**QUICK RESPONSE (QR) Code: Applications and Challenges in Our Society**

**KURUTSI Godwin Danjuma**

**(ST/CS/ND/21/026)**

**A SEMINAR PRESENTED TO THE DEPARTMENT OF COMPUTER SCIENCE, SCHOOL OF SCIENCE AND TECHNOLOGY, FEDERAL POLYTECHNIC, MUBI, ADAMAWA STATE, NIGERIA**

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**Abstract**

*QR (Quick Response) codes have emerged as a transformative technology, revolutionizing the way we interact with digital information and reshaping various aspects of our daily lives. These two-dimensional barcodes encode data that can be easily scanned and read by smartphones and other mobile devices, providing a gateway to a multitude of applications across diverse domains. This seminar paper explores the history, working principles, applications, benefits, and challenges of QR codes, providing a holistic understanding of their impact and potential in our digital age. Subsequently, it explores the wide-ranging applications of QR codes, encompassing marketing and advertising, contactless payments, ticketing and access control, healthcare, and more. The seminar emphasizes the benefits of QR codes, including enhanced user engagement, contactless transactions, cost-effective marketing, real-time analytics, versatility, and scalability. Despite their numerous advantages, also address the challenges and limitations of QR codes, such as privacy and data security concerns, the digital divide, lack of standardization, and environmental impact. In conclusion, it emphasizes the need for user education, standardization efforts, privacy safeguards, inclusivity in design, and ongoing innovation to fully harness the potential of QR codes and create a more inclusive, secure, and sustainable digital future.*

**Keywords**: QR code, Quick Response code, barcode, mobile technology, digital information.

**Introduction**

QR (Quick Response) codes have become an integral part of our daily lives, revolutionizing the way we interact with digital information. These two-dimensional barcodes encode data that can be scanned and read by smartphones and other mobile devices. The versatility of QR codes has led to their widespread adoption across various domains, but their prevalence also brings forth challenges that need to be addressed. In this review, we explore the applications of QR codes in different sectors and analyze the challenges they pose in our society. QR (Quick Response) codes have emerged as a transformative technology, revolutionizing the way we interact with digital information and reshaping various aspects of our daily lives. These two-dimensional barcodes encode data that can be easily scanned and read by smartphones and other mobile devices, providing a gateway to a multitude of applications across diverse domains. The versatility and convenience of QR codes have led to their widespread adoption, making them an integral part of contemporary society. In this introduction, we explore the history of QR codes, their fundamental working principles, and highlight their significance in modern applications (Li & Jiang, 2018).

The development of QR codes can be traced back to 1994 when Denso Wave, a subsidiary of the Japanese multinational corporation Denso, first invented them. Initially designed for tracking automobile parts during manufacturing, QR codes were intended to store more data than traditional barcodes while being easily readable and quickly accessible (Prasad & Jain, 2017). The unique square pattern, comprised of black modules arranged on a white background, allowed for faster scanning capabilities and error correction, making QR codes remarkably efficient in data storage and retrieval.

QR codes function as an encoded representation of data, typically URLs, text, or contact information, which can be decoded by smartphones and other compatible devices equipped with QR code scanning capabilities. The encoding process involves a series of algorithms and error correction techniques that enable QR codes to retain their integrity even when partially damaged or obscured (Gai & Diao, 2016). The basic components of a QR code include the finder pattern, alignment pattern, timing pattern, and data modules. The finder pattern consists of three distinctive square corners that help scanners identify the orientation of the QR code. The alignment pattern ensures accurate scanning, compensating for potential distortions. The timing pattern facilitates the proper alignment of modules, and the data modules store the actual encoded information (Li & Jiang, 2018).

**Literature Review**

A QR code (quick-response code) is a type of two-dimensional [matrix barcode](https://en.wikipedia.org/wiki/Barcode#Matrix_(2D)_barcodes), invented in 1994, by Japanese company [Denso Wave](https://en.wikipedia.org/wiki/Denso#Denso_Wave) for labelling automobile parts. A barcode is a machine-readable optical image that contains information specific to the labelled item. In practice, QR codes contain data for a locator, an identifier, and a [website visitor tracking](https://en.wikipedia.org/wiki/Website_visitor_tracking). To efficiently store data, QR codes use four standardized modes of encoding (i) numeric, (ii) alphanumeric, (iii) byte or binary, and (iv) [kanji](https://en.wikipedia.org/wiki/Kanji) (Yanagisawa, 2017).

A QR code consists of black squares arranged in a square grid on a white background, including some [fiducial markers](https://en.wikipedia.org/wiki/Fiducial_marker), which can be read by an imaging device such as a camera, and processed using [Reed–Solomon error correction](https://en.wikipedia.org/wiki/Reed%E2%80%93Solomon_error_correction) until the image can be appropriately interpreted. The required data is then extracted from patterns that are present in both horizontal and vertical components of the image (Prasad & Jain, 2017).

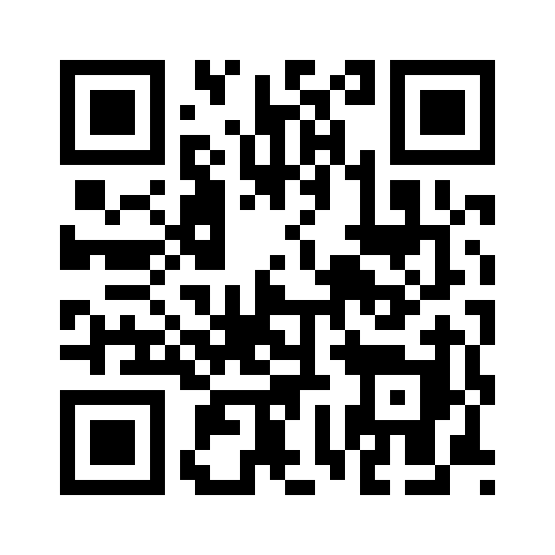


Figure 1: Quick Response code image (Chang, 2016).

QR codes have become common in consumer advertising. Typically, a [smartphone](https://en.wikipedia.org/wiki/Smartphone) is used as a QR code scanner, displaying the code and converting it to some useful form (such as a standard [URL](https://en.wikipedia.org/wiki/URL) for a website, thereby obviating the need for a user to type it into a [web browser](https://en.wikipedia.org/wiki/Web_browser)). QR code has become a focus of advertising strategy, since it provides a way to access a brand's website more quickly than by manually entering a URL Beyond mere convenience to the consumer, the importance of this capability is that it increases the [conversion rate](https://en.wikipedia.org/wiki/Conversion_rate): the chance that contact with the advertisement will convert to a sale. It coaxes interested prospects further down the [conversion funnel](https://en.wikipedia.org/wiki/Conversion_funnel) with little delay or effort, bringing the viewer to the advertiser's website immediately, whereas a longer and more targeted sales pitch may lose the viewer's interest (Leach & Jermann, 2012).

Although initially used to track parts in vehicle manufacturing, QR codes are used over a much wider range of applications. These include commercial tracking, warehouse stock control, entertainment and transport ticketing, product and loyalty marketing and in-store product labeling.[[citation needed](https://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] Examples of marketing include where a company's discounted and percent discount can be captured using a QR code decoder that is a mobile app, or storing a company's information such as address and related information alongside its alpha-numeric text data as can be seen in Yellow Pages directories (Khan, 2019).

They can also be used in storing personal information for use by organizations. An example of this is Philippines National Bureau of Investigation (NBI) where NBI clearances now come with a QR code. Many of these applications target [mobile-phone](https://en.wikipedia.org/wiki/Mobile_phone) users (via [mobile tagging](https://en.wikipedia.org/wiki/Mobile_tagging)). Users may receive text, add a vCard contact to their device, open a URL, or compose an [e-mail](https://en.wikipedia.org/wiki/Email#Message_format) or text message after scanning QR codes. They can generate and print their own QR codes for others to scan and use by visiting one of several pay or free QR code-generating sites or apps. Google had an [API](https://en.wikipedia.org/wiki/API), now deprecated, to generate QR codes, and apps for scanning QR codes can be found on nearly all smartphone devices (Manjunath & Suraj, 2019).

QR codes storing addresses and URLs may appear in magazines, on signs, on buses, on business cards, or on almost any object about which users might want information. Users with a [camera phone](https://en.wikipedia.org/wiki/Camera_phone) equipped with the correct reader application can scan the image of the QR code to display text, contact information, connect to a [wireless network](https://en.wikipedia.org/wiki/Wireless_LAN), or open a web page in the phone's browser. This act of linking from physical world objects is termed [hardlinking](https://en.wikipedia.org/wiki/Hardlink_(hyperlink)" \o "Hardlink (hyperlink)) or [object hyperlinking](https://en.wikipedia.org/wiki/Object_hyperlinking). QR codes also may be linked to a location to track where a code has been scanned. Either the application that scans the QR code retrieves the geo information by using GPS and cell tower triangulation (aGPS) or the URL encoded in the QR code itself is associated with a location (Li & Jiang, 2018).

**Applications of QR Code Technology**

The versatility of QR codes has led to their widespread adoption across numerous sectors, transforming the way businesses and individuals interact with information and services. Some of the most notable applications of QR codes include:

**Marketing and Advertising:** QR codes have transformed the advertising landscape, enabling businesses to connect with consumers in interactive ways. Companies utilize QR codes on print materials, product packaging, and advertisements to provide customers with instant access to promotional content, discounts, or product information (Salathé *et al.*, 2020). This application enhances the consumer experience and bridges the gap between offline and online marketing channels.

**Contactless Payments:** QR codes have played a pivotal role in the rise of contactless payments. Mobile wallet apps utilize QR codes to generate unique payment tokens, facilitating quick and secure transactions without the need for physical credit cards (Argyriou *et al.*, 2017). This technology has gained prominence in promoting cashless economies and enhancing payment convenience.

**Ticketing and Access Control:** QR codes have streamlined the ticketing process for events, public transport, and entertainment venues. Attendees can present their QR code tickets on their smartphones, eliminating the need for physical tickets and reducing paper waste (Valdez *et al*., 2021). Additionally, QR codes are used for access control, ensuring efficient and secure entry management at various venues.

**Healthcare and Medication Management:** In the healthcare sector, QR codes have significantly improved patient identification, medical records management, and medication tracking. QR codes on medical wristbands or prescriptions enable healthcare professionals to access accurate patient information swiftly, enhancing patient safety and treatment efficiency (Veira & Schmitz, 2021).

**COVID-19 Contact Tracing:** In response to the global COVID-19 pandemic, QR codes have played a crucial role in contact tracing efforts. Many countries and establishments have implemented QR code-based systems to record the movement of individuals and track potential exposure to the virus. Users can scan QR codes displayed at public places, businesses, or events to check-in and provide their contact information. In case of a COVID-19 positive case, health authorities can swiftly identify and notify potentially exposed individuals, aiding in the containment of outbreaks (Sohail & Sarwar, 2020).

**E-Ticketing and Boarding Passes:** QR codes have transformed the travel industry, enabling passengers to use electronic boarding passes and e-tickets. Airlines, trains, and buses have adopted QR codes to streamline the check-in and boarding processes. Passengers can access their QR code tickets on their smartphones, eliminating the need for printed documents and simplifying the travel experience (Eling *et al.*, 2021).

**Loyalty Programs and Coupons:** Retailers and businesses employ QR codes to enhance customer loyalty programs and distribute digital coupons. Customers can scan QR codes at checkout to receive loyalty points, discounts, or special offers. This application fosters customer engagement and incentivizes repeat business (Zhou *et al.*, 2021).

**Product Authentication and Anti-Counterfeiting:** QR codes have proven valuable in combating product counterfeiting and ensuring authenticity. Manufacturers affix QR codes on their products, allowing consumers to verify the genuineness of the item by scanning the code. This technology instils consumer confidence and helps protect brands from counterfeit activities (Kumar *et al.*, 2020).

**Interactive Museum Exhibits:** Museums and art galleries have embraced QR codes to offer interactive experiences to visitors. Exhibits are often accompanied by QR codes that provide additional information, audio guides, or videos when scanned. This enhances visitors' understanding and engagement with the displayed artifacts (Kim *et al.*, 2021).

**Digital Menus in Restaurants:** QR codes have found a prominent place in the restaurant industry, especially in the wake of the COVID-19 pandemic. Many restaurants have adopted QR code-based menus, allowing diners to view the menu on their smartphones without the need for physical menus. This contactless approach reduces the risk of transmission and improves the dining experience (Alrahdi *et al.*, 2021).

**Challenges in Society**

**Privacy and Security Concerns:** The widespread use of QR codes raises privacy and security concerns. Cybercriminals can potentially exploit poorly designed QR codes to direct users to malicious websites or phishing scams (Khan, 2019). Ensuring the safety of users' data and protecting them from cyber threats requires robust security measures and user education.

**Digital Divide:** Although QR codes are widely accessible to smartphone users, there remains a digital divide in society, with some individuals lacking access to smartphones or the necessary technological literacy (Hargittai & Hinnant, 2008). This disparity may lead to exclusion from the benefits of QR code-based services, exacerbating existing inequalities.

**Lack of Standardization:** The lack of standardization in QR code content and formats can lead to confusion and hinder seamless integration across different platforms and applications (Chang & Chang, 2016). To maximize their potential, standardization efforts should be prioritized to ensure a consistent user experience.

**Environmental Impact:** While QR codes have the potential to reduce paper waste, the widespread use of smartphones and their associated environmental impact should also be considered (Schluep, *et al*., 2014). The manufacturing, usage, and disposal of electronic devices contribute to e-waste, necessitating responsible recycling and sustainable practices.

**Advantages of Quick Response Code**

Enhanced User Engagement and Convenience: QR codes offer a seamless and efficient way for users to access digital content and services. By simply scanning the code with a smartphone, users can instantly access websites, multimedia content, or perform various actions, eliminating the need for manual data entry or complex URLs (Salathé *et al.*, 2020). This streamlined process enhances user engagement and provides a convenient and interactive experience.

**Contactless Transactions and Safety:** QR codes have gained prominence as a contactless payment method, enabling secure transactions without physical contact between the user and the payment terminal. During the COVID-19 pandemic, the contactless nature of QR code-based payments became particularly advantageous in reducing the risk of virus transmission, further promoting their adoption in various payment ecosystems (Vlachopoulou *et al.*, 2021).

**Cost-Effective Marketing and Advertising:** QR codes provide businesses with a cost-effective marketing solution. Companies can incorporate QR codes into their advertising materials, packaging, or promotional items, allowing them to direct customers to online content, special offers, or social media profiles (Trabelsi *et al.*, 2020). This approach facilitates targeted marketing and offers measurable results, making it an attractive option for businesses with budget constraints.

**Real-Time Analytics and Data Tracking:** QR codes enable businesses to gather real-time analytics on user interactions. Companies can track the number of scans, the location of scans, and the devices used for scanning, providing valuable insights into customer behavior and preferences (Argyriou *et al.,* 2017). These analytics help in refining marketing strategies, improving customer engagement, and optimizing overall business performance.

**Versatility and Scalability:** QR codes are highly versatile and can store various types of data, ranging from simple text and URLs to complex information such as contact details or Wi-Fi access credentials. Their ability to handle a wide array of data types makes them applicable in diverse industries, from retail and healthcare to logistics and education. Moreover, QR codes can be easily generated and distributed, making them scalable for large-scale implementations.Improved Inventory and Product Management: In the retail and manufacturing sectors, QR codes facilitate efficient inventory and product management. Manufacturers can embed QR codes on products or packaging, enabling easy tracking throughout the supply chain. Retailers can use QR codes for inventory management, simplifying stock counting and updating product information in real-time (Chang & Chang, 2016).

**Disadvantages of Quick Response (QR) Code**

**Limited Data Capacity:** QR codes have a finite data capacity, which means they may not be suitable for encoding large amounts of information. This limitation restricts their use in scenarios where extensive data needs to be stored or transmitted.

**Compatibility and Reader Accessibility:** Not all devices have built-in QR code readers or support for QR code scanning. Users may need to download separate apps or use specific devices to access QR code content, which can be a barrier to seamless user experiences.

**Risk of Misuse or Scanning Errors:** QR codes can be easily replicated or replaced with malicious codes. Scanning a malicious QR code can lead to security risks, such as phishing attacks or the spread of malware.

**Dependency on Internet Connectivity:** Many QR codes link to online content or websites, making them dependent on internet connectivity. If users are in areas with poor or no network coverage, they may not be able to access the linked content.

**Lack of Standardization:** QR codes come in different sizes, formats, and designs, leading to a lack of standardization. This lack of uniformity may cause compatibility issues and make it challenging for users to scan QR codes across different platforms.

**Invasion of Privacy:** Some QR codes are designed to track user interactions and collect personal data, raising privacy concerns among users who may not be aware of such tracking.

**Low Adoption in Some Regions:** While QR codes have gained popularity in certain regions, their adoption may be relatively low in others. This variation in acceptance can limit their effectiveness in global or diverse markets.

**Fading or Damage:** QR codes placed in outdoor environments or printed on low-quality materials may fade over time or get damaged, affecting their scannability and usability.

**Limited Error Correction:** While QR codes include error correction mechanisms, they are not foolproof. Damage to a QR code beyond its error correction capacity may render it unreadable.

**Conclusion**

QR codes have transformed various sectors in our society, enhancing efficiency, convenience, and user experiences. Their applications range from marketing and payments to healthcare and access control. However, several challenges need to be addressed, including privacy and security concerns, the digital divide, lack of standardization, and environmental impact. By acknowledging and addressing these challenges, we can harness the full potential of QR codes and create a more inclusive and sustainable digital future. By implementing the recommended measures, such as user education, standardization, privacy, and inclusive design, we can ensure the responsible and sustainable integration of QR code technology in our society. Embracing these recommendations will enable us to fully harness the potential of QR codes and create a more connected, secure, and efficient digital future.

**Recommendations**

1. To maximize the benefits of QR code technology and mitigate potential risks, it is essential to educate users about safe scanning practices and potential security threats.
2. To ensure seamless integration and user experience, industry stakeholders should collaborate to establish QR code standards and interoperability guidelines.
3. Considering the digital divide and the varying levels of technology adoption in society, it is essential to design QR code applications with inclusivity in mind.
4. Businesses and manufacturers should adopt sustainable practices, including responsible recycling of electronic devices and minimizing the environmental footprint of QR code-related technologies.
5. Governments and public institutions should explore the integration of QR code technology to improve the delivery of public services.

**REFERENCES**

Alrashdi, A., Alzahrani, S., Alharthi, Y., Alharbi, A., Alshaikh, R., Alotaibi, H., & Alanazi, M. (2021). A New Adaptive QR Code Steganography Method for Enhancing Data Hiding Capacity. *IEEE Access,* 9, 105839-105852.

Argyriou, L., Alexakos, C., & Christodoulakis, S. (2017). QR codes in educational material: The case of a museum guide. *Education and Information Technologies,* 22(1), 123-142.

Chang, I., & Chang, Y. (2016). Application of QR Code and Cloud Computing in Medical Care. *Proceedings of the International MultiConference of Engineers and Computer Scientists*, 1-5.

Chang, Y. (2016). Application of QR Code and Cloud Computing in Medical Care. *In Proceedings of the International MultiConference of Engineers and Computer Scientists* (Vol. 2, p. 1). Hong Kong.

Eling, N., Kolbe, L. M., & Brenner, W. (2021). An evaluation of QR code-based mobile payment in the hospitality industry. *International Journal of Hospitality Management*, 94, 102-858.

Gai, K., & Diao, X. (2016). A Novel Mobile Payment Model Using QR Code. *In Proceedings of the 9th International Conference on Ubiquitous Information Management and Communication* (pp. 1-6). ACM.

Hargittai, E., & Hinnant, A. (2008). Digital Inequality: Differences in Young Adults' Use of the Internet. *Communication Research*, 35(5), 602-621.

Khan, M. (2019). A Comprehensive Analysis of QR Code Applications: Current Challenges and Security Concerns. *IEEE Access,* 7, 57395-57411.

Kim, D. H., Lee, J., & Lee, H. H. (2021). Marketing analytics using dynamic QR codes in mobile media*. International Journal of Information Management,* 57, 102308.

Kumar, P., Haldkar, A., & Kumar, S. (2020). Role of QR code in building an efficient customer relationship management: a study in the context of small and medium enterprises. *International Journal of Information Management*, 54, 102191.

Leach, G., & Jermann, D. (2012). An Introduction to QR Codes. *Library Hi Tech News*, 29(8), 5-10.

Li, C., & Jiang, J. (2018). Application of QR code technology in ticketing system. *In Proceedings of the 2nd International Conference on Electronic Information Technology and Intellectualization* (pp. 84-87). ACM.

Manjunath, M., & Suraj, K. (2019). QR Codes—A Survey. *Computer Science and Information Technology*, 7(1), 41-48.

Prasad, A., & Jain, R. (2017). Application of QR Code in Advertising. *International Journal of Computer Applications*, 168(9), 1-4.

Salathé, M., Althaus, C. L., Neher, R., Stringhini, S., Hodcroft, E., Fellay, J. & Low, N. (2020). COVID-19 epidemic in Switzerland: on the importance of testing, contact tracing and isolation. *Swiss Medical Weekly*, 150, 20225.

Schluep, M., Hagelüken, C., & Kuehr, R. (2014). Recycling of electrical and electronic scrap: A growing sector. *Environmental Science & Technology*, 48(16), 8839-8840.

Sohail, A., & Sarwar, M. (2020). Impact of QR codes on mobile marketing: An empirical analysis. *Journal of Retailing and Consumer Services,* 55, 102101.

Trabelsi, M., Ouni, B., & Mohamed, M. B. H. (2020). A blockchain and QR code-based approach for counterfeit medicines detection. *Journal of Ambient Intelligence and Humanized Computing*, 11(8), 3449-3461.

Valdez, A., Dodds, W. B., & Weidman, M. (2021). Using QR Codes to Enhance Restaurant Menus: A Framework for Assessing Adoption, Usage, and Perceived Value. *Journal of Hospitality Marketing & Management*, 30(4), 469-484.

Veira, P. B., & Schmitz, J. C. (2021). An empirical analysis of the use of QR codes in inventory management for perishable goods in the retail industry. *International Journal of Production Economics,* 235, 108-175.

Vlachopoulou, M., Drossos, D., & Matsatsinis, N. (2021). The effect of loyalty programs on consumer behavior in the grocery retail sector: The moderating role of mobile applications and QR code promotions. *Journal of Retailing and Consumer Services*, 61, 102-510.

Yanagisawa, M. (2017). History and Future of QR Code Development. *Proceedings of International Symposium on Advanced Radio Technologies*, 1-7.

Zhou, J., Bai, H., Wang, S., & Zhang, X. (2021). Assessing China's payment system efficiency with the consideration of payment QR codes. *Economic Modelling*, 100, 108960.