

Application of QR Codes in Tourism Industry: A Review of literature

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Abstract

The impact of technology on our lives has resulted in the rise of innovative tools and applications designed to make everyday tasks simpler. QR codes is one such tool that is popularly used today in the service industry – especially in tourism industry – to enhance customer experiences. This review paper explores various aspects of QR codes and the ways in which QR codes are currently being used globally in tourism industry. This is done through review of available literature on and related to the theme of this paper. The trend of adoption of the same by countries is traced. The paper concludes that though several opportunities for QR code implementation exist, it also faces several challenges like lack of awareness of QR code technology, among others. However, addressing these challenges along with designing innovative applications for use of QR codes in tourism will catalyse the acceptance and use of these applications.

1. Introduction

Quick Response code, commonly known as QR code, is a type of 2-dimensional barcode that can be read with smartphones and web applications. Though developed by Japanese corporation Denso Wave in 1994 for industrial use, QR codes are extensively used today in advertising and packaging of products all over the world [1]. The increasing popularity of smartphones with round-the-clock Internet connectivity, along with the development of innovative commercial applications of QR codes, has led to its widespread use.

QR codes are widely used in service industry today, such as transport, food services, hospitality, entertainment industry, financial services, and tourism, to name a few. These applications include QR codes being used in restaurant menus to provide information on dishes served, QR codes being displayed on service receipts, or on transport tickets purchased through scanning of QR codes at stations and much more.

This review paper focuses on various aspects of QR codes and the applications of same in the tourism industry. This paper concentrates on how QR codes are made a part of consumers' overall experience when visiting a store, attraction or destination and how the tourism industry utilizes them in a number of ways. The paper also outlines the challenges related to implementation of QR codes, especially in the context of tourism industry.

2. Literature review

2.1. QR Codes: Origin and Evolution

QR codes are two dimensional barcodes invented by the Japanese company Denso Wave in 1994 [2]. It is used for fast encoding and decoding of data. It can be read using a QR reader or a camera-enabled smartphone equipped with QR reader software. Initially used for vehicle parts inventory control, QR codes are now used in a variety of industries.

Rouillard states that QR code is a matrix code developed primarily as a symbol to be easily recognized and decoded by scanner equipment, hence the term "Quick Response" code [2]. It varies from a classical barcode in the sense that QR code stores information in both vertical and horizontal directions. QR codes are now used extensively due to their ease of use and the popularity of smartphones. Depending on the nature of application, QR codes can be used to perform various actions such as opening a website link, dialing a phone number, sending a short text message, playing an .mp3 file, etc. QR codes were first used widely in Japan, appearing in magazines, advertisements, product wrapping and subway billboards. Subsequently, several companies in France, U.K. and Switzerland started using QR codes to promote products such as Swiss online newspaper, or to inform customers about daily rates (European Central Bank). Today, QR codes are used in print advertisements, online advertisements, billboards,

boarding passes, museums, passports, and restaurants to name a few.

“The symbol versions of QR Code range from Version 1 to Version 40. Each version has a different module configuration or number of modules. The module refers to the black and white dots that make up QR Code” [3]. As shown in Fig 1., each version features additional 4 modules per side when compared with the version immediately preceding it. The smallest QR code is a 21x21 matrix while the largest is a 177x177 matrix capable of storing 1261 characters of ASCII text. QR codes can be read even if the codes are dirty or partially obscured. This is due to error correction using Reed-Solomon Codes [3]. The storage capacity of a given QR code depends on factors like the amount of data to be encoded, its character type, and desired error correction level [3].

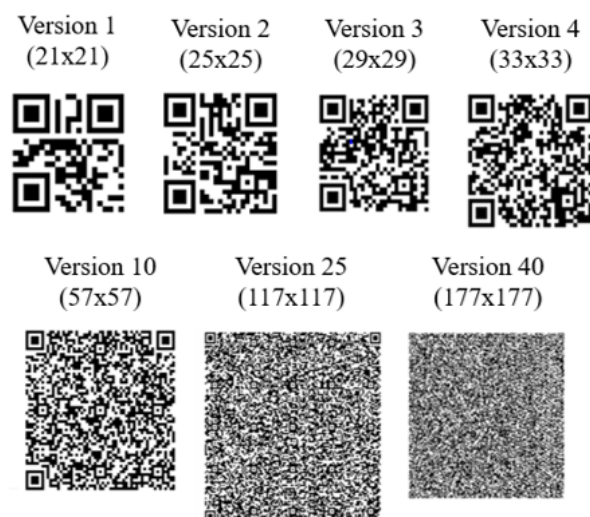


Figure 1. Versions of QR codes [4]

Thus, QR codes have progressed significantly since their invention in 1994. Whereas in early days, QR codes were capable of only coding numerals, QR codes today are capable of displaying a website, SMS, or even an mp3 file. With continuous development of QR code system over the years, information storing capacity as well as error correction capabilities have significantly improved.

2.2. User acceptance and behaviour towards QR codes

Though QR codes were invented 23 years ago, their potential has not been fully realized. Actual use of QR codes depends significantly on user acceptance and behavior towards them.

Bamoriya notes that “if marketers want desired response from consumers then their QR Code marketing promotion should be well planned” [1]. The author also mentions that “Marketers must provide some real value to customers once they scan a QR Code” unlike, for example, “a QR Code scan simply leading to homepage of a website which is not optimized for mobile phones or a QR Code placed on billboard on a speedy highway.” Some critics such as Patel believe that despite their rapid growth, QR codes are just a fad and are used by companies to communicate an impression of being innovative [5]. Others argue that QR codes are a powerful and cost effective tool which is not being utilized properly. Marketers are not focusing on clear objectives and value addition through QR codes, and thus fail to engage customers. Okazaki, Hirose, and Li found that a majority of Japanese consumers used QR codes to access coupons that are redeemed through scanning [6], whereas a study conducted by Watson, McCarthy, and Rowley in UK found that 75% of consumers use QR codes to obtain further information from a website, followed by access to games and discount vouchers [7]. Another study by Shin, Jung, and Chang states similar findings [8]. It also states that consumers are more likely to use QR codes when they perceive it to be more useful and easy to use. Additionally, they found that rather than being perceived as a commerce channel, QR codes are seen as social venues from which customers derive entertainment, education, and social interaction. This is evidenced by the growing trend of QR codes being printed on products. Scanning these codes lead users to manufacturers’ social media accounts such as Facebook or Twitter. Another association between entertainment aspect of QR codes and their perceived ease of use was found in a study conducted in US by Ryu and Murdock [9]. According to the authors, consumers find QR codes more useful and easy to use when they perceived using the QR code as enjoyable. This in turn leads to increased use of QR codes. Another factor that influences consumers’ intention to use QR codes is the consumers’ previous experience with the same [10]. In other words, consumers who have used QR codes in the past are more likely to do so in future. Based on the above discussion, it can be concluded that QR codes must be integrated into a marketing campaign such that they add value and entertainment to customers, as opposed to offering redundant information or being used by businesses just to be perceived innovative.

According to a study by Narang, Jain, and Roy, “for high involvement products where the associated risk is higher, consumers are more likely to use the QR codes [11]. If the QR codes are present, they are more likely to have more favorable attitudes.

Therefore, the impact of QR codes on consumer attitudes would depend on their nature of involvement in the product category". Tolliver-Walker states that most QR code users are primarily male smartphone users with above-average education and income [12]. They are usually looking for product information, discounts, and deals. Many scan QR codes because they are curious where it would lead them to. Tolliver-Walker opines that the fundamental problem related to QR codes is lack of awareness among masses and that marketers should focus on educating its customers on how to go about obtaining a scanner, scanning a code, and developing reasonable expectations from its use [12]. Watson et al. reported a similar finding, stating that lack of awareness of technology and benefits of QR codes were the primary reasons preventing people from using QR codes [7]. Consumers also felt that they would have been less hesitant to use QR codes if they had been taught how to scan QR codes.

Thus, it can be concluded that QR codes are generally used by customers for high involvement products or when customers are looking for product information, discounts, deals, or even to satisfy their curiosity. This may perhaps be due to the increased risk associated with select categories of products. Based on the discussion, it can be summarized that raising awareness of QR codes among the public and designing effective marketing campaigns involving QR codes is required.

2.3. QR Codes: Competing systems

The systems competing with QR codes include the traditional one-dimensional barcode and the Radio Frequency Identification (RFID) system.

Lotlikar, Kankapurkar, Parekar, and Mohite conducted a comparative study of barcode, QR-code and RFID System [13]. According to their study, 1-D barcodes differ from QR codes, especially in terms of functionality. 1-D barcodes are mechanically scanned using a narrow beam of light. However, QR codes are detected as a 2-dimensional image, and require a programmed processor to analyze image digitally. Moreover, QR codes can also hold much more data than a barcode, which has a limit of 20 alphanumeric characters as opposed to 7,089 characters stored in a QR code. Error correction techniques present in QR codes enable them to be read more reliably than other codes. According to the said study, QR codes offer significant advantages over RFID such as low cost. However, QR code requires line of sight to be read by a scanner, and information stored in QR code cannot be updated/ changed after generation, i.e., it is a read only technological application. Thus, QR

codes are superior to traditional barcodes and RFIDs in terms of data storage capacity, error correction techniques, ease of use, and low cost.

According to Várallyai, a limitation of barcodes is that some scanners cannot scan codes printed in very small dimensions, i.e., where the width of the narrow bar is too small [14]. Barcodes also require more expensive specialized scanners whereas QR codes can be scanned easily with a smartphone equipped with QR reader software.

QR codes are less susceptible to damage from water as the algorithm used to create QR codes allows for an error margin of 7-30% [14]. QR codes can easily be printed on any required surface and thus, relatively inexpensive to implement. Another advantage of QR codes is the ease with which they can be generated, it is even possible to do so using a smartphone. This is at odds with the effort and high cost that goes into implementing any other competing system, e.g. RFID. QR codes' distinctive square matrix design is easily recognizable as opposed to RFID tags which are not known to public.

Thus, it can be inferred that QR codes offer several advantages over competing systems such as RFID and traditional barcodes. QR codes are easier to use due to easy availability of scanners, low cost, ease of generation and implementation, and widespread recognition of their use. However, its drawbacks include inability to change stored information, requirement of line-of-sight and close range for scanning.

2.4. QR Codes: Security Issues

Despite several advantages, QR codes can also be used with malicious intent. The various security issues related to QR codes are presented next.

Peng, Sanabria, Wu, and Zhu state that QR code attacks are of two types – attacks on human interaction and attacks on automated systems [15]. Since the information in a QR code is completely obfuscated, human beings in general are not able to differentiate a legitimate QR code from a manipulated one. This makes them vulnerable to phishing attacks. Moreover, automated systems are quite prone to being attacked through SQL injections and command injections. Thus, QR codes may be used for undesirable activities because humans cannot distinguish a legitimate QR code from one that is not. The authors note that automated attacks often result from the assumption that the encoded information in QR codes is sanitized. Nevertheless, QR codes can easily be manipulated to attack the

backend software. The authors suggest that new security standards such as Public Key Encrypted QR codes, Signed QR codes, and Symmetric Encrypted QR codes can be implemented within the existing QR standards to increase protection. Thus, QR codes can be used to attack humans and automated systems, leading to phishing attacks or attacks on the backend software.

Kharraz, Kirda, Robertson, Balzarotti, and Francillon conducted an experiment by analyzing 14 million unique web pages over a ten-month period using a web crawler and concluded that relatively few malicious QR codes were found online and that the frequency of these attacks were not alarmingly high [16]. They observed that distributing harmful .exe files via QR codes are more frequent than other malware types. Their results indicate that personal/business websites and those websites offering free downloads are primarily used for QR code attacks. One of earliest uses of malicious QR codes was in 2011, where people scanned QR codes which then sent texts to premium-rate short numbers [17].

Vidas, Owusu, Wang, Zeng, Cranor, and Christin conducted a study on how vulnerable smartphone users are to phishing attacks through QR codes [18]. The researchers found that among those who scanned a QR code, 85% visited the corresponding URL thereafter. Many QR code applications automatically open a hyperlink without first permitting the user to verify it. A study conducted by Yao and Shin in 2012 found that 26% of the QR code applications present in Google Play Store didn't display a confirmation message asking the user whether s/he wants to visit a particular URL or not [19]. An astute user may identify a suspicious hyperlink if the reader displays the URL to her/him. However, "URL shorteners" are used to make it harder to assess the validity of a URL. The limited screen size of phones also hides long URLs. Among the top ten free QR scanning applications available in Google Play Store and Apple App Store, 30% and 50% respectively automatically visit a scanned URL in default configuration [18]. Vidas et al. also noted that 36% of phishing participants do not recall checking the link [18]. In fact, hackers have changed their twitter profile picture to a QR code encoded with a shortened URL that hosted malicious code, and users have fallen victim to this [20]. Thus, we conclude that the lack of awareness of QR code security issues leads users to blindly follow QR code links without verifying them.

Kieseberg, Leithner, Mulazzani, Munroe, Sinha, and Weippl investigated the use of QR codes as an attack vector, enumerating the various ways a QR code can be used for malicious purposes and

consequences of the same [21]. According to the authors, an attacker may manipulate a QR code by inverting any module, i.e., changing a white module to a black one or vice versa. A limited attacker, like one who is confined to the use of a black sketch pen, can only change white modules to black and not the other way around. They may change different parts of the QR code, such as the masks, character encoding mode, character count indicator, or data part and error correction so as to change the information embedded in it. By doing so, harmless QR codes can be turned into malicious ones. QR codes are capable of carrying harmful software, as the maximum amount of binary data capable of being stored in version 40 of QR code is 2953 bytes, whereas a computer worm capable of denial-of-service attacks is just 376 bytes in size [22]. Thus, different segments of a QR code can be modified by inverting any module, resulting in drastic change in the information stored.

The study by Kieseberg et al. also mentions various ways in which QR codes are used to attack human interaction [21]. If QR codes are used for web links, an attacker may redirect users to a fake website by changing the code. This can lead to phishing attacks if some form of identification is required to access the fake website. Similarly, in case of advertisements, these fraudulent websites can be used by an adversary to sell an unsolicited product without satisfying the agreement requirements. Furthermore, QR codes can attack reader software in cell phones and computers through command injection if the encoded information is not sanitized, thus exposing information stored in phones to attackers. Hence we conclude that QR codes can be used to manipulate users into believing that they are interacting with a legitimate source, whereas in reality they are being attacked.

Based on the above discussion, it is evident that QR codes can be used to attack both human interactions as well as automated systems. The inability of humans to distinguish between a valid and invalid code leads them to fall prey to attacks such as phishing or fraud. Awareness of security issues related to QR codes must be raised as most users do not check the authenticity of a QR code link before selecting it.

3. Methodology

This review paper is based on a review of available literature on QR codes. Online sources such

as Google Scholar and EBSCOHOST were used to seek information on QR codes. Further information on the same was obtained from magazine articles, newspaper clippings, and websites. Travel blogs, official websites of famous museums, and official YouTube videos from companies implementing QR codes were also inspected to identify contemporary applications of QR codes which were not otherwise available in published literature. The keywords ‘QR Code’ and ‘Quick Response Code’, along with keywords ‘tourism’, ‘user acceptance’, ‘applications’, ‘user behaviour’, ‘security issues’ and ‘competing technologies’ were used to filter search results on the Internet. From the search results, 20 research papers were selected on the basis of relevance to the topic, i.e., QR codes and their applications. They were

perused to review information on the origin of QR codes, their advantages and limitations over existing competing systems, consumer attitudes towards them, pertinent security issues, and contemporary applications of QR codes in various industries including the tourism sector. Based on a review of existing literature relevant to QR codes, numerous applications of the same worldwide as mentioned in the available literature were compiled.

4. Findings and Analysis

A summary of numerous applications of QR codes worldwide obtained from perusal of Internet sources and available literature is compiled below in Table 1.

Table 1. Use of QR codes in tourism industry

Application Type	Year	Country	Application	Source
QR codes on signboards	2016	JAPAN	QR codes mounted on police boxes in the city of Kyoto to help tourists find nearby attractions	(Cunningham, 2016)
	2015	INDIA	QR coded signboards are placed on road networks in the Indian state of Kerala which give information on nearby tourist destinations	(“Kerala Tourism Launches QR Code-Aided Search,” 2015)
	2014	CANADA	Track Toronto – QR codes are placed on signboards which link to music related to that location.	(Tyrrell, Doesburg, & Barhydt, 2014)
	2013	BRAZIL	QR codes are incorporated in the black and white mosaic pavements in Rio de Janeiro which give information about the city and its culture.	(G Garg, 2014)
	2013	SOUTH KOREA	Gangnam-gu has placed QR codes on the sidewalks. Tourists can scan them to get information about tourist destinations, restaurants and shopping areas in different languages	(News, 2013)
	2012	UK	Used in Kew Gardens – QR codes provide information about plants and heritage in video format	(Whiting, 2012)
	2012	NEW ZEALAND	Display of QR codes on retail outlets and buildings which lead users to online content related to dining/ retail offers and history of city respectively.	(O’ Sullivan, 2013)
QR codes used in transport services	2016	INDIA	Mumbai Railways – QR code ticketing systems whereby travelers can avoid long queues Brihanmumbai Electricity Supply and Transport – QR codes placed in buses; travelers scan these codes to obtain an e-ticket	(Rizwan, 2016)
	2012	UK	QR codes introduced in bus stops in West Yorkshire, scanning of the same provides real-time information related to the bus stop including bus schedules.	(“Metro introduces QR codes to bus stops,” 2012)
	-	NEW ZEALAND	QR codes displayed in bus stops	(“QR Codes,” n.d.-a)
	2010	USA	Incorporated in Washington DC bus stops	(Bonnington, 2010)
	2009	FRANCE	Bus stops in Paris feature QR codes to aid	(Colleen, 2013)

			travelers in finding bus schedules	
	-	CANADA	Winnipeg Transit, the public transit agency in Winnipeg, uses QR codes at bus stops	("QR Codes," n.d.-b)
QR codes in museums	2014	SERBIA	Usage of QR code in Museums	
	2013	AUSTRALIA	National Museum Australia (NMA) – QR codes help users to know more about the museum	(Mall, 2016a)
	2013	ITALY	QR codes used in Archaeological Museum of Bologna	("Information / For the Visitor", 2013)
	2013	CHINA	National Museum of China uses QR codes to link multimedia content and exhibit information.	("Website, Mobile Apps, QR Code, and 3D: the National Museum of China is banking on digital!," 2013)
	2012	RUSSIA	Contemporary art museum and gallery Erarta uses QR codes to display information in multiple languages and allow visitors to order prints of displayed art.	(Gautam Garg, 2015)
	2011	USA	QR codes used in Brooklyn Museum.	(Bernstein, 2011)
	2011	UK	Museum of London – QR codes are placed next to every exhibit which lead users to related short films	(Lee, 2012)
	2011	POLAND	QR codes used in Sukiennice museum in Krakow to bring paintings to life by showing videos related to exhibits.	("Creative QR Codes: Bringing Paintings to Life," 2013)
	2012-2014	FRANCE	QR codes are used in several museums in Paris, including the Musée des Arts décoratifs.	(Colleen, 2013)
QR codes used at tourist attractions	2014	UAE	The Dubai Islamic Affairs and Charitable Activities Department (IACAD) – QR codes placed in nine mosques provide information about the history, category, construction and capacity of these mosques	(Mall, 2016b)
	2013	AUSTRALIA	Whadjuk Trail Network – QR codes placed on walking trails allow trail users to listen to Aboriginal stories or know more about local flora and fauna	(Mall, 2016a)
	2010	USA	New York's Central Park – QR codes show trivia questions to visitors, the solutions to which provide them more information about the park. The River Walk Tour – QR codes provide photos and audio recordings to visitors.	(Ford, 2010) (Olivo, 2011)
QR codes used in hotels	2015	UAE	Kempinski Hotel at Ajman – QR codes placed in guestrooms help guests order food in 4 different languages. These orders are directly forwarded to the kitchen.	(Mall, 2016b)
	2012	FRANCE	Use of QR codes in hotels such Best Western Hotel Le Montparnasse, Fontainebleau Hotel Miami Beach and The Mirage Hotel and Casino. QR codes lead to PDFs detailing amenities available in hotel rooms and/ or provide improved customer experiences.	(Goula, 2012)
	2011	UK	The Radisson Edwardian Hotel – QR codes are placed in menus which lead to videos of dishes being prepared.	(Charlton, 2011)
QR code virtual	2014	QATAR	Virtual store launched by Vodafone where customers can scan QR codes to purchase prepaid	(Mall, 2016b)

stores			and postpaid phone plans.	
	2012	SWEDEN	Pop-up QR code store was placed at the Stockholm Central Railway Station to help travelers make purchases while waiting for trains by scanning the codes.	(Roman, n.d.)
	2012	USA	Online grocery store Peapod set up a QR code store in a railway station at Philadelphia.	(Roman, n.d.)
	2012	AUSTRALIA	Australian supermarket chain Woolworths set up a virtual QR code store in a railway station at Sydney.	(Roman, n.d.)
	2012	CANADA	Online health and beauty retailer Well.ca launched QR code virtual store at Toronto railway station.	(Roman, n.d.)
	2011	GERMANY	Natural cosmetics shop Aliqua placed 55 huge posters throughout Germany with the same look of their stores.	(Roman, n.d.)
	2011	UK	Online groceries shop Ocado set up a shopping wall with QR codes in London. A QR code wall was placed on the window of a John Lewis department store. Products that were ordered before 7pm could be collected the next day from the shop.	(Roman, n.d.)
	2011	SINGAPORE	Supermarket chain Cold Storage set up a QR code store in Bugis MRT Station.	(Roman, n.d.)
	2009	SOUTH KOREA	Tesco set up a virtual store in a subway station.	(Shop2mobi, 2012)

The above-mentioned illustrations of usage of QR codes in the tourism industry worldwide give a comprehensive understanding of the extent to which QR codes can enhance a tourist's experience. QR codes are cost effective, trackable and easy to use. The tourism industry uses QR codes to provide visitors with information about the national history and culture in different languages, thus overcoming language barriers. They also provide visitors ease of access to services which are offered to them. As a result, the use of QR codes as discussed in these applications adds value to customers' experience and simplifies activities undertaken by them. Though initially used in developed nations, the use of QR codes in tourism industry is fast becoming common in other parts of the world, as well.

5. Applications of QR codes

As illustrated in Table 1, the applications of QR codes in tourism industry are growing in popularity among different countries. The most common application of QR codes in tourism appears to be the display of codes on signboards, scanning of which provides further information on local history, culture, flora and fauna. These signboards may be kept on road-sides, integrated into city pavements, or even displayed on sides of buildings. National parks, zoos,

and museums also use QR codes to display more information on local attractions and museum exhibits. Integrating QR codes into public transport systems is also a popular application. Customers can scan QR codes at bus or railway stations to purchase tickets, facilitating paperless ticketing system which avoids long queues. QR codes are also integrated into boarding passes of airlines. Hotels and restaurants use QR codes to supply customers with details on amenities provided and display information on the ingredients and calories present in each dish, with videos of the dish being prepared. Apart from these applications, the use of QR codes to facilitate virtual shopping has also been adopted in some developed economies. Customers are able to make product purchases shown on displays at railways stations and other public places by scanning the corresponding code. However, some of these virtual stores were part of QR advertising campaigns and were removed after an interval of time. Thus, QR codes are used in tourism industry in several countries in a number of innovative ways to add value to their customers' experiences.

From Table 1. it is clear that developed nations such as USA, UK, France, Australia, Sweden, etc. adopted applications of QR codes in tourism faster than developing nations such as India, UAE, Brazil, Qatar and so forth. Though initially slow in

embracing benefits of QR codes, developing nations are now trying to implement applications of QR codes similar to those found in developed countries, as well as some innovative applications of their own. From the information obtained in Table 1., global use of QR codes in tourism industry are represented in the world map given below in Fig 2. This map was created using mapchart.net and is based on information found from Internet sources and

available literature, and is not based on actual use. Developed economies are shown in green and developing nations are shown in orange – this classification was done as per a world economic and financial survey carried out by International Monetary Fund [50]. Application of QR codes in tourism began in countries such as USA, UK, and Korea, later moving onto Australia, Italy, and Brazil, and most recently to India, UAE, and Qatar.

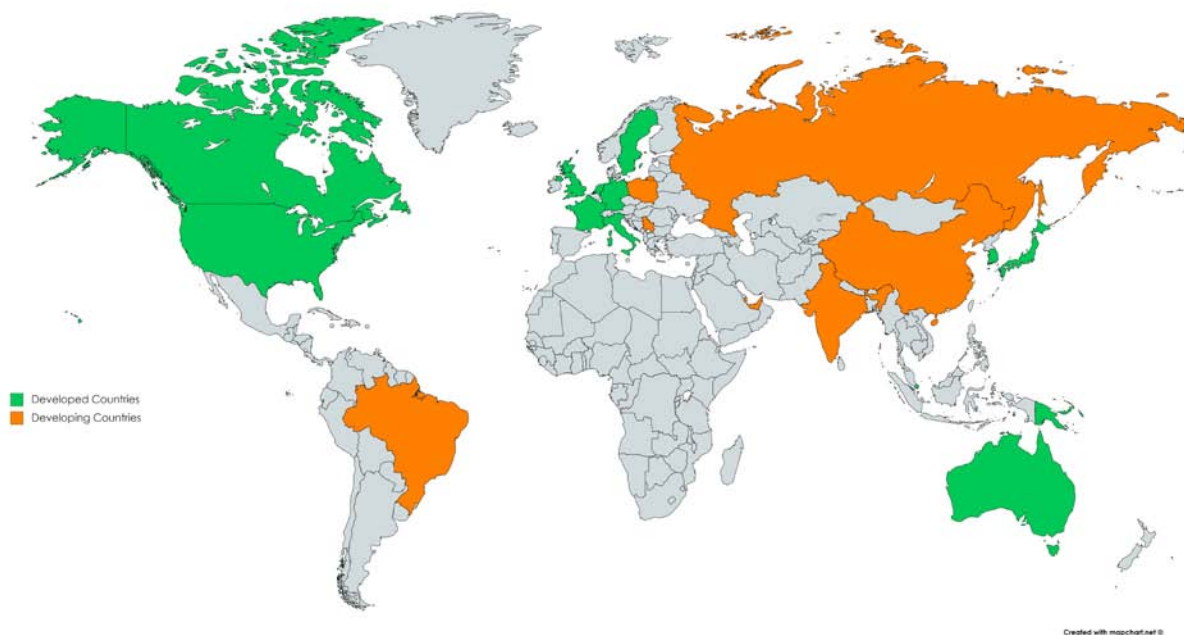


Figure 2. Global use of QR codes in tourism industry

Although QR codes have a variety of applications, they face several challenges as well. Unlike RFID tags, after a QR code has been printed, the information stored in it cannot be changed or updated. Additionally, QR codes require line of sight to be read and cannot be read through proximity of scanning device(s) alone. Moreover, QR code reader applications, though available for free download, do not come pre-installed in phones and this dissuades people from using them. The users of QR codes might also require access to Internet connection as most QR codes link to information online. This poses problems as Internet connectivity may not be available at all tourist locations. Additionally, the awareness of QR codes is less in certain parts of the world, which poses serious challenges for their successful implementation by different industries. Another challenge is the logistics required for collecting and organizing required data as well as the infrastructure necessary for generating, printing and putting up multiple QR codes at numerous appropriate locations.

To summarize, implementation of QR codes is hindered by a number of challenges such as lack of awareness of QR codes, limited Internet access in certain locations, the fact that QR code applications do not come pre-installed in smartphones, and the logistics and infrastructure required to undertake a large-scale application of QR codes.

6. Conclusion

QR codes are two-dimensional matrix barcodes used for encoding and decoding information quickly. They are used worldwide in numerous industries due to the popularity of smartphones and their ease of use. Specifically, QR codes are used by different stakeholders in tourism industry in innovative ways to add value to the services provided to tourists. They are integrated into the overall experience of customers while visiting shops, restaurants or tourist attractions. These include incorporating QR codes in museums, restaurants, hotels, bus and train stations, airline tickets, and street signs. QR codes are also

used to overcome language barriers, provide access to relevant information and provide location details via geotagging to name a few.

However, the implementation of QR codes is hampered by several challenges which include a lack of awareness of QR code technology in certain parts of the world, infrastructure required for wide scale implementation, and limited Internet availability in several destinations. Nevertheless, use of QR codes in tourism industry is widespread, and is expected to grow in popularity in coming years. Addressing the challenges faced and devising innovative applications for use of QR codes in tourism industry will certainly catalyze the acceptance and use of these applications seeing large interests of different stakeholders.

7. References

- [1] H. Bamoriya, "Cross-cultural Exploration of Consumers' Beliefs and Behavioral Intentions towards QR Codes in Marketing An Experimental Study in India and USA," *Acta Univ. Danubius. (Economica)*, vol. 10, no. 4, pp. 61–81, 2014.
- [2] J. Rouillard, "Contextual QR codes," *Proc. - 3rd Int. Multi-Conf. Comput. Glob. Inf. Technol. ICCGI 2008 Conjunction with Comp2P 2008 1st Int. Work. Comput. P2P Networks Theory Pract.*, pp. 50–55, 2008.
- [3] "QRcode.com," *Denso Wave*. [Online]. Available: <http://www.qrcode.com/en/>. [Accessed: 23-Nov-2017].
- [4] "QR code," *Wikipedia*. [Online]. Available: https://en.wikipedia.org/wiki/QR_code. [Accessed: 23-Nov-2017].
- [5] K. Patel, "Marketer Love for QR Codes Not Shared by Consumers. Advertising Age," 2012. [Online]. Available: <http://adage.com/article/digital/marketer-love-qr-codes-shared-consumers/231854/>.
- [6] S. Okazaki, M. Hirose, and H. Li, "QR code mobile promotion: an initial inquiry," *Adv. Advert. Res.*, vol. 2, pp. 405–420, 2011.
- [7] C. Watson, J. McCarthy, and J. Rowley, "Consumer attitudes towards mobile marketing in the smart phone era," *Int. J. Inf. Manage.*, vol. 33, no. 5, pp. 840–849, 2013.
- [8] D. H. Shin, J. Jung, and B. H. Chang, "The psychology behind QR codes: User experience perspective," *Comput. Human Behav.*, vol. 28, no. 4, pp. 1417–1426, 2012.
- [9] J. Sang Ryu and K. Murdock, "Consumer acceptance of mobile marketing communications using the QR code," *J. Direct, Data Digit. Mark. Pract.*, vol. 15, no. 2, pp. 111–124, 2013.
- [10] J. H. Jung, R. Somerstein, and E. S. Kwon, "Should I Scan or Should I Yawn? Consumers' Motivations for scanning QR Code Advertising," *Int. J. Mob. Mark.*, vol. 7, no. 3, pp. 25–36, 2012.
- [11] S. Narang, V. Jain, and S. Roy, "Effect of QR Codes on Consumer Attitudes," *Int. J. Mob. Mark.*, vol. 7, no. 2, pp. 52–65, 2012.
- [12] H. Tolliver-Walker, "Making Best Use of QR Codes: Gleaning Lessons from the Latest Data," *Seybold Rep. Anal. Publ. Technol.*, vol. 11, no. 23, pp. 2–8, 2011.
- [13] T. Lotlikar, R. Kankapurkar, A. Parekar, and A. Mohite, "Comparative study of Barcode, QR-code and RFID System," *Int. J. Comput. Technol. Appl.*, vol. 4, no. 5, pp. 817–821, 2013.
- [14] L. Várallyai, "From barcode to QR code applications," *Agric. Informatics*, vol. 3, no. 2, pp. 9–17, 2012.
- [15] K. Peng, H. Sanabria, D. Wu, and C. Zhu, "Security Overview of QR Codes."
- [16] A. Kharraz, E. Kirda, W. Robertson, D. Balzarotti, and A. Francillon, "Optical delusions: A study of malicious QR codes in the wild," *Proc. - 44th Annu. IEEE/IFIP Int. Conf. Dependable Syst. Networks, DSN 2014*, no. December, pp. 192–203, 2014.
- [17] G. Alexander, D. Tarakanov, Y. Namestnikov, S. Golovanov, and D. Maslennikov, "Monthly Malware Statistics: September 2011," *Kaspersky Lab*, 2011. [Online]. Available: <https://securelist.com/monthly-malware-statistics-september-2011/36426/>. [Accessed: 06-Nov-2017].
- [18] T. Vidas, E. Owusu, S. Wang, C. Zeng, L. F. Cranor, and N. Christin, "QRishing: The susceptibility of smartphone users to QR code phishing attacks," in *International Conference on Financial Cryptography and Data Security*, 2013, pp. 52–69.
- [19] H. Yao and D. Shin, "Towards preventing QR code based attacks on android phone using security warnings," *Proc. 8th ACM SIGSAC Symp. Information, Comput. Commun. Secur. - ASIA CCS '13*, p. 341, 2013.
- [20] K. Krombholz, P. Frühwit, P. Kieseberg, I. Kapsalis, M. Huber, and E. Weippl, "QR code security: A survey of attacks and challenges for usable security," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 8533 LNCS, pp. 79–90, 2014.
- [21] P. Kieseberg et al., "QR Code Security," in *Proceedings of the 8th International Conference on Advances in Mobile Computing and Multimedia*, 2010, pp. 430–435.
- [22] V. Sharma, "A Study of Malicious QR Codes," *Int. J. Comput. Intell. Inf. Secur.*, vol. 3, no. 5, pp. 3–8, 2012.
- [23] P. J. Cunningham, "Kyoto police in Japan will point the way for tourists with QR codes," 2016. [Online]. Available: <http://www.lonelyplanet.com/news/2016/09/30/kyoto-japan-police-tourists-qr-codes/>.
- [24] "Kerala Tourism Launches QR Code-Aided Search," *Huffington Post*, 2015. [Online]. Available: http://www.huffingtonpost.in/2015/02/18/kerala-qr-code-tourism_n_6706350.html. [Accessed: 06-Nov-2017].

- [25] J. Tyrrell, C. Doesburg, and L. Barhydt, "Track Toronto," 2014. [Online]. Available: <http://listentotrack.ca/>. [Accessed: 23-Nov-2017].
- [26] G. Garg, "How cities are becoming tourist-friendly on a low budget," 2014. [Online]. Available: <http://scanova.io/blog/blog/2014/06/30/make-city-tourist-friendly/>.
- [27] T. News, "Korea- Travel Smart with these Sidewalk QR Codes," 2013. [Online]. Available: http://english.visitkorea.or.kr/enu/AKR/FU_EN_15.jsp?cid=1782576.
- [28] J. Whiting, "The Rise and Success of QR Codes in London," 2012. [Online]. Available: <http://www.innovcity.com/2012/01/18/rise-success-qr-codes-london/>.
- [29] P. O' Sullivan, "QR code plan for Napier," 2013. [Online]. Available: <http://www.nzherald.co.nz/hawkes-bay-today/news/article.cfm?cid=1503462&objectid=11057084>.
- [30] Z. Rizwan, "Mumbai local trains to take the QR Code ticketing route," 2016. [Online]. Available: <http://scanova.io/blog/blog/2016/09/21/mumbai-local-trains-qr-code-ticketing/>.
- [31] "Metro introduces QR codes to bus stops," *West Yorkshire Combined Authority*, 2012. [Online]. Available: <https://www.youtube.com/watch?v=wEnc-dKI-Lw>. [Accessed: 23-Nov-2017].
- [32] "QR Codes," *metro*. [Online]. Available: <http://www.metroinfo.co.nz/info/Pages/QRCodes.aspx>. [Accessed: 23-Nov-2017].
- [33] C. Bonnington, "Check if Your Bus is On Time Via QR Codes at DC Bus Stops," *Gizmodo*, 2010. [Online]. Available: <https://gizmodo.com/5629783/check-if-your-bus-is-on-time-via-qr-codes-at-dc-bus-stops>. [Accessed: 23-Nov-2017].
- [34] Colleen, "Handy QR Codes for Paris Buses and Museums," 2013. [Online]. Available: <http://www.colleensparis.com/2013/09/handy-qr-codes-for-paris-buses-and-museums/>. [Accessed: 23-Nov-2017].
- [35] "QR Codes," *Winnipeg Transit*. [Online]. Available: <http://winnipegtransit.com/en/schedules-maps-tools/transittools/qr-codes/>. [Accessed: 23-Nov-2017].
- [36] S. Mall, "How QR Codes are used in Australia – 11 Examples," 2016. [Online]. Available: <https://scanova.io/blog/blog/2016/02/02/qr-codes-australia/>.
- [37] "Information / For the Visitor," *Archaeological Museum of Bologna*, 2013. [Online]. Available: <http://www.museibologna.it/archeologico/documenti/66371>. [Accessed: 23-Nov-2017].
- [38] "Website, Mobile Apps, QR Code, and 3D: the National Museum of China is banking on digital!," 2013. [Online]. Available: <https://app.pch.gc.ca/s/gc-cms/nouvelles-news/anglais-english/?p=6664>. [Accessed: 23-Nov-2017].
- [39] G. Garg, "How museums can enhance visitor experience," *Scanova*, 2015. [Online]. Available: <https://scanova.io/blog/blog/2015/08/08/visitor-experience-museums-qr-codes/>. [Accessed: 23-Nov-2017].
- [40] S. Bernstein, "QR Code Conundrum," 2011. [Online]. Available: <https://www.brooklynmuseum.org/community/blogosphere/2011/10/20/qr-code-conundrum/>. [Accessed: 23-Nov-2017].
- [41] V. Lee, "Museum of London," 2012. [Online]. Available: <http://www.museumsassociation.org/museum-practice/your-mobile-case-studies/15052012-museum-of-london>. [Accessed: 23-Nov-2017].
- [42] "Creative QR Codes: Bringing Paintings to Life," *Scandit*, 2013. [Online]. Available: <https://www.scandit.com/creative-qr-codes-bringing-paintings-to-life/>. [Accessed: 23-Nov-2017].
- [43] S. Mall, "QR Codes Gaining Popularity in the Middle East," *Scanova*, 2016. [Online]. Available: <http://scanova.io/blog/blog/2016/01/18/qr-code-middle-east/>.
- [44] N. Ford, "QR Codes in New York's Central Park," 2010. [Online]. Available: <http://qranywhere.blogspot.com/2010/05/qr-codes-in-new-yorks-central-park.html>.
- [45] B. Olivo, "New River Walk tour uses QR technology," 2011. [Online]. Available: <http://blog.mysanantonio.com/downtown/2011/05/new-river-walk-tour-uses-qr-technology/>.
- [46] J. Goula, "How hotels are using QR codes to provide improved customer experiences," 2012. [Online]. Available: <http://www.qrcodepress.com/how-hotels-are-using-qr-codes-to-provide-improved-customer-experiences/856515/>.
- [47] G. Charlton, "Q&A: Radisson Edwardian on QR codes and social media," 2011. [Online]. Available: <https://econsultancy.com/blog/7738-qa-radisson-edwardian-on-qr-codes-and-social-media>.
- [48] Roman, "Top 10 QR Code Store examples," *shop2mobi*. [Online]. Available: <http://www.shop2mobi.com/virtual-qr-code-store-examples/>. [Accessed: 23-Nov-2017].
- [49] Shop2mobi, "Tesco QR Code Subway Store," 2012. [Online]. Available: https://www.youtube.com/watch?v=Ups8_f95TOg.
- [50] IMF, *World Economic Outlook: Uneven Growth—Short- and Long-Term Factors*. 2015.