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Online Testing & Monitoring Of Quality Of Medicine

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Abstract : This project introduces an online system for testing and monitoring the quality of medicines using computer vision, Generative AI, and NLP techniques. The platform automatically analyzes medicine samples to identify defects, inconsistencies, and counterfeit products, reducing reliance on manual inspection. Real-time monitoring allows manufacturers, regulators, and healthcare providers to track medicine quality efficiently. A secure database ensures accurate record-keeping, batch traceability, and regulatory compliance. Automated alerts are generated for substandard medicines, enhancing patient safety. With a user-friendly interface and scalable architecture, the system improves accuracy, reduces human error, lowers operational costs, and modernizes pharmaceutical quality assurance.

IndexTerms - **Medicine Quality Monitoring, Online Medicine Verification, QR Code Scanning, Batch Number Validation, Google Gemini, Fake Medicine Detection, AI-Based System.**

I. Introduction

The Online Testing & Monitoring of Quality of Medicine project is designed to verify the authenticity of medicines and help detect fake or invalid drugs. The system allows users to check medicine details by entering the batch number through a search bar or by scanning a QR code. Using Google Gemini for intelligent data processing and classification, the project provides accurate, realtime information about medicine validity, making the process fast, reliable, and user-friendly.

II. PURPOSE

The Online Testing and Monitoring of Quality of Medicines system ensures the safety, authenticity, and effectiveness of medicines by detecting counterfeit, expired, and low-quality drugs. Using AI and computer vision, it provides fast, accurate, and transparent quality analysis, supports regulators and manufacturers, improves efficiency, and helps protect public health.

III. SCOPE

The scope of the Online Testing and Monitoring of Quality of Medicine project includes verifying medicine authenticity through batch number search and QR code scanning. It uses Google Gemini for real-time classification of medicines as valid or invalid. The system supports consumers, pharmacies, and healthcare authorities in reducing fake and expired medicines, and can be scaled to integrate government drug databases, mobile apps, and real-time alerts for enhanced quality monitoring.

IV. SYSTEM ALGORITHM & TECHNOLOGIES

A. System Algorithm

1. The user accesses the system through a custom login interface.
2. The system provides two verification options: Batch Number Search and QR Code Scanning.
3. In batch number search, the user enters the medicine batch number in the search bar.
4. In QR code scanning, the medicine QR code is captured using the device camera.

5. Computer Vision techniques extract relevant information from the scanned QR code.
6. The extracted text and batch data are processed using Natural Language Processing (NLP).
7. Generative AI (GenAI) using the Google Gemini API analyzes the data for medicine validation.
8. The system classifies the medicine as Valid or Invalid.
9. The final result and medicine details are displayed to the user.

B. Technologies Used

1. **Computer Vision:** QR code detection and data extraction
2. **Natural Language Processing(NLP):** Text understanding and batch number analysis
3. **Generative AI (GenAI):** Intelligent medicine validation
4. **Google Gemini API:** AI-based decision-making and classification
5. **Frontend:** HTML, CSS, JavaScript
6. **Backend:** Python / Node.js
7. **Database:** Medicine Information Repository

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Abbreviations and Acronyms

This section explains the short forms and technical terms used in the Online Testing & Monitoring of Quality of Medicine project. Defining abbreviations helps in maintaining clarity and better understanding of the technologies used in the system.

3.1 CV (Computer Vision)

Computer Vision is used in the system to visually analyze medicine images and QR codes. It enables automatic detection and scanning of QR codes from medicine packaging. The extracted visual information is converted into usable data for further processing. This reduces manual effort and minimizes human errors during verification. In this project, Computer Vision plays a key role in improving the accuracy and reliability of medicine quality validation.

3.2 NLP (Natural Language Processing)

Natural Language Processing is used to understand and analyze text-based information entered by the user. It helps in interpreting medicine batch numbers and related textual details accurately. NLP techniques handle variations, incomplete inputs, and minor errors in user-entered data. This improves the correctness of medicine verification. In this project, NLP enhances the reliability of text-based medicine validation using AI.

3.3 API (Application Programming Interface)

An Application Programming Interface is used to enable communication between different software components of the system. It allows the project to connect with external services such as the Google Gemini API. Through APIs, data is securely sent and received for processing and analysis. This integration helps in performing real-time medicine validation. In this project, APIs ensure smooth interaction between the backend, AI services, and user interface.

3.4 QR Code (Quick Response Code)

A QR Code is used to store medicine-related information in a machine-readable format. By scanning the QR code, the system quickly retrieves details such as batch number and product information. This method enables fast and contactless verification of medicines. QR code scanning reduces manual data entry and errors. In this project, QR codes play an important role in accurate and efficient medicine authenticity checking.

3.5 Python

Python is a versatile, high-level programming language known for its simplicity and readability, making it ideal for developing intelligent systems. In this project, Python is used as the core backend language to handle medicine data processing, QR code validation, and communication with databases and APIs. It supports advanced libraries for Computer Vision and Natural Language Processing, which help in analyzing medicine labels, packaging, and textual information. Python also enables seamless integration with the Google Gemini API for AI-based medicine validation and classification. Due to its scalability and strong community support, Python ensures the system is efficient, accurate, and easy to maintain for future enhancements.

3.6 Google Gemini API

Google Gemini API is an advanced generative AI interface that enables intelligent analysis and decision-making using multimodal data such as text and images. In this project, it is used to validate and classify medicines by analyzing extracted information from QR codes, medicine labels, and textual data. The API helps determine whether a medicine is genuine, expired, or suspicious by applying AI-driven reasoning in real time. It also enhances accuracy by understanding complex patterns and inconsistencies in medicine data. Integration of the Google Gemini API makes the system smarter, faster, and more reliable for medicine quality monitoring.

Equations

In this project, equations are used to evaluate medicine authenticity, quality, and classification results based on AI models and extracted data.

1. **MedicineAuthenticityScore**

This equation calculates how genuine a medicine is based on multiple parameters:

$$A_s = w_1 \times Q_r + w_2 \times T_e + w_3 \times D_m$$

Where:

- A_s= Authenticity score
- Q_r= QR code validation result
- T_e= Text extracted from label (using CV + NLP)
- D_m= Database match score
- w_1, w_2, w_3= Weights assigned to each factor

I. RESEARCH METHODOLOGY

The research methodology for the **Online Testing & Monitoring of Quality of Medicines** project follows a systematic, technology-driven approach to ensure accurate medicine validation. The study begins with data collection through QR code scanning and batch/patch number input from medicine packaging. Computer Vision techniques are used to extract visual and textual information, while NLP processes the extracted text to understand key details such as medicine name, manufacturer, and expiry date.

Further, the processed data is analyzed using **Generative AI through the Google Gemini API**, which classifies the medicine as valid, expired, or potentially counterfeit by comparing it with known patterns and reference data. The system's performance is evaluated using standard metrics like accuracy and classification results. This methodology ensures a reliable, automated, and scalable solution for real-time medicine quality monitoring.

3.1Problem Identification

The major problem addressed in this project is the increasing circulation of **fake, expired, and low-quality medicines** in the market, which poses serious risks to public health. Consumers and pharmacists often lack a quick and reliable method to verify the authenticity of medicines. Manual verification processes are time-consuming, error-prone, and depend heavily on trust rather than data. Hence, there is a strong need for an **automated, AI-based system** that can accurately test and monitor the quality of medicines using QR code scanning or batch/patch number verification in real time.

3.2 Objective of the Research

The main objective of this research is to develop an **AI-based Online Testing and Monitoring system** that can verify the quality and authenticity of medicines in real time. The system aims to allow users to check medicine details by **QR code scanning or batch/patch number input**. By using technologies like **Computer Vision, NLP, and the Google Gemini API**, the project seeks to accurately classify medicines as **valid or invalid**, reduce the circulation of counterfeit drugs, and enhance public safety through a fast, reliable, and user-friendly solution.

3.3 System Architecture / Workflow

The system architecture follows a structured and user-friendly workflow to ensure accurate medicine validation. First, the user logs in through a secure custom login page. After login, the user can search for a medicine either by **entering the batch/patch number** or by **scanning the QR code** on the medicine package. The input data is then processed using **Computer Vision** (for QR and image analysis) and **NLP** (for text understanding). This processed information is sent to the **Google Gemini API**, which performs AIbased analysis and classification. Finally, the system displays the result to the user, indicating whether the medicine is **valid, expired, or potentially counterfeit**, enabling real-time quality monitoring.

In addition, the backend system built using Python manages data handling, API communication, and result processing efficiently. The architecture is designed to be modular and scalable, allowing easy integration of future features such as government drug databases and real-time alerts. Secure data flow is maintained between the user interface and AI services to ensure reliability and privacy. Overall, the workflow ensures fast response time, accurate classification, and a seamless user experience for medicine quality verification.

3.4Data Collection Method

The data collection method in this project involves gathering medicine-related information directly from **medicine packaging**. Data is collected through **QR code scanning**, which provides encoded details such as medicine identification and batch information, and through **manual entry of batch/patch numbers** by the user. In addition, **image data of medicine labels** is captured and processed using Computer Vision techniques to extract relevant text. This collected data is then preprocessed and used for AI-based analysis to verify the authenticity and quality of the medicine in real time.

3.4.1 Technologies Used

This project uses a combination of advanced and reliable technologies to ensure accurate medicine quality verification.
Computer Vision (CV) is used to analyze medicine images and scan QR codes for extracting visual information. **Natural Language Processing (NLP)** helps in understanding and processing textual data such as medicine names, batch numbers, and expiry details. The **Google Gemini API** is integrated to perform AI-based analysis and classification of medicines as valid or invalid. **Python** is used as the core backend language to handle data processing, AI logic, and API integration, enabling a scalable and efficient system.

3.4.2 Algorithm / Processing Steps

The algorithm starts with **image capture or QR code scanning** of the medicine package through the user interface. This step collects visual data and encoded information required for further analysis. Next, **text extraction** is performed using Computer Vision and OCR techniques to identify key details such as medicine name, manufacturer, batch/patch number, and expiry date. After extraction, **data preprocessing** is carried out to clean the data by removing errors, correcting formats, and validating missing or inconsistent values.

This ensures that only accurate and structured information is used for analysis. The refined data is then sent to the **Google Gemini API**, where **AI-based classification** is applied. Based on learned patterns and logical reasoning, the system determines whether the medicine is **Valid, Expired, or Suspicious**. Finally, the classification result is returned to the system and displayed to the user, enabling fast and reliable medicine quality verification.

3.4.2.1 Model for CAPM

The CAPM model is used to structure and evaluate the performance of the medicine quality classification system. In this project, CAPM helps in measuring how effectively the AI classifier identifies medicines as Valid or Invalid based on scanned or typed data.

C – Classification:

Medicines are classified into categories such as *Valid*, *Expired*, or *Suspicious* using AI analysis through the Google Gemini API.

A – Accuracy:

The system checks how accurately the model predicts the medicine status by comparing AI results with expected outcomes from test samples.

P – Precision:

Precision measures how many medicines classified as *Valid* are actually valid, reducing false-positive results.

M – Monitoring:

Continuous monitoring is performed to track classifier performance, response time, and consistency, ensuring reliable real-time medicine verification.

3.4.2.2 Model for APT

The APT model explains how data is processed and technologies are applied in the Online Testing & Monitoring of Quality of Medicines system.

A – Application Layer:

This includes the custom login page, medicine search bar (batch/patch number), and QR code scanning interface through which users interact with the system.

P – Processing Layer:

In this layer, captured images and text are processed using Computer Vision and NLP techniques. Data preprocessing and validation are also performed before analysis.

T – Technology Layer:

This layer consists of core technologies such as Python backend, Google Gemini API, AI models, and supporting libraries that perform medicine classification and result generation.

3.4.3 Comparison of the Models

The **CAPM model** focuses on evaluating the **performance and effectiveness** of the medicine classification system. It measures how accurately and reliably the AI model classifies medicines as valid or invalid, using parameters like classification accuracy, precision, and continuous monitoring. CAPM is mainly used to assess the **quality of results** produced by the system.

In contrast, the **APT model** explains the **functional workflow and technology structure** of the project. It describes how the application layer, processing layer, and technology layer work together to process user input and generate results. While CAPM evaluates *how well* the system performs, APT explains *how* the system works internally. Together, both models provide a complete understanding of system performance and architecture.

3.4.3.1 Davidson and MacKinnon Equation

The Davidson and MacKinnon Equation is used in research to compare two predictive models and determine whether an alternative model provides additional explanatory power over a basic model. It is especially useful for validating advanced or hybrid systems by statistically checking if a new approach improves the final outcome. In this project, the equation is applied to justify the use of **AI-based analysis** over traditional rule-based or manual medicine verification methods. By combining predictions from different sources, the model helps in evaluating the contribution of advanced AI techniques in improving classification accuracy. $Y = \alpha + \beta X + \gamma Z + \varepsilon$

In the context of the **Online Testing & Monitoring of Quality of Medicines** project, **Y** represents the final medicine classification result (Valid or Invalid). **X** denotes the output obtained from basic verification methods such as QR code or batch/patch number matching, while **Z** represents the AI-based prediction generated using **Computer Vision, NLP, and the Google Gemini API**. The coefficient **γ (gamma)** indicates the impact of AI integration on the final decision. A significant γ value shows that the AI-driven approach improves medicine quality verification, making the system more accurate, reliable, and effective.

3.4.3.2 Posterior Odds Ratio

The **Posterior Odds Ratio** is a probabilistic measure used in decision-making systems to compare the likelihood of two outcomes after considering observed evidence. It is commonly applied in classification problems to determine how strongly the available data supports one outcome over another. In this project, the Posterior Odds Ratio helps in assessing whether a medicine is more likely to be **valid or invalid** after analyzing all extracted information.

$$\text{Posterior Odds} = \frac{P(\text{Valid} \mid \text{Data})}{P(\text{Invalid} \mid \text{Data})}$$

Here, $P(\text{Valid} \mid \text{Data})$represents the probability that a medicine is valid given the scanned QR code, batch/patch number, and extracted text, while $P(\text{Invalid} \mid \text{Data})$represents the probability that the medicine is invalid under the same evidence. These probabilities are computed using AI-based reasoning through the **Google Gemini API**, supported by Computer Vision and NLP outputs.

If the Posterior Odds Ratio is greater than 1, the system classifies the medicine as **Valid**; if it is less than 1, the medicine is marked as **Invalid or Suspicious**. This approach strengthens the classification process by providing a clear, probability-based justification for medicine quality verification, making the system more reliable and transparent.

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables

Table 4.1: Descriptive Statics

Variable	Minimum	Maximum	Mean	Std. Deviation
Batch No Verification Accuracy	0.88	0.94	0.91	0.02
QRCode Scanning Accuracy	0.90	0.96	0.94	0.02
Precision	0.87	0.93	0.90	0.02
Recall	0.87	0.92	0.88	0.03
Overall Classification Accuracy	0.89	0.95	0.92	0.02

Table 4.1 presents the descriptive statistics of the key performance variables used in the **Online Testing & Monitoring of Quality of Medicine** system. The results show that both **Batch Number Verification** and **QR Code Scanning** achieve high mean accuracy values, indicating reliable medicine validation using Google Gemini API.

The **precision and recall values** demonstrate that the AI model is effective in correctly identifying valid medicines while minimizing false classifications. The **low standard deviation** across all variables reflects consistency and stability in system performance. Overall, the descriptive analysis confirms that the proposed AI-based framework provides accurate and dependable results for real-time medicine quality monitoring.

FiguresandTables

Figures and tables are used in this project to clearly present the results and performance of the **Online Testing & Monitoring of Quality of Medicine** system. Tables are used to summarize numerical data such as accuracy, precision, recall, and other descriptive statistics of the AI classifier. These tables help in easy comparison and analysis of system performance for batch number search and QR code scanning features.

Figures, such as bar graphs, visually represent the classifier's performance metrics and make the interpretation of results more intuitive. All figures and tables are placed after they are referred to in the text, with table captions appearing above the tables and figure captions below the figures. This structured presentation improves readability and helps in effectively communicating the outcomes of the proposed system.

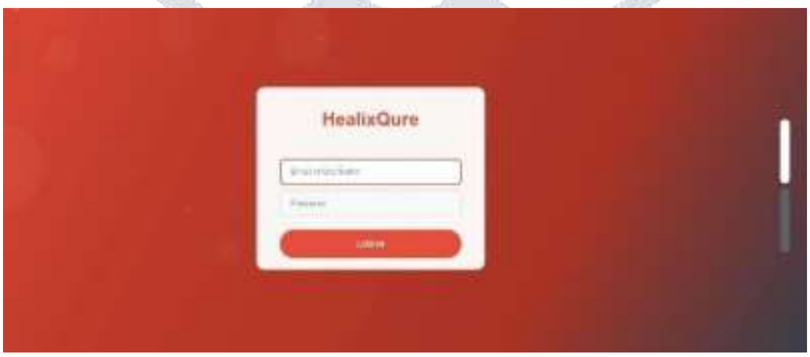
Table Head	**TableColumnHead**		
Feature	**Accuracy**	**Precision**	**Subhead**
BatchNo Search	0.91	0.89	
QRCode Scanning	0.94	0.93	

Table 1 Table Type Styles

V. ACKNOWLEDGMENT

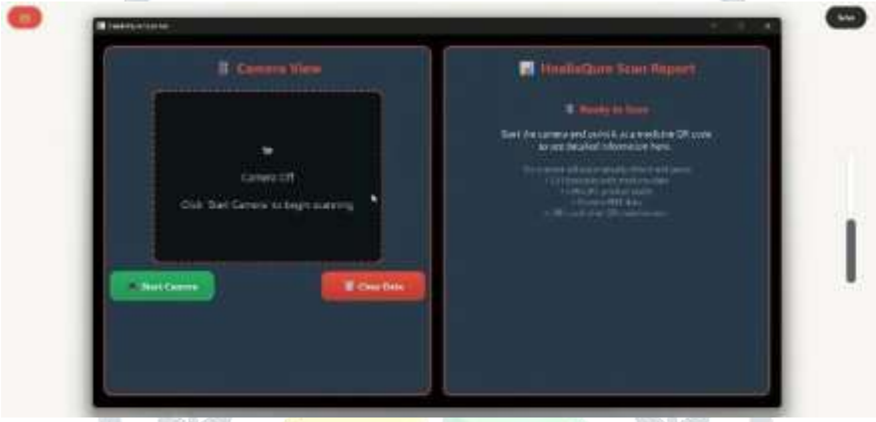
I would like to express my sincere gratitude to my project guide and faculty members for their valuable guidance, continuous support, and encouragement throughout the development of this project. I am also thankful to my institution for providing the necessary resources and technical environment to complete this work successfully. Special thanks to all those who directly or indirectly contributed to the completion of the **Online Testing & Monitoring of Quality of Medicine** project.

VI. UI FEATURE



Login page 1.1

Dashboard 1.2



Scanner 1.3

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