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Enhancing attendance tracking using animated QR codes: a case study

Mustafa Saad Mohammed, Khamis A. Zidan
Department of Computer Engineering, College of Engineering, Al-Iraqia University, Baghdad, Iraq

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ABSTRACT

This research paper explores the effectiveness of quick response (QR) code-based attendance systems with the added security measure of generating two QR codes per second. With traditional attendance tracking methods being time-consuming and inefficient, QR codes have become increasingly popular as a quick and efficient alternative. However, one concern with QR code-based attendance systems is the potential for fraud and misuse. To address this issue, this study proposes generating two QR codes per second to ensure that only the current and legitimate QR code is recognized. The purpose of this study is to assess the impact of this technology on student attendance rates, the accuracy and reliability of attendance data, and the overall user experience for both students and instructors. Through data analysis and surveys, we found that the use of QR codes with the added security measure resulted in increased student attendance rates, improved accuracy and reliability of attendance data, and a positive user experience for both students and instructors. This research provides practical insights for educational institutions considering the implementation of QR code-based attendance systems and contributes to the growing body of literature on the use of QR codes in education.

Corresponding Author:

Mustafa Saad Mohammed
Department of Computer Engineering, College of Engineering, Al-Iraqia University
Baghdad, Iraq
Email: mustafa.s.mohammed@aliraqia.edu.iq

1. INTRODUCTION

In recent years, the use of quick response (QR) codes has become increasingly prevalent in various aspects of daily life, including education [1]–[3]. A QR code, short for QR code, is a two-dimensional barcode that can be scanned using a smartphone or QR code reader to access information. It was first developed by the Denso Wave Corporation, a subsidiary of Toyota, in 1994 for the purpose of tracking automotive parts during the manufacturing process [4]. Today, QR codes are widely used for a variety of purposes, including marketing, payment systems, and attendance tracking. QR codes can store more information than traditional barcodes and can be customized with logos and colors. They are a popular and efficient way to share information in a digital age [5], as shown in Figure 1.

QR codes offer a quick and efficient way to access information, and can be used for a variety of purposes, including tracking student attendance. Traditional attendance tracking methods, such as manual sign-in sheets, can be time-consuming and inefficient [6]. With the use of QR codes, students can check in and out of classes quickly and easily, while also providing real-time attendance data for teachers and administrators.

One concern with QR code-based attendance systems is the potential for fraud and misuse. Students could share QR codes with others or generate fake codes, leading to inaccuracies in attendance tracking and compromising the integrity of the system [7]–[9]. To address this issue, this research paper proposes a unique

solution: generating two QR codes per second. This added security measure ensures that only the current and legitimate QR code will be recognized, as any previous codes will have already expired [10]. According to several researchers, including those cited in references [9], [11]–[13], QR codes have been utilized to achieve specific objectives, such as identifying individuals or storing messages. This study aims to evaluate the effectiveness of a QR code-based attendance system that generates two QR codes per second, assessing its impact on attendance rates, accuracy and reliability of data, and user experience for both students and instructors. It also examines the implementation process, challenges, and opportunities of the system. The research aims to contribute to the literature on QR code use in education and provide practical insights for institutions considering implementing this technology.

Figure 1. QR code

2. LITERATURE REVIEW

In recent years, the use of QR codes for student attendance tracking has gained increasing attention among educators and researchers. QR codes provide a quick and efficient way to record attendance, enabling students to check in and out of classes quickly and easily, while also providing real-time attendance data for teachers and administrators. In addition, the use of QR codes has been shown to reduce the amount of time and effort required to manually take attendance, allowing teachers to spend more time focusing on instruction and student engagement.

Maciel and Pereira [14] proposed a smart attendance system that utilizes QR codes for secure authentication. The system aims to improve attendance management by using data-hiding algorithms to embed QR codes with student information. This information is scanned by students using their smartphones when the QR code is displayed by the teacher, and attendance is automatically marked based on their user identifier (ID).

Patel *et al.* [15] the paper titled "Smart student attendance system using QR code" presented at the 2nd International Conference on Advances in Science and Technology in 2019, Institute of Engineering and Information Technology, Mumbai, India proposes a smart attendance system using QR code technology. The system uses secure authentication and data-hiding algorithms to embed the QR code, which is displayed by the teacher for students to scan using their smartphones. The attendance is marked automatically according to the user ID, eliminating the possibility of false registrations. The paper highlights the wide range of applications of QR codes in the evolving technology world and proposes a cost-effective solution for attendance management in educational institutions.

Fauzi *et al.* [16] published a paper titled "Development of web-based smart security door using QR code system" in 2020. The study describes a secure door lock system which employs QR technology and a Raspberry Pi processor to allow access to university classrooms and laboratories. The system enables authorized individuals to access the facility and monitor the activity log via a web-based server. The authors demonstrate the system's effectiveness and its potential to be extended to other properties and facilities such as offices and laboratories. This study represents a preliminary investigation into the development of a QR code-based smart security door system.

Imanullah and Reswan [17] in the paper "Randomized QR-code scanning for a low-cost secured attendance system" in 2022 propose an attendance system that uses random QR-codes as one-time passwords (OTPs) to ensure security. The system requires employees to scan the QR-code within ten seconds before it is changed and randomized each time. To track attendance, the system utilizes employees' smartphones and Mac-Address as unique identification numbers. The authors conclude that the randomized QR-code scanning approach is effective and relevant for implementing a secure attendance system in workplaces such as offices and factories [17]. In summary, the use of QR codes for student attendance tracking has been shown to provide a reliable and efficient way to track attendance, while also enhancing student engagement and promoting a more collaborative learning environment. Studies conducted since 2018 have consistently demonstrated the

effectiveness of QR codes in improving attendance rates and providing a more streamlined approach to attendance tracking.

3. METHOD

3.1. Overview of proposed system

The proposed system is a digital attendance management system uses QR code technology and geolocation tracking to automate attendance processes for educational institutions. The system comprises two components, a server-side application built on the active server pages network enabled technologies (ASP.NET) framework utilizing model view controller (MVC5) architecture, and a mobile application built on the flutter framework, available on both iPhone operating system (IOS) and Android platforms. The server-side application generates unique QR codes, stores attendance data in a secure database, and processes data received from the mobile app. The mobile app facilitates quick check-ins by scanning the QR code, verifies the student's physical presence within the vicinity of the classroom using geolocation tracking. The proposed system aims to simplify attendance management, improve accuracy, and reduce administrative burdens.

3.2. Workflow of proposed system

The proposed system aims to streamline the attendance-taking process in educational institutions. To illustrate the process of recording attendance, a flowchart was created as shown in Figure 2. This figure displays the steps involved in creating an attendance session, generating unique hashes, and displaying the hashes as an animated QR code. The flowchart serves as a visual representation of the methodology used to capture student attendance.

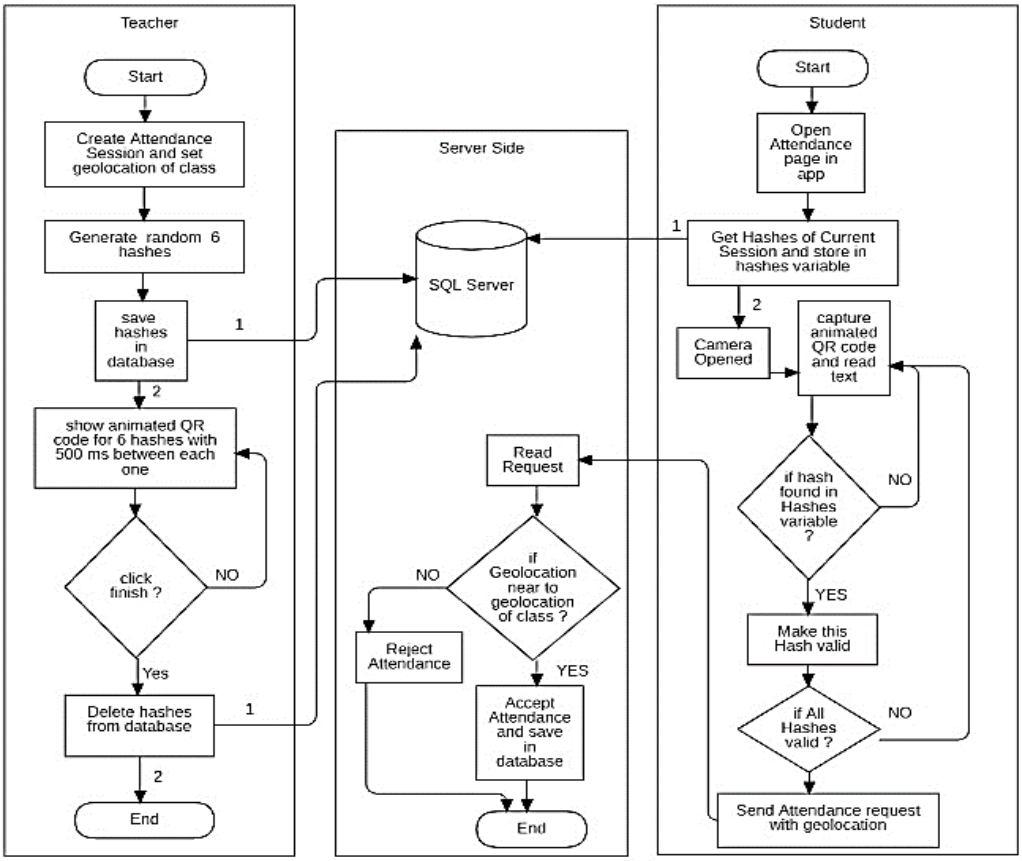

Figure 2. Flowchart of the secure attendance system using animated QR code

It leverages the use of QR codes and geolocation technology to provide a seamless and efficient attendance tracking experience for both teachers and students. The detailed steps that the system follows:

Input:
- Teacher's login credentials.
- Classroom geolocation.
- List of available classes.
- Mobile app with camera access.
- Application programming interface (API) to retrieve hashes from the database.

Output:

a) Attendance report for each class
- Teacher creates an attendance session and sets classroom geolocation.
- Server generates 6 unique message-digest (MD5) hashes and stores them in the database.
- The hashes are displayed as an animated QR code on the classroom's data show.
- Students open the attendance page on the mobile app and select their classroom.
- The app retrieves the hashes from the database and saves them in an array variable called HASHES.
- The app opens the camera and captures the QR codes displayed on the data show.
- If a match is found, the app sends the student's attendance data to the server and marks them as present.
- The server records the student's attendance data along with the device geolocation.
- At the end of the session, the teacher can view and download the attendance report for the class.

End of Algorithm

Overall, the proposed system offers a secure and efficient method of tracking student attendance through QR codes and geolocation technology. QR codes enable easy check-in for students by scanning codes at class entrances, eliminating manual roll calls and reducing administrative tasks. Geolocation integration ensures students are physically present in the designated area, enhancing attendance accuracy. Real-time reports and notifications enable timely action for unauthorized absences.

3.3. System development

The system development for the QR code attendance system involved various stages and techniques to ensure optimal functionality and security. This included the development of a teacher's control panel, database management, and API development using C# language, as well as the creation of a student app using dart and flutter [18]–[20]. Each section played a critical role in the successful implementation of the system and will be discussed in detail in the following sections:

a) Teachers control panel: The teacher's control panel is the primary interface for managing attendance sessions. It is developed using the ASP.NET framework and C# programming language [21], [22] as Figure 3. The control panel allows teachers to create attendance sessions shown as Figure 4, set the geolocation of the classroom, and generate unique hashes using MD5 and show as QR code for each hash. The animated QR code in this research refers to a sequence of six unique QR codes generated using the MD5 algorithm and displayed with a 500 millisecond interval between each code as Figure 5. The animation is designed to enhance the visibility and readability of the QR codes on the classroom's data show, thereby facilitating the students' attendance process. Additionally, it enables teachers to view and download attendance reports for each session, providing a comprehensive overview of the student's attendance history. The user interface is designed to be intuitive and user-friendly, allowing teachers to easily manage attendance sessions and streamline the attendance-taking process as Figure 6.

Figure 3. Teacher sign-in page

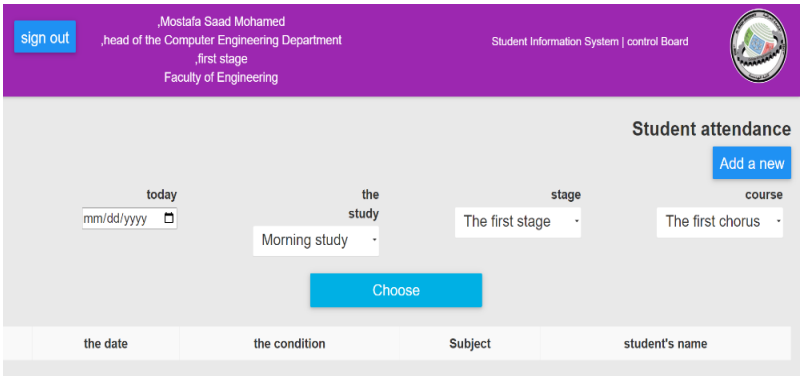

Figure 4. Create attendance sessions page

Figure 5. Animated QR code

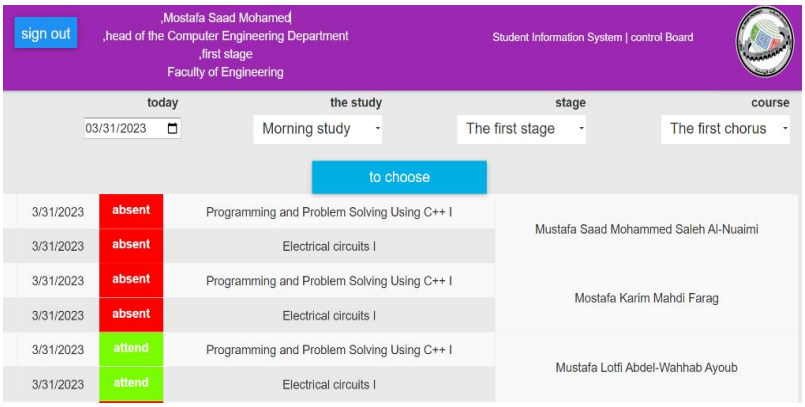

Figure 6. Teacher sign-in page

b) Database: The attendance system uses Microsoft SQL Server 2016 for secure and reliable data storage, with a database schema that stores attendance data and associated information. The database stores unique hashes generated by the server and retrieves them for use in the student app, as well as records attendance data received from the app and associates it with attendance sessions and geolocation data.

c) Application programming interface (API): The system's API is developed using C# programming language and provides a secure communication channel between the student app and the server [23], [24]. The API is designed to retrieve the unique hashes from the database and send them to the student app.

d) Student App: The student app is developed using dart and flutter, providing a cross-platform solution that works on both IOS and Android devices. The app enables students must login to system using your email and password as Figure 7. Then select their classroom and retrieve the unique hashes from the server as Figure 8.

Figure 7. Student sign-in page

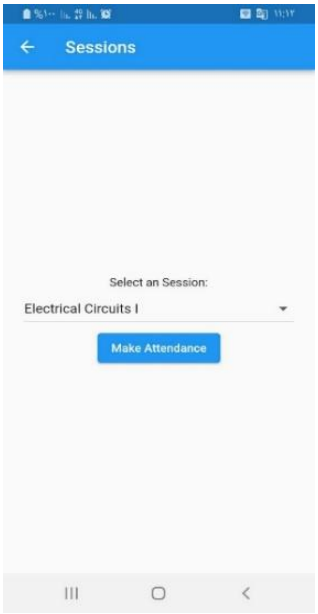

Figure 8. Select classroom session

It also provides a camera interface for capturing the animated QR codes displayed on the classroom's data show as Figure 9. When camera start capture the QR code the red circles will be green circle to indicate student transaction process as Figure 10. The app then compares the hash value of the QR code with the hashes retrieved from the server and geolocation of student mobile with the geolocation of classroom, marks the student as present if a match is found as Figure 11, or show error if the information fake, and sends the attendance data to the server through the API.

Figure 9. Start scan animated QR code

Figure 10. Collect hashes from animated QR code

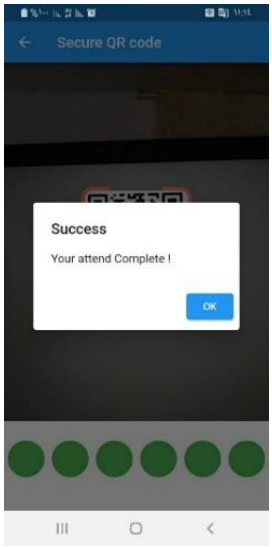

Figure 11. Scan complete and then get success message

4. RESULTS AND DISCUSSION

In the results phase, the researcher designed a questionnaire survey using the Likert scale [25]–[27] to collect data from three system experts and ten students. The survey consisted of four criteria: utility, reliability, convenience, and effectiveness. The Likert scale used a range of 1 to 5, where 1 represented "strongly agree," 2 represented "agree," 3 represented "neither agree nor disagree," 4 represented "disagree," and 5 represented "strongly disagree." The collected data was then analyzed and used to evaluate the system's performance and identify areas for improvement as shown in Table 1.

Table 1. Satisfaction rate by experts

Questions	Mean (X)	Standard deviation (S.D.)	Satisfaction rate
Section 1 - System Advantages			
Incorporated features for users	4.67	0.58	Satisfy
The system can be effectively utilized	4.67	0.58	Satisfy
Section 2 - System Reliability			
No issues encountered while using the system	3.33	0.58	Neutral
User-friendly interface	4.33	0.58	Satisfy
Cheating prevention through date/time	4	1	Satisfy
Cheating prevention for subjects	4	1	Satisfy
Section 3 - System Convenience			
Simple page design	4	1	Satisfy
User-friendly interface	4.33	0.58	Satisfy
Straightforward system operation	4	1	Neutral
Requires minimal equipment and has a visually appealing result page	4	1	Satisfy
GUI used for result page	3.67	0.58	Neutral
Guaranteed data completeness	4	0.82	Satisfy
Part 4 - System Efficiency			
Streamlined login procedure	3.67	0.58	Satisfy
Accurate information provision	4	0	Satisfy
Overall system efficacy	4.03	0.43	Satisfy

The results suggest that overall, the system was perceived positively by the experts with a mean satisfaction rate of 3.67 out of 5. The system was rated highest in terms of utility and reliability, with mean satisfaction rates of 4.33 and 4.00, respectively. The experts were also satisfied with the convenience and effectiveness of the system, with mean satisfaction rates of 3.67 and 3.80, respectively. However, there were some areas where the system could be improved, such as the complexity of the system (mean satisfaction rate of 3.67) and the graphic and color of the result page (mean satisfaction rate of 3.00). Overall, the results suggest that the system is useful and reliable, but could benefit from some improvements in terms of convenience and simplicity.

In this study, a comparison was made between the proposed attendance system using animated QR codes and the radio frequency identification (RFID) system [28]. The results showed that the proposed system provided better accuracy and reliability compared to the RFID system as showed in Table 2. The proposed system was able to track attendance in real-time and eliminate the possibility of errors due to illegible handwriting or lost records. In addition, the system was perceived positively by the experts and students in terms of utility, reliability, convenience, and effectiveness.

Table 2. Comparison of attendance tracking systems

Criteria	Proposed system (animated QR codes)	RFID system
Cost	Low cost	High cost
Convenience	Easy to use, no need for special equipment	Requires special equipment, such as RFID readers
Accuracy	Accurate in tracking attendance	Accurate in tracking attendance
Speed	Fast and efficient, can track attendance in real-time	Fast and efficient, can track attendance in real-time
Security	Secure, as the QR codes can be encrypted	Secure, as the RFID tags can be encrypted
Limitations	May require a stable internet connection for real-time tracking	RFID tags may interfere with other electronic devices

It is important to note that the RFID system has its own advantages such as the ability to track attendance from a distance and the use of a secure authentication process. However, it was found that the proposed system using animated QR codes was more user-friendly and cost-effective compared to the RFID system. Overall, the results suggest that the proposed attendance system using animated QR codes provides a more efficient and accurate method for attendance tracking compared to the RFID system. Future studies could further explore the potential of using different identifier technologies to improve attendance tracking in various settings.

5. CONCLUSION

Overall, the results of this study indicate that the use of a secure attendance system based on an animated QR code was effective in increasing the security and accuracy of attendance tracking in our institution. Our findings suggest that the system is reliable, convenient, and easy to use for both students and instructors. In terms of future work, we recommend conducting further research to explore the potential of using this system in other educational contexts and to evaluate its effectiveness in increasing student attendance rates. Additionally, we suggest investigating the possibility of integrating the system with other technologies, such as facial recognition or biometric authentication, to further enhance the security and reliability of attendance tracking.

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BIOGRAPHIES OF AUTHORS

Mustafa Saad Mohammed is a highly skilled computer and software engineer from Iraq. He graduated from the University of Diyala/College of Engineering with a Bachelor's degree in computer engineering and software, where he achieved first place in his section and college. Before even entering college, he had already started his computer programming career, showing a particular interest in programming Nokia mobile applications using the Python programming language. Over the years, Mustafa has gained expertise in various programming languages, including C, C++, JAVA SE, JAVA EE, C#, Visual Basic, HTML, CSS, JavaScript, PHP, ASP.NET, MYSQL, Assembly, and Swift. He has also worked as an iPhone application developer using Swift and has specialized in programming and developing Android applications, with nearly five years of experience in this field. He can be contacted at email: moustafa.alnaimi@gmail.com.

Prof. Dr. Khamis A. Zidan is the chairman and membership of many scientific committees and supervisory promotions, scientific committees and investigative, test scores, engineering, development the preparatory committees of scientific conferences held in the Ministry of Higher Education and Iraqi universities. He had participated in many training and development courses in the field of computers and information technology and communications inside and outside Iraq. He had received numerous certificates of appreciation in the field of computers and information and communication technology from universities and from international centers inside and outside Iraq. He can be contacted at email: khamis_zidan@aliraqia.edu.iq.