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Original Paper

QR Code Version Analysis for Improved Pharmaceutical Label Identification Using Open Source Libraries

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ABSTRACT

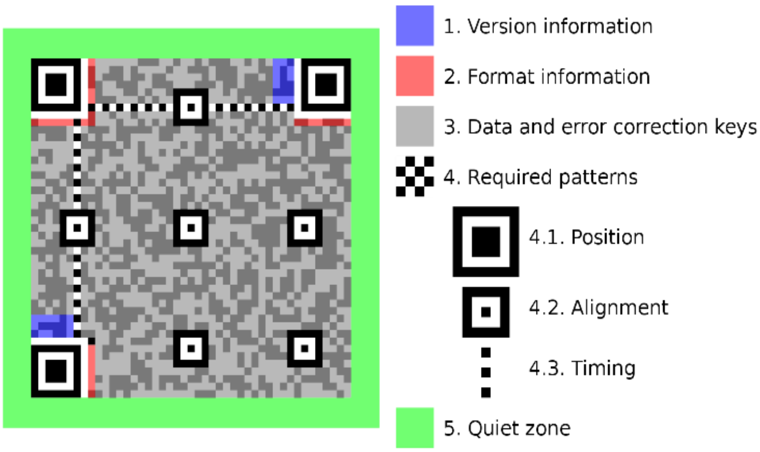
The pharmaceutical industry finds itself at an important juncture, driven by an increasing need to enhance the identification of drug labels. This imperative arises from a commitment to safeguard patient well-being and maintain compliance with stringent regulatory standards. Within this context, our research paper conducts a comprehensive exploration into the utilization of various QR code versions as a means to optimize pharmaceutical label identification. Leveraging open-source libraries, we delve into the multifaceted capabilities of QR codes, which are renowned for their capacity to store a wide array of data types. However, we emphasize that the selection of a specific QR code version can wield a substantial influence on the efficacy and reliability of label identification processes. Our study takes a deep dive into the diverse QR code versions available, with a particular focus on their data encoding capacities, error correction capabilities, and suitability for the intricate landscape of pharmaceutical labels. We rigorously evaluate the performance of these QR code versions across various conditions and constraints, including label dimensions, print quality, and decoding speed. Importantly, we employ open-source libraries to implement QR code generation and decoding, ensuring cost-effectiveness and accessibility for a broad spectrum of stakeholders within the pharmaceutical sector. The outcomes of our research shed light on the QR code version that best aligns with the specific requirements and constraints of the pharmaceutical industry. These findings offer invaluable insights for pharmaceutical manufacturers, healthcare providers, and regulatory bodies as they endeavour to refine and streamline drug label identification processes. By making informed decisions regarding the most suitable QR code version, stakeholders can elevate patient safety, optimize medication management, and ensure strict adherence to evolving regulatory frameworks. This research contributes significantly to the ongoing mission of harnessing technology to advance healthcare practices, emphasizing the pivotal role of informed decision-making in pharmaceutical labeling through the optimization of QR codes.

KEYWORDS

QR Code, Drug Label, Version, Pharmaceutical, Patient, Open Source Libraries.

1. INTRODUCTION

In an age marked by swift technological progress, the pharmaceutical sector exists as a dynamic arena in which innovation continually shapes patient care and safety. Within the realm of pharmaceuticals, one of the crucial elements revolves around the accurate identification of drug labels. This aspect proves indispensable, serving the dual purpose of ensuring patient well-being and compliance with stringent regulatory requirements [1]. The emergence of Quick Response (QR) codes has presented an encouraging avenue for addressing the challenges associated with pharmaceutical label identification. QR codes, known for their ability to encapsulate extensive data in a concise visual format, represent a transformative solution for disseminating essential drug-related information to both healthcare professionals and patients. This research endeavour embarks on an exhaustive exploration of QR code versions as a means to optimize the identification of pharmaceutical labels, leveraging the capabilities provided by open-source libraries. While QR codes have garnered substantial attention for their potential within healthcare contexts, the selection of an appropriate QR code version is an oft-neglected yet pivotal determinant that can profoundly influence the efficiency, dependability, and efficacy of label identification within the pharmaceutical sphere. This study delves into the realm of QR code technology, meticulously inspecting various QR code versions with a particular emphasis on their data encoding capacities, error correction capabilities, and suitability for pharmaceutical labels. It systematically assesses the performance of these QR code iterations under a variety of conditions and constraints, taking into consideration factors such as label dimensions, print quality, and decoding speed. By harnessing open-source libraries for QR code generation and interpretation, this research ensures accessibility and affordability for a broad spectrum of stakeholders within the pharmaceutical sector[2]. The outcomes of this study are poised to shed light on the optimal QR code version for pharmaceutical label identification, all while taking into account the distinct requirements and limitations of the industry. These revelations hold the promise of being invaluable to pharmaceutical manufacturers, healthcare providers, and regulatory bodies, all of whom endeavour to enhance the process of identifying drug labels. The capacity to make well-informed choices regarding the selection of the most suitable QR code version has the potential to elevate patient safety, streamline medication management, and maintain alignment with the ever-evolving landscape of regulatory frameworks. In doing so, this research underscores the pivotal role of technology-driven solutions in advancing healthcare practices and underscores the significance of informed decision-making within pharmaceutical labeling through the optimization of QR codes.



(Source: https://en.wikipedia.org/wiki/QR_code)
Figure. 1 Structure of QR Code

Starting from August 1, 2023, India's amended Drug Rules 2022 will require over 300 medicines manufactured or sold in the country to include a web-linked dynamic QR code or barcode, primarily on their primary packaging. This regulatory change aims to address the significant issue of counterfeiting within India's pharmaceutical industry, valued at $60 billion, where approximately 60% of domestically sold Indian pharmaceutical products are affected. The remaining 40% of medicines produced in India, which are exported, already adhere to authentication and traceability requirements. This shift signifies a substantial move towards combating counterfeit drugs and enhancing traceability within the vast Indian pharmaceutical sector. It poses a challenge as it necessitates the inclusion of a considerable amount of data in a limited space, such as on blister packs or labels. There are many firms which are already collaborating with leading Indian pharmaceutical companies to implement traceability measures, including 2D barcodes and QR codes, on blister packs, labels, and other primary or outer packaging materials to safeguard a brand's reputation and, more importantly, the health of consumers.

Under this new rule, which is an amendment to the Drugs and Cosmetics Act of 1940 and subsequent Drugs Rules of 1945, pharmaceutical products sold in India must include eight sets of data on their smallest sellable unit. The rule specifies that either a barcode or Quick Response (QR) code should contain authentication information, either on the primary packaging label or, if space is insufficient, on the secondary package label that can be read using software for authentication purposes.

2. VARIOUS VERSIONS AND CAPACITY OF QR CODE TO BE USED FOR DRUG LABEL

To determine the appropriate QR code version for including the specified information on a drug label, we will need to consider the data capacity of each QR code version and ensure it can accommodate all the required information. Numerals (numerical values) are often used for QR code version detection as the type of input data because QR codes have a structured encoding format that includes a version indicator in the form of numerical values. There exist 40 variations of the traditional QR code, with each variant featuring a distinct quantity of data modules. Data modules refer to the individual black and white squares composing a QR code [3]. As the QR code version increases, the number of data modules also rises. Consequently, a higher number of data modules translate to an increased capacity for data storage within the QR code. Starting with Version 1 (21 × 21 modules) and extending to Version 40 (177 × 177 modules), each subsequent version adds 4 modules per side. Consequently, as data volume, character types, and error correction levels vary, each QR Code symbol version adapts to maximize data capacity. In simpler terms, when more data is needed, QR Code symbols grow larger by employing additional modules [4].

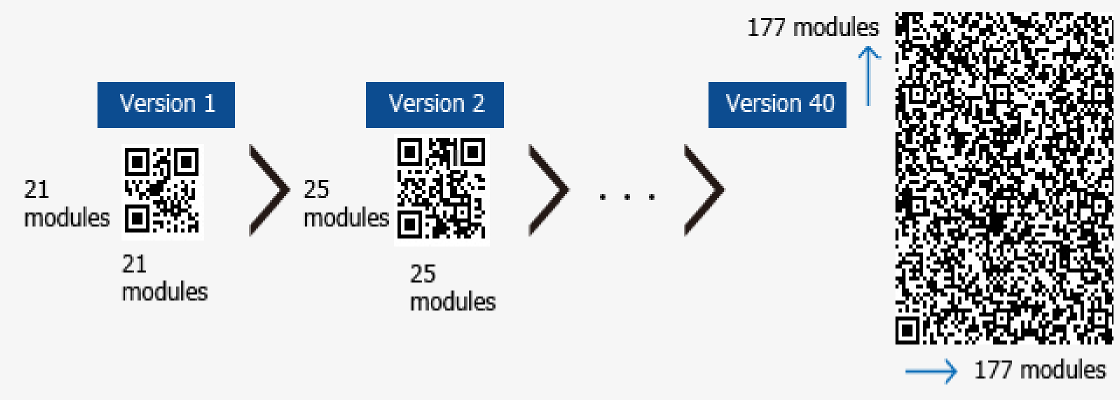


Figure. 2 Versions of QR Code

Starting on August 1, 2023, it will be a requirement by the Department of Health and Family Welfare for the leading 300 brands to incorporate QR codes or barcodes. As per Schedule H2, some of the included medications with various strengths are as follows:

Table 1. Frequently Used Drugs shown based on 300 Drug Names, Gazette-Notifications for Drug Rules, 2022

Some of Schedule H2 Medications		
Aciloc	Actemra	Allegra
Amlokind	Ascoril D Plus New	Asthalin inhaler
Becosules Capsules	Betadine ointment, solution, and gargle	Calpol

Combiflam	Dolo 650 mg	ElectralSache
Fabiflu	Foracort	Gelusil

(Source:https://cdsco.gov.in/opencms/opencms/en/Notifications/Gazette-Notifications/)

Our analytical journey delved into the realm of pharmaceutical nomenclature, specifically focusing on a meticulously compiled dataset consisting of 300 unique drug names thoughtfully arranged within an Excel spreadsheet. This dataset was culled from the authoritative Gazette-Notifications for Drug Rules, 2022, which serves as the bedrock of pharmaceutical regulatory guidelines. Our analytical approach hinged upon the application of the Length Formula, a mathematical tool we deployed with precision and diligence. This formula was systematically employed to scrutinize each of the 300 drug names, enabling us to assess and rank them based on their character length quantitatively. In the process, one particular drug name emerged as the undisputed leader, boasting a character count of 53, and it goes by the name "CREMAFFIN PLUS SF 1.25 ML/3.75ML/3.33MG LIQUID 225 ML." The significance of this discovery transcends mere numerical data. The length of a drug name holds profound implications within the pharmaceutical realm, offering insights into its composition, therapeutic application, regulatory compliance, and potential considerations for patient safety. Thus, "CREMAFFIN PLUS SF 1.25 ML/3.75ML/3.33MG LIQUID 225 ML" represents not just a long name but a unique case warranting further exploration. Understanding the rationale behind such an extensive name can unveil broader trends and practices within the pharmaceutical industry, providing a nuanced perspective on the factors influencing drug nomenclature [5] [6]. Moreover, this discovery paves the way for deeper investigations into naming conventions, potentially uncovering patterns and trends that can inform regulatory decisions, enhance healthcare communication, and contribute to the overall safety and efficacy of pharmaceutical products. Our meticulous analysis, powered by the Length Formula, has pinpointed "CREMAFFIN PLUS SF 1.25 ML/3.75ML/3.33MG LIQUID 225 ML" as the drug name with the most extensive character count among the 300 drug names derived from the Gazette-Notifications for Drug Rules, 2022. This finding underscores the multifaceted nature of pharmaceutical nomenclature and beckons further exploration into the complex interplay of factors that shape drug naming within the pharmaceutical industry [3].

Table 2. Drug Name having Maximum Length from 300 Drugs

Serial Number	**Brand Name of Drug Formulation**	**String Length**
60	CREMAFFIN PLUS SF 1.25 ML/3.75ML/3.33MG LIQUID 225 ML	53

If we want to determine the version of the QR Code to be used for the Drug Label, We have to opt for "numeral" as your selected input data type. After that, the data correction level is selected from the options L, M, Q, or H.

To determine the suitable QR Code version for encoding a drug name with a length of 53 characters, we can use the following guidelines:

Character Count: The drug name has a length of 53 characters.

Character Encoding: The standard QR Code character encoding modes include numeric, alphanumeric, and byte encoding. Alphanumeric encoding mode is commonly used for text that includes a combination of letters and numbers, while byte encoding is used for encoding binary data.

Error Correction Level: QR Codes can have different error correction levels, such as L (Low), M (Medium), Q (Quartile), and H (High). The error correction level affects the QR Code's resistance to damage and readability.

Now, let's calculate the suitable QR Code version for a 53-character drug name using alphanumeric encoding and assuming a reasonable error correction level (e.g., M or Q):

The alphanumeric mode can encode approximately 2 characters per data module. Therefore, for a 53-character drug name, we would need 53 characters / 2 characters per module = 26.5 modules (approximately).

To encode 53 characters with alphanumeric encoding, you would require at least 27 modules in both the horizontal and vertical directions. QR Code versions are typically defined by the number of modules in one direction. So, we would need a QR Code version with at least 27 modules in one direction.

QR Code version-2 meets this requirement with a grid size of 25x25 modules. This version should be suitable for encoding a 53-character drug name using alphanumeric encoding, and it provides a moderate level of error correction (M or Q). However, the actual suitability may also depend on any additional information you plan to include in the QR Code, such as manufacturer details, dosage instructions, or other relevant data [7] [8].

Table 3. QR Code Version-2 Information

2	25x25	L	272	77	47	32	20
		M	224	63	38	26	16
		Q	176	48	29	20	12
		H	128	34	20	14	8

(Source: https://www.qrcode.com)

3. EXPLORING SUITABLE OPEN-SOURCE LIBRARIES FOR QR CODE DETECTION

Efficiency analysis for Python libraries involves considering factors such as speed, accuracy, resource usage, and ease of use. Here's a high-level efficiency analysis for some commonly used Python libraries for 2D data matrix and QR code detection [9] [10]:

3.1. OpenCV:

- Speed: OpenCV is known for its speed due to its optimized C++ backend. It offers real-time processing capabilities suitable for applications like video streams.
- Accuracy: OpenCV's barcode detection accuracy is generally good, especially for QR codes. It can handle various lighting conditions and orientations.
- Resource Usage:While OpenCV is efficient, it might require more resources compared to lighter libraries due to its feature-rich nature.
- Ease of Use: OpenCV's comprehensive documentation and community support make it approachable, but its extensive functionality might require some learning curve.

3.2. ZBar:

- Speed: ZBar is reasonably fast and performs well for barcode detection tasks.
- Accuracy:ZBar is accurate for detecting various types of barcodes, including QR codes.
- Resource Usage:ZBar is relatively lightweight and can be suitable for resource-constrained environments.
- Ease of Use: ZBar's API is straightforward, making it easy to integrate for QR code detection.

3.3.PyZbar:

- Speed: PyZbar's speed is comparable to ZBar since it's a wrapper around the same core library.
- Accuracy: Accuracy is on par with ZBar.
- Resource Usage: Similar to ZBar, PyZbar is lightweight and efficient in terms of resource usage.
- Ease of Use: PyZbar provides a Pythonic interface, making it simple to integrate with Python applications.

3.4. qrcode and pyQRCode:

- Speed: Both libraries are primarily for QR code generation, not detection. Thus, their speed isn't a significant factor for detection.
- Accuracy:N/A for detection, as these libraries focus on generating QR codes.
- Resource Usage:Resource usage is minimal for generating QR codes.
- Ease of Use:Both libraries are easy to use for QR code generation tasks.

3.5. qrtools and zxing:

- Speed: Speed varies; zxing might be slower due to its Java backend when used via a Python wrapper.
- Accuracy:Accuracy is acceptable for many applications, though not always as high as OpenCV or ZBar.
- Resource Usage:Resource usage varies but is generally moderate.
- Ease of Use: These libraries might require more effort for setup and integration compared to others.

3.6. Cognex SDK:

- Speed: SDKs can offer high-speed processing, but this depends on the specific implementation and the device it's running on.
- Accuracy: Commercial SDKs often offer high accuracy.
- Resource Usage: Commercial SDKs might be optimized for efficiency but can vary based on the implementation.
- Ease of Use: Commercial SDKs can have more complex integration and licensing considerations.

4. RESULTS AND DISCUSSION

The statement "OpenCV and ZBar or its Python wrapper PyZbar are generally considered efficient choices for QR code detection on drug labels" suggests that when it comes to the specific task of detecting QR codes on drug labels, these software libraries are commonly recommended and regarded as effective solutions.

OpenCVis known for its efficiency in various computer vision tasks, including QR code detection. It utilizes an optimized C++ backend, which results in fast processing; making it suitable for real-time applications like scanning QR codes on drug labels.It generally offers good accuracy in barcode detection, which is essential for accurately reading QR codes on drug labels.While primarily recognized for its speed, OpenCV's versatility extends to handling different lighting conditions and orientations, which is crucial when dealing with drug labels that may vary in appearance.

ZBar and its Python wrapper PyZbarare known for their efficiency in barcode and QR code detection. They are often considered lightweight and can perform well even in resource-constrained environments. Both ZBar and PyZbar provide accurate QR code detection, making them suitable for applications like reading QR codes on drug labels. Bar and PyZbar offer user-friendly APIs, simplifying the integration process, which is essential for developers working on drug label scanning applications.

Now, let us consider why these libraries are efficient choices for QR code detection on drug labels:

4.1 Speed: Drug label scanning typically requires a quick response time, especially in healthcare settings. OpenCV, ZBar, and PyZbar are all known for their speed, making them well-suited for this purpose.

4.2 Accuracy: The accuracy of QR code detection is crucial in the context of drug labels, as misinterpretation could have serious consequences. OpenCV, ZBar, and PyZbarare known for their reliable barcode and QR code detection accuracy.

4.3 Resource Efficiency: Drug label scanning may occur on various devices, including mobile phones or tablets with limited resources. ZBar and PyZbar, in particular, are recognized for their resource efficiency, ensuring they can function effectively on a wide range of hardware.

4.4 Ease of Integration: The statement mentions that PyZbar is a Python wrapper for ZBar, making it easier to integrate into Python-based applications. This ease of integration can save development time and effort when building drug label scanning solutions.

5. CONCLUSION

In conclusion, the recommendation of OpenCV and ZBar, coupled with PyZbar, as proficient choices for detecting QR codes on pharmaceutical labels is well-founded. Their combined strengths, which include impressive processing speed, precise accuracy, judicious resource management, and user-friendly interfaces, position them as optimal candidates for the pivotal task of recognizing QR codes in healthcare and pharmaceutical contexts. As the healthcare industry increasingly relies on QR codes to convey vital information such as medication details, dosages, and expiration dates, the reliability of these libraries becomes of utmost importance. Their efficiency facilitates smooth integration into existing healthcare systems, preventing excessive computational demands. For developers and organizations embarking on QR code implementation for drug labeling, adopting OpenCV and ZBar (alongside PyZbar) holds the promise of tangible advantages, including enhanced accuracy and operational efficiency, thus fortifying the healthcare and pharmaceutical sectors with a robust technological solution.

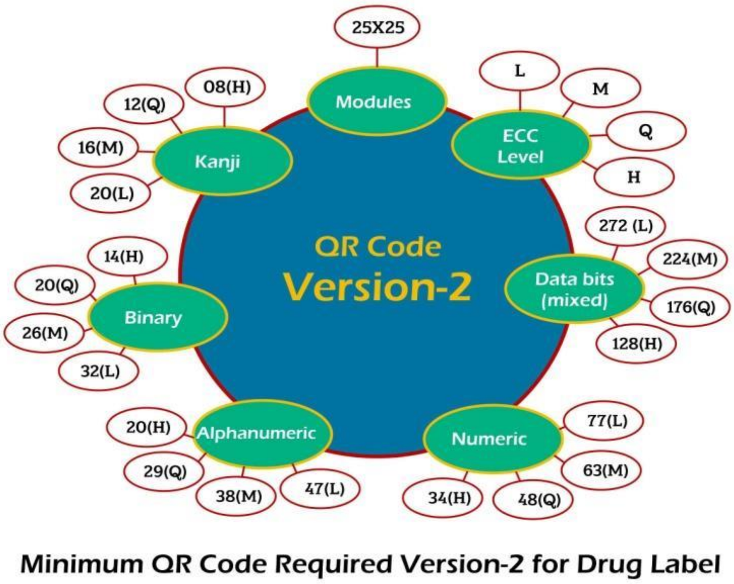


Figure 3. QR Code Version 2

In Conclusion, after conducting a comprehensive evaluation of various QR Code versions and their suitability for pharmaceutical label utilization, our research unequivocally directs us towards the adoption of QR Code version-2 as the most optimal choice. This particular version possesses a grid size measuring 25x25 modules, aligning seamlessly with the requirements for encoding extensive drug information, even accommodating lengthy 53-character drug names through alphanumeric encoding. In addition to its generous data capacity, QR Code version-2 strikes equilibrium by providing a moderate level of error correction, particularly through Modes M or Q. This inherent feature substantially reinforces the dependability of data retrieval from pharmaceutical labels, a crucial element in healthcare and pharmaceutical contexts.

Consequently, QR Code version-2 emerges as a practical and remarkably efficient choice for pharmaceutical label applications. It impeccably manages the interplay between data capacity and error resilience, ensuring the precise and secure storage and retrieval of pharmaceutical data. This conclusion underscores the paramount significance of meticulous deliberation when choosing QR Code versions for pharmaceutical labeling, as such decisions have a direct impact on the precision, efficiency, and overall integrity of drug identification and data retrieval procedures within the healthcare and pharmaceutical sectors.

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