**IoT Smart Pill Expert System**

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**ABSTRACT:**

* **Domain:**

This project addresses the Healthcare sector combined with the Internet of Things (IoT), focusing on automation and remote monitoring to improve medication adherence. The integration of systems, cloud technologies, and real-time notifications offer a robust solution to medicine management for best adherence practices.

* **Drawbacks:**

Adherence to medication is often managed by manual medical schedulers, mobile ringtone alarms or even post-it notes, which are rather ineffective. Moreover, caregivers do not know in real time whether the medicine has been taken, thereby increasing the chances of non-adherence and possible health consequences.

* **Overcoming Drawbacks:**

Automated pill dispensing and consumption logging eliminates human intervention. IoT enabled Smart Medicine Dispenser increases dose compliance by enabling users to receive their medication with the correct dosage at the specified times. Users are alerted through an LED display, buzzer, and smartphone application while real-time data is uploaded to the cloud for the caregivers’ supervision. An advanced Monitoring System ensures that all patients are receiving their medications on time while reminders about missed doses guarantee increased patient safety.

* **Novel Features and Comparison:**

The IoT-enabled smart pill dispenser provides automated dispensing, real-time tracking, and remote monitoring that outperform traditional pill organizers and clock alarms, making this solution much nearly reliable and user-friendly. In comparison to a basic pill dispenser that merely sits on its own, ours connects over the cloud with the user through mobile alerts and possible future upgrades can include AI-based analytics to optimize reminders. Future enhancements might include an RFID for governance, a voice assistant, and pill quantity detection for security and usability.

The practical, low-cost, and scalable solution can significantly enhance medication adherence among the elderly, patients suffering from chronic illnesses, and those monitored remotely for healthcare purposes. The fusion of IoT, automation, and real-time data analytics makes this project provide a new and commercially impactful contribution to the field of smart healthcare technologies.

**KEYWORDS:**

* **Healthcare:** Healthcare in our project refers to the integration of IoT with medical systems to improve patient care. Our smart medicine dispenser enhances healthcare by:
* Ensuring medication adherence through automated reminders.
* Providing remote monitoring for doctors and caregivers.
* Using real-time alerts for missed doses.
* Reducing human error in medication management.
* **Smart Medicine Dispenser:** A Smart Medicine Dispenser is an IoT-driven device designed to automate and monitor medication intake, ensuring adherence and patient safety. In our project, it:
* Automates dispensing based on a scheduled time.
* Integrates with cloud systems for remote monitoring.
* Sends real-time notifications to patients and caregivers.
* Reduces medication errors and improves adherence.
* **Android application:** An Android Application in our project serves as the user interface for the smart medicine dispenser, enabling interaction between patients, caregivers, and the IoT system.

In our project, the app:

* Displays medication schedules and reminders.
* Sends real-time alerts for missed doses.
* Allows remote monitoring by caregivers and doctors.
* Integrates with cloud storage for data management.
* **Drug dosage:** Drug Dosage in our project refers to the precise amount of medication dispensed to a patient at scheduled intervals to ensure correct intake and adherence.

In our Smart Medicine Dispenser, drug dosage:

* Automates dispensing based on prescription.
* Prevents overdose or missed doses with real-time alerts.
* Tracks consumption history for caregivers and doctors.
* Integrates with cloud storage for remote access and monitoring.
* **Adherence:** Adherence in our project refers to ensuring that patients take their prescribed medications correctly and on time.

In our Smart Medicine Dispenser, adherence is improved by:

* Automated reminders to notify users when it’s time for medication.
* Real-time alerts for missed doses, sent to caregivers or doctors.
* Tracking medication intake using cloud storage for monitoring.
* Preventing overdose or underdose through controlled dispensing.

**INTRODUCTION:**

Medication **non-adherence** and **improper dosage** are among the leading causes of **preventable health complications** and **fatalities** worldwide. Despite advancements in healthcare, a significant number of patients fail to take their medication on time or consume incorrect dosages, leading to deteriorating health conditions, prolonged treatments, and increased hospitalizations. **Human errors, forgetfulness, and lack of supervision** remain key contributors to these issues, emphasizing the need for a **technology-driven solution** to ensure medication adherence.

The evolution of **Internet of Things (IoT) in healthcare** has opened new opportunities for **automation, real-time monitoring, and intelligent decision-making**. Conventional medication management methods, such as **manual pill organizers and reminder-based mobile apps**, often fail due to human dependency and lack of real-time intervention. To overcome these limitations, **IoT-integrated smart healthcare devices** provide a **seamless, efficient, and proactive** approach to medication management, ensuring timely medication intake and preventing potential health risks.

The **Smart Pill Expert System**, an **IoT-powered intelligent medicine dispenser**, is designed to **automate medication dispensing, ensure accurate dosage, and provide real-time alerts** to patients, caregivers, and healthcare professionals. By leveraging **cloud connectivity, embedded systems, and AI-driven analytics**, this system enhances **efficiency, security, and accessibility** in medication adherence. The integration of **sensors, wireless communication, and smart notifications** enables personalized medication schedules, remote monitoring, and automated interventions to prevent missed doses.

Additionally, **machine learning algorithms** and **biometric authentication** can be incorporated to tailor medication regimens based on **patient behavior, medical history, and real-time health conditions**. The system also supports **multi-user functionality**, making it beneficial for **elderly individuals, patients with chronic diseases, and those requiring strict medication adherence**. By reducing **human intervention** and **minimizing errors**, this Smart Pill Expert System aims to **revolutionize medication management** by offering a **reliable, patient-friendly, and technologically adaptive** healthcare solution.

As **IoT adoption in healthcare** continues to expand, the development of **automated and AI-driven medication dispensers** will play a crucial role in **enhancing patient safety, reducing healthcare costs, and improving overall medical outcomes**. By integrating **real-time notifications, cloud-based record-keeping, and intelligent tracking**, this **IoT-enabled Smart Medicine Dispenser** contributes to the vision of a **smarter, more connected, and patient-centric healthcare ecosystem**.

**Literature Survey:**

Authors [1] provide a user-friendly design to operate and troubleshoot any problems faced during the usage of the device with an intelligent chat assistant. Non-adherence in the feld of medicine is a critical factor; SPES also helps in live tracking and analysis of the medication history of the patient and tried to reduce the ambiguous dosage consumptions. Authors [2] specially designed and modeled to meet the needs of the elders and visually impaired beings to maintain and manage their medicine consumption pattern. This feature is presented by ofering an approach to sort their daily medicine cycle. In addition, the device is programmed to give out alerts when a person must consume his dosage. Authors [3] programmed to give buzzer notifcations along with LED lights to users indicating their medicine consumption time. This is an upgrade that has been made for healthy world. The IoT-based medicine container [4] has various features along with the sensors to supervisor health check-ups. It also has a temperature sensor to monitor the patient’s body temperature along with wireless communication facility between the patient and the caretaker. Authors [5] state about how efectively can food pattern be observed and maintained through a pet feeder machine. Here, the dry pet food has been pre-stored by the owner of the pet and is customized for certain time intervals to feed their pets. The system [6] can be regulated through phone or by use of buttons on the device and set time intervals for medicine intake. It also sends text messages to indicate if the tablets were pickup from the container box at the given time period or not helping the care-taker to track the consumption of the medicines. System [7] is similar to the system described by authors [6] with advanced options of security provided to the device to prevent kids unintentional consumption of the tablets when at households. This device is designed such that it reads the prescription and sets its time intervals or respective drugs. The use of “Blynk” mobile application [8] improvises the automations of the device that had have more user control over the network. All actions performed by the device are monitored through the application like dispensing the drug, opening the valve for drug consumption, etc. Authors [9] use Instapush feature for providing notifcations to cell phones along with microcontrollers and infrared sensors to monitor medicine consumption. The designing and development described by Authors [10] was a very crucial and all components were interlinked. Thus, failure of a single component would lead to failure of the complete system. There was a precise methodology incorporated to enhance the model and reduce the number of failures and is presented in the IEC62304 guidelines. This also helped in enhancing the medical dispenser’s probability of function right. Based on TOPSIS, In [11], a workfow scheduling method for cloud computing has been proposed. This method involves selecting the most suitable virtual machine for each task, achieved through the utilization of the TOPSIS approach. We have considered a cloud system with DVS and heterogeneous VM instances that are based on pay-peruse. The MIPS (Million Instructions Per Second) of the virtual machine (VM) instances used in the experiment is directly correlated with the VM price. Kumar et al. [12] states a projection model-based approach to risk evaluation and decision-making for information system assets is suggested, and it is utilized to address the MADM issue where the evaluation index value is an IVIFN and the index weight is unknowable. In [13], the decision-making process regarding the prioritization of pipe network improvement projects for replacement and rehabilitation is infuenced by the age of pipe installation. The study evaluated the economic efciency of these renovation projects, considering multiple factors associated with non-revenue water (NRW), including pipe deterioration and demand energy ratio [14]. The proposed approach can eliminate the issues that arose when utilizing CCR, such as many optimal solutions occurring and DMUs that cannot be fully sorted, as well as avoid the over-subjective evaluation matrix in the AHP. The suggested approach is therefore more logical and scientifc than some of the existing approaches. The research discussed in [15] demonstrates the implementation of a mixed performance measurement approach, which involves combining game theory with the balanced scorecard methodology. This integration enables players or perspectives to optimize their rewards while striving to achieve equilibrium by selecting the most efcient methods available. The outcomes indicate that the proposed model efciently selects the appropriate set of indicators and the balanced scorecard’s equilibrium point, resulting in cost minimization and maximizing returns for the perspectives, all achieved without the need for laborious mathematical computations. In [16], the study demonstrates the application of a hybrid algorithm to create an ensemble technique for short-term load forecasting (STLF) in a wind energy system. Combining deep neural network (DNN) and chicken swarm optimization (CSO), the hybrid method combines these two techniques. The New England ISO provides 24-h demand data for the wind energy system, which is frst used to train the DNN network and analyze load forecasting. In [17], the research is centered around multivariate timeseries data gathered from diverse felds. The study proposes a bi-directional long short-term memory (LSTM) model that considers the unique properties of these felds. Unlike existing models, this new approach involves splitting the data input into the input layer, allowing the model to learn distinct features from each feld. Additionally, the study aims to simultaneously learn the data’s value and its variations, enabling the model to grasp the trend of the time series data efectively. Deep neural networks were used to develop two decision-making approaches in [18] for the Spares reserve that address the issue of too many subjective elements in comparison with more conventional approaches like fuzzy comprehensive assessment, grey evaluation, and hierarchical analysis. These techniques frequently have the drawbacks of difcult calculation and signifcant subjectivity in determining the index weight vector. In [19], the study introduces the incorporation of graph convolutional networks (GCNs) into the Transformer architecture. This addition aims to train and consider dependencies at a more detailed level, thereby addressing the dynamics of changing dependencies more efectively. Furthermore, the researchers include the temporal convolutional network (TCN) as a component of the self-attention layer to tackle the local insensitivity issues of the Transformer model. This combined approach aims to enhance the model’s ability to capture complex patterns and dependencies in the data, improving its overall performance. The Dombi aggregation operators for spherical fuzzy sets are efectively studied and introduced in [20]. Additionally mentioned and examined are the fundamental characteristics of spherical fuzzy Dombi operators. Then, after examining the drawbacks and benefts of the prior literature, we present a novel method for solving the decision-making problem based on the suggested Dombi aggregation operators. Additionally, the decision method’s decision-making processes were built. The suggested method will solely use data from the choice problem to produce an objective decision result. In [21], cluster approaches are employed to develop an ANFIS-based reconstruction method for multifunctional sensing. By using cluster analysis to the experimental data with subtractive clustering, the structure of the produced ANFIS may be adaptively recognized. In-depth analysis of the fuzzy MCDM-based WS selection techniques discussed in the [22]. It then categorizes the studied schemes in accordance with the used fuzzy MCDM approaches, illustrative of the background information regarding the WS selection. It outlines their primary contributions and describes how, during the WS selection process, they employed MCDM methods, particularly the fuzzy ones, to rank the WS and select the best one. In [23], the study suggests the use of emerging tools such as the wavelet transform (WT), adaptive autoregressive modeling (AARM), and vector machines (VMs) like the support vector machine (SVM) and relevance vector machine (RVM) for diferent purposes. WT is recommended for pre-processing due to its improved time–frequency resolution, while AARM is suitable for feature extraction as it can capture characteristics that change over time, allowing measurement of time-varying spectra. VMs, specifcally SVM and RVM, are proposed for classifcation tasks as they efectively model nonlinear data Additionally, [24] focuses on creating an innovative hybrid model designed to predict sugarcane yield using nonlinear time series data. The study utilizes recurrent neural networks (RNNs) due to their extensive memory capabilities, which enable reliable forecasts with fewer parameters. To enhance the efciency and accuracy of the RNN, the researchers improve its weights and thresholds using the whale optimization method. This hybrid approach is designed to produce more accurate results and increase the overall efciency of the neural network in predicting sugarcane yield. It might be difcult to steadily improve performance when predicting time series volatility. WOARNNGARCH, RNN-GARCH, and BPNN-GARCH are three hybrid models. By taking into account meteorological conditions (temperature, humidity, and pressure), in [25], the study demonstrates the efectiveness of a hybrid 3-level wavelet transform extreme learning machine for short-term (a day ahead) and medium-term (a season ahead) load forecasting. This hybrid approach proves to be efcient in predicting both short-term and medium-term loads with improved accuracy. The Extreme Learning Machine (ELM) is trained and tested using data that has been separated into multiple frequency components through the utilization of Wavelet Transform (WT) on load and weather data. This approach allows for improved load forecasting performance, making it suitable for both short-term and medium-term predictions. Investigating pertinent ELM weights and biases improves the performance of the proposed technique. Travel routes are defned with operational efciency in mind, which is not always connected to the passenger experience in [26]. The topic of how fexible the passenger transportation options now ofered by the sector are raised as a result. As far as our knowledge goes, there have been no prior proposals that integrate artifcial emotions into cognitive agents employed in the context of fexible passenger transportation. This novel approach aims to equip these agents with the ability to independently reason and make decisions, taking into account both objective factors (such as travel time or cost) and subjective variables (such as emotions and passenger satisfaction) within a unifed and integrated layer, using individual traveler and passenger profles. This novel approach would enable these agents to independently reason and make decisions, considering both objective factors like travel time and cost, as well as subjective variables such as emotions and passenger satisfaction, all within a unifed and integrated layer. The system would be designed to leverage traveler and passenger profles, ensuring a personalized and efcient travel experience that takes into account individual preferences and emotions, alongside practical considerations. Comparative Analysis Study. The following comparative analysis was conducted based on the kind of technology that was used and implemented in the products. There is also an analysis provided for the currently available dispensers in the market. An overall conclusion can be brought after comparison of the features and limitations provided for each technology-based system in Table 1. Sensor-based systems [27–30] detect the operation of medicine compartments, mobile application integration, antibacterial, portability, battery life and accuracy to detect the medication is very low. Visibility- based systems [31, 32] operate with the help of antenna and senses the open and close of the compartments, requires group of detectors for validation. There are lot of assumptions made regarding medicines that are self-sorted. Vision-based systems [31, 33] require good camera resolution to recognize movements. The placement of the camera is very critical and is presumed to monitor the medication region and analyses the usual and unusual medication behaviors via hand gestures. Philips’ Pill Dispenser [34] offers various features, including fall detection and a fexible monthly payment option based on usage rates. The device has been enhanced from its previous model, boasting an elegant and compact design. It allows users to customize their service plans according to their specifc needs. Additionally, the gadget integrates with a mobile app to facilitate seamless communication between the user and their caregiver, streamlining coordination and ensuring efcient assistance. This combination of advanced features and user-friendly design makes the Philips’ Pill Dispenser a comprehensive and convenient solution for medication management and care. Waterproof designing has been implemented for a better and efcient life cycle. A good battery life with customer care services is a plus point for this model. Hero’s Pill Dispenser[20, 21] provides fexible programming of up to 10 various medicines for everyday consumption. The device caters for a 90-day period with predefned intervals for medicine dispensing. These are not dependent on the shape or size of the medicine. Audible and visible alarm alerts [22, 23] are provided for missed dosages along with security notifcations. It is the most afordable option that never runs out and has a pay per plan service[35].

**Architecture:**