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## REVIEW OF EXISTING BARCODE SOLUTIONS IN BIOMETRICS AND ITS APPLICATIONS BASED ON QR CODES

**Abstract.** In this study, a comprehensive analysis of existing solutions for encoding barcodes in the field of biometrics is presented, with a special emphasis on integration into QR codes. The research begins with an introduction to the analysis topic, highlighting the critical intersection of biometrics and QR code technology. The main objective is to assess potential areas of application and the advantages of using QR codes as a means of encoding biometric data. The study underscores the importance of this integration in strengthening security measures, optimizing identification processes, and expanding the scope of application in various domains. Additionally, the study describes the methodology employed, including a detailed review of relevant literature and a general analysis of existing solutions. The results of this research shed light on the effectiveness and adaptability of biometric QR codes, providing valuable insights into their practical application. This study makes a significant contribution to the field of biometric technology, illuminating the innovative use of QR codes. The research findings serve as a valuable resource for both academic circles and practical implementation, offering a foundation for further refinement of secure identification methods.

**Key words:** Biometric Methods, Barcodes, QR Codes, Personal Identification, Biometric Authentication, Biometric Technology.

### 1 Introduction

Relevance of the Topic: Since the beginning of the 21st century, we have witnessed a rapid development of technologies that affect all aspects of modern life. A crucial aspect of this progress is the question of personal authentication in the digital environment. In this context, the topic addressed in this article – the interaction of biometric authentication methods and QR codes – represents an extremely relevant and promising research direction. Research Objective: Our main goal is to survey existing biometric authentication methods and QR codes, and then analyze the possibilities of their combined application. This analysis will allow us to assess the prospects for improving authentication methods and enhancing security in the digital environment. With the growth of online transactions, electronic documents, and data storage, security and authentication issues become critically important. Traditional authentication methods, such as passwords, are increasingly vulnerable to new forms of cyber threats. In this context, the development and analysis of biometric methods and QR codes appear as promising avenues to enhance security in the digital space. Despite the active interest in the authentication topic, the integration

of biometric methods with QR codes remains a relatively underexplored area. Existing works focus on partial aspects of this issue, suggesting the presence of untapped potentials in this field [1-2].

### 2 Overview of Existing Biometric Methods

Facial recognition is a widely used technology in the modern world, as it can be applied in all areas of society's activities. Facial recognition utilizes facial characteristics, unlike other types of biometric authentication (which we will discuss below). This technology records the spatial geometry of distinctive facial features for further recognition. Facial recognition can be divided into four major groups based on the method of processing: 2D facial recognition, 3D facial recognition, facial recognition based on skin texture, and facial recognition based on thermal imaging. In 2D facial recognition, the person's image is used for identification [3]. It goes through several stages before yielding an identification result with the answer to who exactly is depicted on it. The identification process consists of the following stages:

- Face recognition;
- Face detection;
- Face alignment;

- Feature extraction;
- Matching features with other features from the database consisting of people’s features for identification.

Some of the most common biometric characteristics applied in modern technologies worldwide [4], including in Kazakhstan, include:

*Fingerprint recognition:* One of the most common and widely used types of biometric identification. Fingerprints are unique to each individual and extremely difficult to forge.

*Facial recognition:* A technology that uses geometric features of the face for identification and authentication. Applied in surveillance systems, mobile devices, and other fields.

*Iris recognition:* This method uses the unique features of the iris of the eye for identification.

*Voice biometrics:* Analysis of unique characteristics of a person’s voice, such as tone, speech features, and other parameters, for authenticity verification.

*Retina scan:* Examination of the unique retina pattern for establishing identity.

*Electrocardiogram (ECG):* Measurement and analysis of unique electrical signals of the heart for biometric authentication.

In Kazakhstan, biometric technologies are also actively applied in various fields, including government identification management, security, access control, financial services, and many others. They are used for creating passports, driver’s licenses, electronic identity documents, as well as in security and access control systems in enterprises and organizations. These technologies contribute to enhancing security levels, improving efficiency, and convenience in various areas of activity.

### 3 Barcode Technology

Barcode technology plays a crucial role in modern business by providing efficient tools for the identification and tracking of goods, as well as optimizing logistical and managerial processes. Barcodes, as an established technology, have several significant advantages that are important to consider when analyzing biometric QR codes.

Barcodes stand out for their ease of use. Generating and reading them requires minimal resources and time. This is particularly important in the context of widespread adoption – even untrained users can operate this technology.

The effectiveness of barcodes is not limited to a single industry. They are successfully used in

retail, logistics, healthcare, and many other sectors. This versatility confirms their importance as a fundamental tool for tracking and identification.

The use of barcodes significantly reduces the likelihood of errors compared to manual data entry. This is especially critical in fields where data accuracy is of paramount importance. Additionally, they serve as a means of protection against counterfeiting, as they are difficult to replicate.

Barcodes, as a technology with a long history, have seamlessly integrated with new technological developments. They easily integrate with modern mobile devices, enabling their use in mobile applications and services.

The use of barcodes allows companies to gather detailed information about sales, inventory, and consumer behavior. This data can be analyzed to optimize processes and develop business growth strategies.

Overall, barcode technology represents a reliable and versatile tool for data identification and tracking. Its effectiveness and ease of use make it indispensable in various industries, making it a significant milestone in the development of modern technologies [5].

### 4 Biometric Barcodes: Technologies and Applications

In the modern world, identification plays a pivotal role in various spheres. Biometrics, the science of recognition based on unique physiological and behavioral characteristics, has become a reliable tool for security, access control, and authentication.

Biometric barcodes have garnered special attention. They are unique symbolic sequences that store information about an individual in a specific format. They combine biometric technologies with the convenience and reliability of encoding.

The fundamental principle behind the operation of a biometric barcode lies in the fact that the unique sequence of bars and spaces in the barcode can be associated with specific characteristics of a person. These characteristics may include various parameters such as anthropometric data, biochemical indicators, medical history, and more. Each barcode represents a unique identifier for the corresponding set of data [6].

Biometric barcodes are unique encoded sequences capable of storing information about an individual’s biological characteristics. There are several different types of biometric barcodes:

Anthropometric Barcodes are used to encode data about measurements and body parameters of a person. They include information about the sizes and shapes of various body parts, such as finger lengths, wrist circumference, and other anthropometric characteristics. This data can be used for identifying a person based on their physical parameters.

Biochemical Barcodes contain information about biological indicators of a person, such as levels of specific substances in the body. This data may include information about the concentration of biochemical markers like glucose, cholesterol, proteins, and other substances that can be used for unique identification.

Genetic Barcodes utilize information about a person's DNA to create a unique identifier. They may contain data about specific genetic markers or sequences that can be unique to each individual.

Geometric Barcodes use geometric parameters, such as face shape, dimensions of facial features, distances between key points, to create a unique identifier. These parameters can be used for facial recognition.

Behavioral Barcodes encode information about a person's behavior, such as walking style, typing manner, gestures, and other behavioral characteristics. This data can be used to create a unique behavior profile of an individual [7].

Biometric barcodes represent an innovative method of identification that has found application in various countries worldwide. Here are several examples of their use:

In the USA, biometric barcodes are employed in healthcare systems for precise patient identification. This improves the quality of medical services and helps prevent errors in treatment.

In India, biometric barcodes are used to authenticate citizens when availing various government services, such as issuing identity cards and voting.

Japan is integrating biometric barcodes into security and access control systems. They are applied in offices and businesses to ensure the safety of personnel and visitors.

In the UK, biometric barcodes are utilized in the financial sector and banking industry. They provide secure customer authentication for financial transactions.

China is actively implementing biometric barcodes across various sectors including education, healthcare, and government services. This helps enhance the efficiency and accuracy of the services provided.

In Brazil, biometric barcodes are employed in access control systems for government institutions and offices. They offer robust protection against unauthorized access.

South Korea uses biometric barcodes in public transport systems. This simplifies fare payment and enhances passenger safety.

Global experience demonstrates diverse applications of biometric barcodes in different areas of life and public activities. Their reliability, effectiveness, and convenience make this technology increasingly popular and in demand [8-9].

Biometric barcode technology represents a promising direction in the field of identification and control in Kazakhstan. It is actively applied in various sectors, covering both governmental structures and the private sector.

*Healthcare and Medicine:* One of the primary applications of biometric barcodes in Kazakhstan is in healthcare. They are used for patient identification, ensuring accurate and swift medical assistance. Biometric barcodes allow linking medical history, analyses, and other data to specific patients, ensuring high-quality healthcare services.

*Government Institutions:* In Kazakhstan, biometric barcodes are used for citizen identification in government institutions. For instance, they may be applied when obtaining passports, driver's licenses, or other documents requiring precise identity verification.

*Financial Sector:* The banking sector in Kazakhstan is also actively incorporating biometric barcodes. They are used to authenticate customers during financial transactions, thereby enhancing security levels and preventing fraud.

*Security Systems and Access Control:* In the realm of security, biometric barcodes find application in access control systems. They help prevent unauthorized access to restricted areas, ensuring high levels of security in offices, enterprises, and other facilities.

*Trade and Retail:* In retail, biometric barcodes can be employed to manage customer loyalty, as well as to ensure accurate identification during payment for goods and services.

*Transport Systems:* In public transport systems and transportation organizations, biometric barcodes can be used for passenger tracking and ensuring travel safety.

*Education:* In educational institutions, biometric barcodes can be used for student identification and ensuring security within educational facilities [10].

Biometric technologies, including the use of barcodes, are in a constant state of development with the emergence of new innovations and the refinement of existing approaches. This leads to expanded capabilities and areas of application for these technologies.

Integration with Artificial Intelligence (AI) improves the data processing algorithms of biometric barcodes, increasing system accuracy and reliability. Multimodal biometric systems combine multiple biometric methods, enhancing the level of security and accuracy in the identification process. Embedded sensors in mobile devices such as smartphones and tablets enable the use of biometric barcodes for various tasks, including authentication and conducting payments. In addition to physiological parameters such as fingerprints, attention is being given to parameters related to individual behavior (e.g., voice analysis or gait analysis) [11]. The application of deep learning and neural networks significantly enhances the efficiency of face recognition. The implementation of biometric barcodes in medical institutions contributes to improved patient identification and the prevention of medical errors. Protecting user privacy is becoming a priority. Methods for anonymizing data are being developed to strike a balance between security and privacy. Biometric technologies utilizing barcodes can be integrated into smart devices, enhancing security levels and providing convenience of use. In the tourism and hospitality industry, biometric barcodes can be applied to expedite the guest check-in process in hotels and airports. Furthermore, in the field of logistics management and inventory, the use of biometric barcodes enables the improvement of inventory management processes and control over the movement of goods [12].

## 5 Representing Facial Information in QR Codes

As part of this experiment, work was conducted to investigate the transformation of facial encodings obtained using the `face_recognition` library into QR codes. The experiment aimed to develop an efficient method for representing facial encodings using QR code technology. The photograph used for the transformation is shown in Figure 1.



Figure 1 – Face Photograph

The encoding of the face generated using the computer vision library `face_recognition`, used in the experiment, is shown in Figure 2.

```
[array([-9.97023135e-02, 4.94740456e-02, 7.98235759e-02, -7.43214488e-02,
-1.74680203e-01, 2.79045738e-02, -1.27507180e-01, -1.43855691e-01,
9.56659392e-02, -1.17645845e-01, 2.61246145e-01, -4.02291156e-02,
-1.64547428e-01, -6.32798672e-02, -9.90153030e-02, 1.91734418e-01,
-1.89899921e-01, -1.40684173e-01, 4.19026706e-03, 6.11237958e-02,
9.44161266e-02, -2.53463201e-02, 2.35297140e-02, 9.19905305e-02,
-1.68697655e-01, -3.25366795e-01, -1.21952787e-01, -6.61166087e-02,
-5.02436869e-02, -1.31008953e-01, -8.16686377e-02, -6.62299246e-03,
-2.20089406e-01, -4.14269194e-02, -2.67850384e-02, 4.34266329e-02,
-1.65863633e-02, -6.26730323e-02, 1.69974893e-01, 6.15422018e-02,
-2.48007476e-01, 1.44100130e-01, 3.63545120e-02, 2.17177197e-01,
1.54172152e-01, 3.73906642e-02, 4.68519032e-02, -1.43617228e-01,
1.15307607e-01, -1.93156064e-01, 5.25930226e-02, 1.44928217e-01,
7.74639547e-02, 6.38333708e-03, -4.41481099e-02, -8.97464156e-02,
1.52576864e-02, 1.51003569e-01, -1.32537097e-01, 1.12094909e-01,
1.00682348e-01, -3.61202210e-02, 3.09028402e-02, -6.22204319e-02,
1.40536264e-01, 1.15435317e-01, -6.55267537e-02, -2.16769978e-01,
8.74410942e-02, -9.69708562e-02, -1.31602004e-01, 6.40264750e-02,
-1.47282735e-01, -2.15343893e-01, -2.94206232e-01, 1.74608827e-03,
4.26398218e-01, 9.73839611e-02, -2.45120198e-01, 4.33005765e-03,
-8.52620453e-02, -4.55107987e-02, 8.27133283e-02, 9.23452899e-02,
2.27138102e-02, -1.54741108e-04, -1.18523955e-01, 2.08501369e-02,
2.84547150e-01, -3.15525308e-02, 2.27908157e-02, 2.60421723e-01,
5.82121126e-02, 5.17934412e-02, 5.40908352e-02, 6.96922839e-02,
-1.01050869e-01, 6.62658662e-02, -1.35656029e-01, -1.46889240e-02,
-5.61088547e-02, -1.68944784e-02, -1.85205936e-02, 8.92843828e-02,
-1.85447246e-01, 1.84819877e-01, -1.52932107e-02, -3.85973640e-02,
-4.33367640e-02, 3.24743390e-02, -1.36015892e-01, -3.40196043e-02,
1.40036732e-01, -2.04911560e-01, 1.80357859e-01, 2.03965828e-01,
1.44400179e-01, 8.23330805e-02, 1.48437679e-01, 5.47322854e-02,
-2.67138630e-02, 8.28737020e-03, -1.76903620e-01, -3.75504792e-02,
9.47215557e-02, -8.78797621e-02, 1.04836330e-01, 2.59825587e-02)])]
```

Figure 2 – Face Encoding

The Python code for converting face encoding into a QR code with a size of  $177 \times 177$  modules is shown in Figure 3.

```

44  qr = qrcode.QRCode(
45      version=1,
46      error_correction=qrcode.constants.ERROR_CORRECT_L,
47      box_size=10,
48      border=4,
49  )
50
51  # Добавляем данные в QR-код
52  qr.add_data(face_encoding_str)
53  qr.make(fit=True)
54
55  # Создаем изображение QR-кода
56  img = qr.make_image(fill_color="black", back_color="white")
57
58  # Изменяем размер изображения до 177x177 на LANCZOS
59  img = img.resize((177, 177), Image.Resampling.LANCZOS)

```

Figure 3 – Part of the Python code

The experiment successfully resulted in converting face encodings into QR codes with module sizes of 177x177 pixels. The generated QR

codes serve as an efficient means for storing and transmitting information about the face encodings. A detailed block diagram is shown in Figure 4.

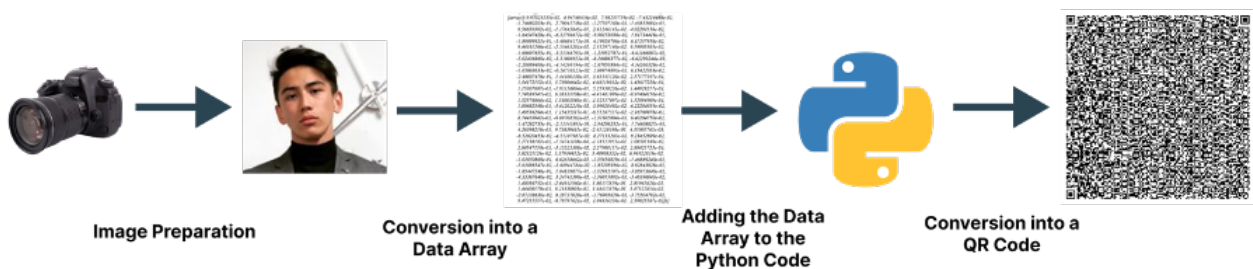


Figure 4 – QR Code Generation Flowchart

## 6 Conclusions

The conducted experiment has demonstrated the unique application of biometric barcodes in the modern technological environment. The specially developed Python algorithm efficiently transformed the facial image into a QR code. This barcode, containing information about a person's biological characteristics, represents an innovative approach to identity verification.

The results of the experiment confirmed the high efficiency and accuracy of converting biometric data into a barcode. This approach can be applied in various fields, ranging from medical institutions and government structures to the financial sector and security systems.

However, despite all the advantages, it is important to consider issues related to data protection and privacy. The implementation of biometric technologies requires careful analysis and compliance with relevant regulations.

Overall, the experiment's results indicate the promising and significant development of biometric barcodes in the modern world. These technologies offer new opportunities to enhance the efficiency and security of various aspects of human activity.

## Funding

This study was funded by the Ministry of Science and higher education of the Republic of Kazakhstan, Grant No. AP19678000.

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