Mendo: An AI Symptom-Based Medicine Recommender for an Over-The-Counter Drug Dispenser

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ABSTRACT

In the era of healthcare digitization, the integration of cutting-edge technologies presents an opportunity to elevate medical services and improve patient well-being. This study focuses on a comprehensive solution—the AI-powered over-the-counter (OTC) drug dispensing system—designed to enhance accessibility to affordable and essential medications in local pharmacies. The system includes an intuitive user interface, multifunctional features, and a machine dispensing mechanism, all empowered by advanced AI algorithms. This innovative approach tailors precise medication recommendations and dispenses pre-packaged doses. Continuously evolving and adaptable to changing user needs, this system has been rigorously evaluated for accuracy, showcasing its efficacy in medication decisions. Positioned to enhance healthcare outcomes and address disparities in access, the AI-enabled OTC drug dispenser signifies a new era of efficiency, personalization, and technological empowerment within community pharmacies.

KEYWORDS

Machine learning model, artificial intelligence, software management system

1 INTRODUCTION

In recent years, the healthcare sector has embraced technological advancements to enhance patient care [16]. However, traditional pharmacy stores continue to face challenges in ensuring patient safety and healthcare efficiency [2]. Medication errors, often caused by illegible prescriptions and communication breakdowns, remain a global concern [15]. In Davao City, Philippines, these challenges persist, affecting medication management and patient safety [16]. The limited accessibility of pharmacy services outside regular hours raises concerns about potential delays in accessing vital medications, particularly over-the-counter (OTC) drugs, leading to inconvenience and health risks [15].

The rapid growth of the IT industry has introduced new infrastructures and devices, offering opportunities to improve healthcare delivery [11]. Despite these innovations, drug dispensers, especially for OTC medications, are not widely available in specific areas [3]. This research focuses on implementing a recommendation system within an OTC drug dispenser to address existing gaps in healthcare technology [11, 14]. These gaps include the need for more accessible OTC medication provision, the accuracy and completeness of recommendation systems, ongoing maintenance and updates, diversity in medication options, and legal constraints on machine commercialization [1, 13, 14].

By reducing pharmacists' time spent on customer interactions, drug dispensers can enhance efficiency [4]. However, integrating recommendation systems into healthcare, especially for OTC medications, remains understudied [6]. This study aims to develop a comprehensive dataset and train a model to recommend drugs based on symptoms, illnesses, or health discomforts [7].

The objectives include gathering diverse patient data, training an accurate recommendation model, developing a user-friendly system, and evaluating system accuracy and usability.

(1) **Gather dataset** - Gather an extensive dataset with diverse patient demographics, medical histories, and treatment outcomes.
(2) **Train a model for drug recommendation** - Train a model to accurately suggest medications based on user symptoms or conditions.
(3) **Develop system** - Develop a user-friendly system integrating the trained drug recommendation model.
(4) **Evaluate the system using Intrinsic Evaluation** - Evaluate the system's accuracy, precision, recall, dispensing accuracy, machine usability, and turnaround time using Intrinsic Evaluation.

Addressing the rising demand for pharmaceutical vending machines, the Anytime Medicine Vending Machine proposes 24/7 access to OTC drugs, especially in areas with limited medical store access [13]. Its architecture, controlled by an advanced ARM processor, includes features like RFID client identification and GSM-based stock management [13]. The machine complements automated pharmacies by offering non-prescription items [8], showcasing advancements in pharmacy intelligence and predictive analysis [8].

In the Philippines, AI-enabled pharmaceutical vending machines like OTC Express are emerging to enhance medication dispensing and inventory management [5]. These systems, supported by government initiatives, promise improved patient outcomes, although ethical and regulatory considerations are crucial [5].

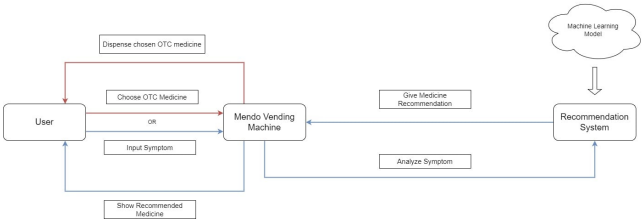

Figure 1: Conceptual Framework of Mendo Machine

Machine learning models are also employed in drug recommendation systems, leveraging datasets like the UCI repository to empower informed decision-making [10]. The investigation assesses content-based recommendation approaches, achieving a 90% accuracy rate in cloud-deployed models [10].

Advancements in administrative functions and patient management are evident, with studies showcasing reduced error rates and improved transparency in clinical scenarios [12]. Innovations in localized product recommendation systems for vending machines, as seen in Lin et al.'s work, further enhancing customer experiences and profitability [9].

2 METHODOLOGY

This section shows and discusses the procedures and methods used in this study to identify the most important characteristics and features of an AI-enabled recommender for an OTC drug dispenser.

2.1 Conceptual Framework

Figure 1 illustrates the comprehensive functionality of the Mendo drug dispenser. The process begins with user interaction, providing users with the choice to either directly purchase from the drug dispenser or opt for the machine's recommendation based on their symptoms. The purchasing option empowers users to select the over-the-counter drug they wish to acquire from the Mendo drug dispenser. On the other hand, the AI assessment option allows users to utilize the recommendation system within the Mendo drug dispenser, which suggests medicines tailored to alleviate their symptoms.

2.1.1 Data Collection. The data collection process entails systematically gathering pertinent information from diverse sources, including pharmacists and database websites such as Kaggle. The compiled data encompasses various criteria, including symptoms, over-the-counter medicines, reviews, on/off label classification, ease of use, effectiveness, and satisfaction. The researchers predominantly constructed their dataset through interviews with duly-registered and licensed pharmacists, simultaneously supplementing it by exploring existing datasets on Kaggle. Consequently, the researchers identified an extant dataset that aligns with the specified criteria and integrated the information obtained through interviews into this existing dataset.

2.1.2 Data Pre-Processing. The researchers initiated data preprocessing by cleaning and preparing the dataset for AI or Machine Learning algorithms, removing inconsistencies, errors, and redundant information. Methods employed included handling missing values using Pandas fillna() and dropna(), train-test splitting, and summarizing the preprocessed data. For data transformation, factorization, text normalization, tokenization, label encoding, and TF-IDF vectorization were utilized to enhance usability and prepare the dataset for analysis. In feature extraction, the researchers used dimensionality reduction to eliminate irrelevant features from the dataset not needed for model training, effectively modifying the dataframe.

2.2 Training the Model

The study revolves around developing an AI-enabled OTC drug dispensing machine, where users interact with the system through a user interface by inputting their specific symptoms. SVM excels in classifying suitable medicines for various health conditions by leveraging labeled data and handling high-dimensional, non-linear relationships effectively. K-Nearest Neighbors (KNN), a machine learning algorithm classifying data points based on proximity, contributes to accurate medication recommendations by considering user input and aligning it with appropriate medications in the training dataset. Together, SVM and KNN offer a comprehensive approach, ensuring user safety and satisfaction in improving the OTC drug dispenser's recommendation capabilities.

2.3 System Development

The development of the Mendo Recommendation System involved a streamlined approach to system architecture. The Front-End was crafted using HTML and Tailwind Flowbite for CSS styling, ensuring a visually appealing and user-friendly interface. Python Flask served as the Back-End framework providing robust functionality, it is also where the researchers integrated the AI Model. The management system, catering to admin tasks such as monitoring dispensed medicines, tracking remaining quantities, and editing prices, was implemented using PHP and MySQL for efficient data management. This cohesive integration of technologies ensures a seamless and effective user experience for both customers and administrators.

2.4 Evaluation

Intrinsic evaluation plays a pivotal role in assessing the trained model and system, with a primary focus on accuracy, precision, and recall for the AI model. Additionally, the evaluation extends to the system's dispensing accuracy, machine usability, and turnaround time, providing a comprehensive analysis of both the model's predictive capabilities and the operational efficiency of the dispensing system.

3 PRELIMINARY RESULTS

In order to provide initial insights on the usability of ErrgoEngine, the following objectives were established:

3.1 Machine Learning Model Results

In Table 1 machine learning model, the researchers opted for a "linear" kernel configuration. The test data portion constituted 20% of the total, utilizing a random state parameter set at 47 for consistent data splitting. These specific settings resulted in an accuracy and recall rate of 40.79%, coupled with a precision rate of 34.20%. It's

Kernel	Accuracy	Precision	Recall
Linear	40.79%	34.20%	40.79%
Sigmoid	40.79%	34.20%	40.79%
Gaussian	40.79%	34.20%	40.79%
Poly	40.79%	34.20%	40.79%

Table 1: SVM Kernel Results

noteworthy that the dataset predominantly consisted of prescription (RX) drugs, with only a limited selection of over-the-counter (OTC) medications available for analysis.

n_neighbors	Accuracy	Precision	Recall
3	40.79%	30.04%	40.79%
5	31.58%	31.25%	31.58%
7	30.26%	34.24%	30.26%
10	30.26%	29.28%	30.26%

Table 2: kNN Kernel Results

In Table 2, it becomes clear that an escalation in the number of neighbors (n_neighbors) aligns with improvements in accuracy, precision, and recall metrics for the k-Nearest Neighbors (KNN) model, maintaining a constant random state of 47 and a test size of 0.2. However, a considerable decline in these performance measures is noted upon reaching 13 neighbors. Consequently, within the scope of this machine learning model, an optimal count of n_neighbors is determined to be 10, underscoring the importance of parameter tuning in optimizing the model's predictive performance.

3.2 System Results

Inputs	Machine Learning Model (SVM)
fever	Paracetamol (Biogesic)
headache	Ibuprofen (Medicol)
cough with phlegm	Carbocisteine (Solmux)
cough without phlegm	Butamirate (Sinecod)
cold	Phenylephrine HCL (Neozep)

Table 3: OTC Medicine Recommendation Results

Table 3, presenting the OTC Medicine Recommendation Results, reflects the recommendation accuracy of the Mendo system in providing appropriate medication recommendations based on inputted symptoms/conditions. The correlation between symptoms and recommended medicines—such as Paracetamol for fever, Ibuprofen for headache, Carbocisteine for cough with phlegm, Butamirate for cough without phlegm, and Phenylephrine HCL for cold—is consistent with both the dataset and pharmacist validations. These findings underscore the reliability of the recommendation system in accurately identifying and addressing common health conditions, enhancing its utility in providing accessible and effective over-the-counter medication guidance.

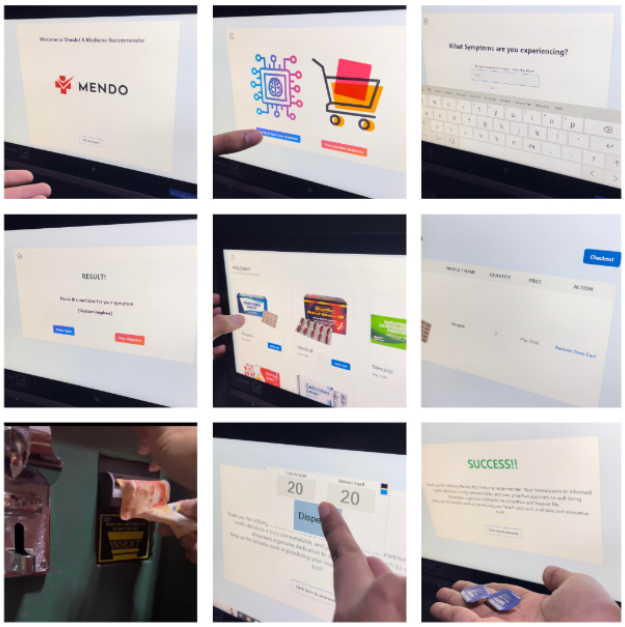

Figure 2: The whole process of interacting and ordering medicine with Mendo

The Mendo Machine evaluation covered dispensing accuracy, system usability, and turnaround time. Accuracy was ensured by comparing checked-out and dispensed medicines. Mendo's user-friendly interface streamlines transactions, requiring upfront payment and updating the admin dashboard for inventory management. Figure 2 shows the user's interaction with Mendo from the AI recommender, confirming Paracetamol for fever, to the dispensing of the actual medicine. Turnaround time analysis revealed efficient processing, ranging from one minute and thirty seconds to two minutes, highlighting Mendo's ability to improve user experience and prompt medication access in healthcare settings.

4 FURTHER WORKS

This section discusses the works to be included in this study.

4.1 Gathering More Data for the Dataset

For future work, gathering additional data, specifically focusing on Over-the-Counter (OTC) drugs, is imperative as the current dataset contains only 756 OTC data points, which may not be sufficient for implementing deep learning models effectively. Increasing the dataset size will enhance the model's accuracy and robustness, enabling more comprehensive analysis and reliable recommendations for OTC medications within the Mendo system.

4.2 Implementation of Deep Learning

After gathering sufficient data, the researchers intend to incorporate advanced deep learning techniques, focusing specifically on Natural Language Processing (NLP) and Named Entity Recognition (NER), into the AI-enabled OTC drug dispensing machine. This integration will enhance the AI's capabilities by enabling it

to extract symptoms like "fever" and "cough" from user inputs for accurate medication recommendations using NLP. Additionally, NER will identify and extract symptom details, medication names, current regimens, and allergies, ensuring personalized and precise non-prescription medication recommendations while considering potential drug interactions and allergic reactions, thus significantly enhancing user safety and efficacy.

The researchers also aim to enhance the AI's capabilities by integrating Natural Language Processing (NLP) into the system not just to detect input errors but to understand diverse languages including Tagalog or Cebuano (Bisaya), as suggested by professional pharmacists. This adaptation is crucial for ensuring seamless communication and user interaction, particularly in culturally diverse settings like the Philippines, where users may prefer to interact in their native languages. Incorporating NLP will not only improve the system's accuracy but also contribute to a more inclusive and user-friendly experience for all potential users.

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