

Assistive QR Code Technologies for Product Identification in Visually Impaired Users

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Abstract: Visually impaired individuals face major challenges in identifying everyday products such as medicines, groceries, and packaged goods, which limits their independence and daily functioning. Braille labels, a traditional solution, are not universally applied and often lack detailed information. To overcome these barriers, voice-based product identification systems using QR code scanning have emerged as a cost-effective and scalable assistive technology. QR codes, when integrated with mobile applications, can be scanned through a smartphone camera and instantly converted into audio output using text-to-speech engines, allowing blind users to access essential product details without external assistance. This survey paper reviews existing QR code-based visual product identification approaches for the blind, comparing them with barcodes, RFID, and computer vision techniques. The paper also highlights current gaps such as dependency on internet access, lack of multilingual voice support, and challenges with damaged or unreadable codes. Finally, it explores future research directions, including AI-driven recognition, offline accessibility, and blockchain-enabled product authenticity to enhance usability and inclusivity.

Keywords: Voice-based system, QR code scanning, Visually impaired, Assistive technology, QR codes, Accessibility, Product identification

Introduction

Visually impaired individuals encounter serious challenges in recognizing and identifying everyday products such as groceries, medicines, and packaged goods, since product information is largely presented in visual form. Conventional solutions like Braille labeling are inadequate due to limited adoption, space constraints, and the fact that not all blind users are proficient in Braille. Recently, assistive technologies have sought to bridge this gap using approaches such as barcodes, RFID, computer vision, and audio labeling, but many of these methods are either costly, require specialized hardware, or lack scalability. Among the available alternatives, QR code scanning combined with voice-based output has emerged as a practical, low-cost, and inclusive solution. QR codes can store detailed product information that can be instantly retrieved via a smartphone camera and converted into audio through text-to-speech systems, thus enabling blind users to access critical details independently. This survey paper reviews existing QR code-based assistive systems, compares them with alternative technologies, and highlights current limitations such as poor handling of damaged codes, dependency on internet connectivity, and lack of multilingual support. Finally, it explores future research directions to enhance the usability, reliability, and inclusivity of such systems.

Literature Survey

According to [1], a purpose-built QR-scanning prototype optimized for visually impaired users that integrates QR detection heuristics with voice prompts and usability tweaks to guide the user during scanning. The authors detail practical improvements such as audible alignment cues and scanning retries to improve the success rate when users cannot visually line up the camera. The evaluation is small-scale but shows meaningful gains in scanning reliability versus a baseline QR reader, and the paper highlights connectivity and content-retrieval latency as remaining issues.

The work is a concrete example of adapting off-the-shelf QR technology for accessibility rather than inventing new hardware.

According to [2], the classification of recent assistive systems across navigation, object recognition, and shopping/product assistance provides a taxonomy that helps position QR-based product ID among broader approaches. Mashiatu emphasizes usability barriers such as the discoverability of tags (where to find a code on a package), the importance of multimodal feedback, and gaps in real-world deployment studies. The paper calls for hybrid systems (tag + computer vision fallbacks) and larger user studies to validate practical utility, which is directly relevant to QR + voice solutions.

According to [3], the study proposes printing embossed (tactile) QR codes on product packaging to improve physical discoverability and alignment for blind users; the QR links point to rich, multimodal web pages that are audio-friendly. The authors report on prototyping and discuss manufacturing and labeling considerations from a producer's viewpoint, arguing embossed codes reduce the cognitive and motor steps needed to locate and scan a code. They also outline privacy and authenticity concerns (spoofed codes) and suggest packaging standards to increase adoption. The paper's practical orientation makes it especially useful for product-level design recommendations.

According to [4], a high-quality teachable object recognition system designed with and for blind users documents design decisions, data-quality helpers (to guide photo capture), and a thorough user evaluation. The authors show that personalized, teachable recognizers often outperform generic object detectors for instance-level tasks (finding your keys, your shampoo bottle), and they present practical solutions to make training accessible to blind users. The paper is important because it argues for user-centered ML pipelines (data capture, feedback, and model update) rather than treating models as black boxes—a key lesson if QR systems are to be combined with AI fallbacks.

According to [5], the survey maps modern assistive trends—AI, wearable sensors, Visible Light Communications (VLC), and tag-based methods—and compares tradeoffs for reliability, cost, and latency. The survey highlights that tag-based solutions (QR/RFID) remain attractive for product-level metadata because they are low-cost and easily integrated into existing packaging ecosystems but also notes discoverability and content accessibility remain unresolved. The authors emphasize the potential of hybrid architectures (tag + on-device AI) to mitigate unreadable tags or occlusion. This state-of-the-art review is a useful reference for positioning QR+voice within the current technology landscape.

According to [6], an applied review of assistive systems with a special focus on smartphone apps, wearables, and multimodal interfaces. The authors discuss practical deployment concerns such as language/localization, offline operation, and privacy—issues directly relevant to voice-based QR systems that fetch metadata over the web. Their analysis includes platform limitations (battery, camera quality) and evaluates which tasks are best served by tags (e.g., product metadata) versus full computer vision (e.g., scene understanding). The authors recommend offline TTS engines and compact metadata formats as immediately usable design items for a QR-voice app.

According to [7], a key operational problem for teachable AI is how blind users can create and verify training photos. The authors propose and evaluate data-quality descriptors (real-time guidance for occlusion/cropping/blur) that enable blind participants to produce useful training sets without sighted help. Their findings show that providing immediate, nonvisual feedback during data capture greatly improves downstream recognition performance and user confidence. The paper's methods and UX principles are relevant when designing fallback CV systems to complement QR scanning.

According to [8], While focused on educational settings, the investigation of QR discoverability and user acceptance—issues that translate to consumer product use for blind people—is ongoing. The study finds that QR codes are feasible and generally acceptable but stresses the importance of clear placement, tactile cues, and error-tolerant landing pages (that work with screen readers). Their mixed-method evaluation provides pragmatic advice: short, predictable URLs, accessible landing pages, and redundancy (text + audio) increase success rates for users with disabilities.

According to [9], the analysis examines how QR-enabled webpages can support object literacy and product understanding, especially for health-related items. The author inspects the structure of QR landing pages and

recommends standards for machine-readable semantic metadata and audio transcripts to make the content screen-reader friendly. The paper also explores content governance and the need for persistent, trustworthy URLs—important because a voice-based QR reader must avoid dead or malicious links. Although not strictly an accessibility technology paper, it provides useful content-design guidance for product metadata pages.

According to [10], the study examines QR usage in clinical waiting rooms and highlights broader usability lessons: consistent placement, simple instructions, and fallback options when scanning fails. While the domain is healthcare, conclusions—especially about users’ familiarity with QR scanning patterns and the need for short, immediate feedback—apply directly to consumer QR systems for blind users. The paper also demonstrates that addressing accessibility issues such as discoverability and audio landing pages can lower the adoption barrier, as many users already possess QR experience.

Table 1: Comparison table for the literature review

Title	Methodology	Algorithm Used	Limitations
“The impact and potential of quick response (QR) codes in healthcare: a comprehensive review” [11]	Review of QR code applications in healthcare for accessibility and information delivery	N/A (Review study)	Focused on healthcare context; lacks empirical evaluation for blind users in consumer product identification; QR usability challenges not deeply tested
“Enhancing object recognition for visually impaired individuals using computer vision” [12]	Computer vision-based object recognition for visually impaired users	YOLOv4, CNN-based detection	High computational cost; requires adequate training data; may not reliably identify fine-grained product details; offline use limited
“Using Embossed QR Codes on Product Packaging for People with Visual Impairments” [13]	Embossed/tactile QR codes for product identification with audio output	QR code scanning + TTS (Text-to-Speech)	Prototype stage; limited user testing; requires modification in packaging standards; dependent on QR integrity
“Blind users accessing their training images in teachable object recognizers” [14]	Teachable AI object recognition for blind users	User-trained machine learning models, data-quality feedback algorithms	Dependent on quality of user-generated images; training overhead; hardware constraints; requires some initial assistance
“A comprehensive survey on emerging assistive technologies for visually impaired persons” [15]	Survey of assistive technologies including AI, VLC, and tag-based solutions	N/A (Survey)	General review; lacks specific experimental validation; does not provide concrete implementation for QR-based product identification

Gap Analysis

- Many QR-based systems are tested on small user groups or in controlled settings, lacking large-scale, real-world validation for visually impaired users [1][4][7].
- Placement and alignment of QR codes on products remain challenging; users often struggle to locate and scan codes independently [3][8][13].
- Several systems require online access to fetch metadata from QR codes, which limits usability in offline environments [1][9][10].

- Most solutions provide basic audio output but lack additional feedback modalities such as haptic cues or personalized guidance [4][6][7].
- While computer vision can complement QR systems, many applications do not integrate hybrid approaches for unreadable or damaged codes [5][12].
- QR-linked webpages or product metadata are often not optimized for screen readers or accessible formats, reducing practical utility [9][11].
- AI-based teachable models require quality user-generated training images, which can be challenging for blind users [4][7][14].
- Real-time recognition systems often demand high-performance devices, which may not be affordable or portable for end users [12][15].
- Most systems support a single language for audio output, limiting accessibility for non-English-speaking users [5][6][10].
- There is no established standard for QR code design, placement, and metadata structure for visually impaired users, hindering wider adoption [3][11][13].

Challenges

- Visually impaired users often face difficulty locating QR codes on products due to inconsistent placement, size, or lack of tactile cues.
- Damaged, obscured, or misaligned QR codes can lead to failed scans, reducing user confidence and system usability.
- Many systems require online access to retrieve product information, limiting functionality in offline or low-connectivity environments.
- Existing solutions often rely solely on audio output, lacking haptic or adaptive feedback to guide scanning and interaction.
- Most QR-based systems do not leverage AI to supplement scanning failures, which could improve recognition in real-world scenarios.
- Teachable AI systems require high-quality user-generated images, which may be challenging for blind users to capture effectively.
- Real-time object recognition and QR scanning often demand high-performance devices, affecting affordability and portability.
- QR-linked webpages or metadata may not be optimized for screen readers, multilingual support, or accessible formats, limiting practical usability.
- There is no universal guideline for QR code size, placement, tactile design, or metadata structure for visually impaired users, hindering wider adoption.
- Limited awareness of available assistive technologies and lack of training can reduce adoption and consistent usage among target users.

Limitation of this study

- This survey primarily focuses on QR code-based and AI-assisted assistive systems for visually impaired users, excluding other emerging technologies like RFID or NFC-based solutions.
- Many referenced systems are prototypes or small-scale implementations; the effectiveness of these solutions in large, real-world user populations remains unverified.
- Contextual Focus: Most studies concentrate on product identification and navigation tasks, so other applications such as educational tools or healthcare-specific scenarios are not deeply analyzed.
- The survey assumes availability of smartphones, QR code scanning apps, and AI-based solutions, which may not reflect accessibility limitations in all regions.
- There is insufficient information on universally accepted QR code placement, tactile design, or metadata formatting, which limits practical deployment recommendations.
- Few studies address language diversity or cultural differences in usability, which could affect the generalizability of solutions.

Conclusion

This survey analyzed recent advances in voice-based and QR code-assisted product identification systems for visually impaired users. Current solutions demonstrate promising usability improvements through audio feedback, AI integration, and tactile QR code designs. However, challenges remain in terms of QR code discoverability, system reliability, offline functionality, standardization, and inclusive design for diverse user populations.

Future Research Directions

We are working on developing hybrid systems that combine QR codes with AI-based object recognition to enhance their robustness in real-world conditions. Efforts are needed to standardize QR code placement, tactile enhancements, and metadata accessibility across different products. Additionally, expanding multilingual support, offline functionality, and large-scale user evaluations will enhance adoption and practical usability. Exploring personalized and adaptive feedback mechanisms, including haptic guidance, can further empower visually impaired users and improve independent interaction with everyday products.

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