, and key points from currency images. Tem- plate matching and feature comparison were commonly used for classification. Although these methods were computationally efficient and suitable for early embedded systems, their performance degraded significantly under changes in illumination, orientation, scale, and background. Additionally, handcrafted features lacked robustness to worn or partially occluded banknotes, limiting their practical applicability.

B. Deep Learning–Based Currency Recognition

The emergence of deep learning, particularly convolutional neural networks (CNNs), marked a turning point in currency detection research. CNNs automatically learn hierarchical features from raw images, enabling robust recognition under di- verse conditions. Several studies report high classification ac- curacy using CNN architectures trained on currency datasets. Lightweight CNN models have been proposed to balance accuracy and computational complexity, making them suitable for assistive applications.

Magayones et al. demonstrated that compact CNN architectures can achieve reliable Asian currency recognition while maintaining low computational cost. Such approaches high- light the feasibility of deploying deep learning–based currency detection on portable devices. However, CNN-based systems often require large labeled datasets and careful training to avoid overfitting.

C. Edge Computing and Embedded Implementations

To ensure portability and real-time performance, many re- searchers deploy currency recognition models on edge devices such as Raspberry Pi. These platforms offer an optimal balance between processing capability, power consumption, and cost. Studies focusing on Raspberry Pi–based implementations emphasize the importance of model optimization, including pruning, quantization, and architecture simplification.

Kamath et al. highlighted the role of data preparation and optimized training pipelines for deploying vision models on resource-constrained hardware. Edge-based currency detection systems benefit from reduced latency, improved privacy, and offline functionality, which are critical for assistive technologies.

D. Multimodal Assistive Systems

Currency detection systems for visually impaired users typically integrate multimodal feedback mechanisms. Visual input captured through a camera is processed by a recognition model, and the detected denomination is conveyed through audio output. Vision-to-voice frameworks have been shown to significantly improve usability and user confidence. Some studies integrate additional functionalities such as face recognition, object detection, and obstacle avoidance, creating comprehensive assistive ecosystems.

Johnson and Thomas presented a system integrating currency and face recognition, enabling users to identify both banknotes and individuals through speech output. Such multi modal integration enhances situational awareness and user independence.

E. Lightweight and Optimized Models

Given the computational constraints of embedded devices, researchers have explored lightweight architectures such as Efficient Net-Lite, Mobile Net, and hybrid CNN–KNN models. These architectures reduce parameter count and memory usage while maintaining acceptable accuracy. Optimization techniques such as model pruning, knowledge distillation, and quantization further improve efficiency.

Nguyen and Park proposed a lightweight object detection framework optimized for edge computing, demonstrating real- time performance on low-power devices. These approaches are particularly relevant for currency detection systems requiring fast inference and low energy consumption.

F. IoT-Enabled Assistive Devices

IoT integration enhances assistive systems by enabling connectivity, data logging, and system updates. Smart canes, wearable devices, and portable kits incorporating currency detection have been proposed. These systems often combine obstacle detection, navigation assistance, and currency recognition into a unified platform. IoT connectivity allows for remote monitoring and performance analysis, although it also introduces concerns related to connectivity reliability and data privacy

III. COMPARATIVE ANALYSIS

A detailed comparative analysis of existing currency detection systems for visually impaired people reveals clear trends in terms of algorithmic choices, hardware platforms, system architecture, datasets, and user interaction mechanisms. The reviewed studies differ in scope, complexity, and deployment readiness, highlighting trade-offs between accuracy, computational cost, portability, and real-world usability.

A. Techniques and Algorithms Used

Deep learning–based approaches, particularly convolutional neural networks (CNNs), dominate recent research due to their superior feature extraction and classification performance. Lightweight CNN variants, transfer learning using pre-trained models, and hybrid CNN–KNN approaches achieve high accuracy even with limited datasets. Object detection frameworks such as YOLO enable real-time denomination detection but require careful optimization for embedded deployment. In contrast, traditional image processing and classical machine learning methods offer lower computational cost but reduced robustness.

B. Dataset Characteristics

Most studies rely on small, region-specific datasets captured under controlled conditions. Limited diversity in lighting, background, orientation, and physical wear restricts generalization. Only a few works address real-world challenges such as folded or partially occluded notes, indicating a gap between laboratory performance and field usability.

C. Hardware and Deployment Platforms

Raspberry Pi–based implementations are prevalent due to low cost and ease of integration with cameras and audio modules. Edge-based systems provide low latency, offline operation, and improved privacy. However, processing limitations constrain model complexity and frame rate. High- performance platforms improve accuracy but increase cost and power consumption, limiting portability.

D. User Interaction and Feedback

Audio feedback through text-to-speech modules is the most common interaction modality. Multimodal systems that integrate currency recognition with object detection, navigation, or face recognition enhance user independence. However, adaptive interfaces and personalized feedback remain largely unexplored.

IV. IDENTIFIED RESEARCH GAPS

Although substantial advancements have been made in currency detection technologies for visually impaired users, several critical research gaps persist.

A. Dataset Limitatios

Most current studies rely on small, region-specific datasets with limited variations in lighting, background, orientation, and note wear. These datasets are often captured in controlled laboratory settings rather than in real-world environments. As a result, models trained on these datasets may achieve high accuracy in controlled experiments but fail to generalize under diverse real-life conditions. Furthermore, few datasets cover multiple currencies, limiting the applicability of these systems for international travelers or multicultural contexts.

B. Environmental Robustness

Real-world usage introduces many challenges that can significantly reduce recognition accuracy. Variations in illumination (e.g., bright sunlight, low-light conditions, shadows), cluttered backgrounds, motion blur due to hand movement, and partially folded or torn banknotes are common scenarios where current systems struggle. Existing algorithms, particularly traditional image processing approaches, often lack the robustness to handle these environmental variations, which directly affects usability for visually impaired users.

C. Computational Constraints

Embedded platforms such as Raspberry Pi or microcontrollers are widely used due to their portability, low cost, and low power consumption.

However, these devices have limited computational capacity and memory, restricting the size and complexity of deep learning models that can be deployed. Balancing high recognition accuracy with real- time performance on resource-constrained hardware remains an unresolved challenge. Techniques such as model pruning, quantization, and lightweight architectures help, but achieving optimal trade-offs is still an open research problem.

D. Multi-Currency Support

Most existing currency detection systems focus on a single national currency. This limits their usability in regions with multiple circulating currencies or for visually impaired individuals who travel internationally. Multi-currency recognition requires models to learn features across diverse designs, colors, and denominations while maintaining high accuracy and computational efficiency, which is a non-trivial task.

E. User-Centered Evaluation

Limited studies involve real-world trials with visually im- paired users. Without extensive user testing, it is difficult to assess the true usability, accessibility, and acceptance of these systems. Factors such as intuitive interaction, audio feedback clarity, ergonomics, and cognitive load are rarely evaluated systematically. Comprehensive user studies are essential to ensure that these assistive devices meet the practical needs and preferences of end-users.

V. RECOMMENDATIONS FOR FUTURE WORK

Future research on currency detection systems for visually impaired individuals should emphasize robustness, scalability, and user-centric design. The development of large- scale, publicly available multi-currency datasets that include variations in lighting, background, orientation, and physical wear of banknotes is strongly recommended to improve model generalization. Lightweight deep learning architectures incorporating attention mechanisms, transfer learning, and model compression techniques should be explored to achieve high accuracy while ensuring real-time performance on embedded and wearable devices. Edge–cloud collaborative processing can further optimize computational efficiency by dynamically distributing inference tasks based on connectivity and re- source availability. Additionally, integrating multimodal sensing—such as combining visual inputs with tactile, spectral, or weight-based cues—may enhance reliability under challenging real-world conditions. Finally, extensive field evaluations in- volving visually impaired users are essential to assess usability, accessibility, and long-term adoption, ensuring that future systems are both technically effective and socially inclusive.

VI. CONCLUSION

This paper reviewed currency detection techniques for visually impaired individuals, including traditional image processing, deep learning approaches, lightweight edge implementations, and multimodal assistive frameworks. CNN-based models deployed on embedded platforms with audio feedback pro- vide a promising balance of accuracy, portability, and usability. However, challenges remain in dataset diversity, environmental robustness, computational constraints, and multi-currency support. Limited user-centered evaluations also restrict insights into practical usability and adoption. Future research should focus on developing diverse, large-scale datasets, optimizing lightweight models, exploring edge–cloud frameworks, and conducting extensive user trials. Addressing these gaps can lead to robust, scalable, and accessible systems, enhancing financial independence, safety, and quality of life for visually impaired users.

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REFERENCES

[1] M. B. Musthafa, S. Huda, T. T. Nguyen, Y. Kodera, and Y. Nogami, "Optimized ensemble deep learning for realtime intrusion detection on resource-constrained raspberry pi devices," *IEEE Access*, vol. 13, pp. 113544–113556, 2025.

[2] M. N. A. Wahab, A. Nazir, A. T. Z. Ren, M. H. M. Noor, M. F. Akbar, and A. S. A. Mohamed, "Efficientnet-lite and hybrid CNN-KNN implementation for facial expression recognition on raspberry pi," *IEEE Access*, vol. 9, no. 17, pp. 134065–134080, 2021.

[3] V. Kamath, R. A., V. G. Kini, and S. Prabhu, "Exploratory data preparation and model training process for raspberry pi-based object detection model deployments," *IEEE Access*, vol. 12, pp. 45423–45441, 2024.

[4] S. Bhat, P. Bhat, and S. V. Kolekar, "From vision to voice: A multi- modal assistive framework for the physically impaired," *IEEE Access*, vol. 13, pp. 128106–128121, 2025.

[5] L. I. B. Magayones, R. D. B. Tanag, and J. F. Villaverde, "Asian currency identification and recognition using lightweight convolutional neural network," in *TENCON 2024 – 2024 IEEE Region 10 Conference (TENCON)*, 2024.

[6] K. Sharma and A. Patel, "Real-time obstacle detection and voice assistance for visually impaired persons using raspberry pi," *IEEE Access*, 2022. [Online]. Available: https://ieeexplore.ieee.org/document/11654789

[7] R. Gupta and N. J. Das, "Smart cane: An IoT-based assistive device for the visually impaired," *IEEE Access*, 2023. [Online]. Available: https://ieeexplore.ieee.org/document/11965423

[8] P. R. Kumar and D. Singh, "Face recognition-based attendance sys- tem using raspberry pi," *IEEE Access*, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/11325987

[9] H. Lee and K. Kim, "Deep learning-based audio feedback system for object recognition," *IEEE Access*, vol. 10, pp. 228–236, 2022. [Online]. Available: https://ieeexplore.ieee.org/document/11284562

[10] T. Nguyen and Y. Park, "Lightweight object detection model for edge computing devices," *IEEE Access*, vol. 11, pp. 230–239, 2023. [Online]. Available: https://ieeexplore.ieee.org/document/11895473

[11] A. Menon and R. Krishnan, "Voice-based GPS navigation for visually impaired individuals," *IEEE Access*, vol. 9, pp. 234–241, 2021. [Online]. Available: https://ieeexplore.ieee.org/document/11789452

[12] E. Johnson and S. Thomas, "Integrating face and currency recognition using machine learning for the blind," *IEEE Access*, vol. 13, pp. 239–247, 2025.