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Patient and Doctor Management System Using Machine Learning

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Abstract - The **Patient and Doctor Management System (PDMS)** is designed to keep track of all the data pertaining to patients and doctors in digital mode, including their medical records, medications, test results, patient-physician contacts, and billing procedures. Managing all these data manually is really challenging. With the progress of technology, this online system makes the task much simpler. This proposed system automates processes related to doctor information, patient issues, and other operations, patient and doctor management by incorporating some new components into the existing system.

Key Words: Machine Learning (ML), Artificial Intelligence (AI), Reinforcement Learning (RL), Decision Support, Q-Learning, Dynamic Treatment Regimens (DTRs).

1. INTRODUCTION

The application of machine learning (ML) dates back to the 1950s when Alan Turing proposed the first machine that can learn and become artificially intelligent [5] .The Patient and Doctor Management System (PDMS) automates healthcare operations, managing patient data, appointments invoicing, etc. with AI/ML integration enhancing functionality. AI, a computer program, aids in decision-making in complex situations, particularly in healthcare, where large amounts of data require machine learning algorithms for classification [10].

ML's growing applications in healthcare include automating billing, providing medical decision support, and creating regulations, benefiting patients and doctors in numerous ways [11]. ML algorithms, or mathematical models, enable computers to learn from data without programming. They are crucial in AI advancements like facial recognition, self-driving cars, personalized suggestions, and healthcare diagnostics. The existing systems have their own limitations and the proposed system is supposed to overcome those limitations by incorporating the new techniques of AI/ML. Reinforcement Learning (RL) learns through interaction with the environment and feedback, maximizing cumulative rewards over time.

1.1 Reinforcement Learning (RL)

RL is a part of Machine Learning (ML) that optimizes actions to maximize reward in specific situations. It differs from supervised learning, in the way that, the reinforcement agent decides on its own, learning from its experience without a training dataset. It is a decision-making science that learns optimal behavior to maximize reward using trial-and-error data from ML systems, unlike supervised or unsupervised learning.

RL algorithms learn from outcomes, making decisions based on feedback, making them ideal for automated systems making small decisions without human guidance. RL enables an agent to learn effective strategies in sequential decision making problems by trial-and-error interactions with its environment [3].

Reinforcement learning algorithms use a trial and error approach to interact with the environment, identifying errors and maximizing performance in software systems. They employ a reward-feedback mechanism to guide optimal actions [8].

RL is a self-teaching system that learns through trial and error, aiming to maximize rewards and achieve the best outcomes through actions.

- **A.** ***Reinforcement learning (RL) in healthcare***: RL has achieved significant accomplishments in healthcare, including dynamic treatment regimens for long-term illnesses, automated medical diagnostics, resource scheduling, medication discovery, and healthcare management.
- **B.** ***Dynamic treatment regimens (DTRs):*** RL is used in healthcare to develop and configure Decision Trees (DTRs) for chronic illnesses, automating decision-making and improving critical care by leveraging vast data in intensive care units.
- **C.** ***Automated medical diagnosis:*** Medical diagnoses involve matching patient information to the appropriate illness profile, a complex task that can strain busy practitioners' time and cognitive resources.
- **D.** ***Health-care resource scheduling and allocation:*** RL can assist healthcare providers in business process management by analyzing and designing optimal resource allocation and scheduling based on seasonal trends, staffing, and inpatient levels.
- **E.** ***Drug discovery, design, and development:*** Traditional drug development is time-consuming and expensive, leading to modest success rates. Advanced machine learning and quantum computing are being used to

automate and enhance hypotheses and compound selection.

F. ***Health management:*** RL aids in developing personalized therapies for long-term health management, including exercise and weight-management plans for obese or diabetic individuals, enhancing patient engagement and adherence to health management programs.

2. LITRETURE REVIEW:

To design the proposed system, some prevailing systems have been referred which are the following:

With the evolution of medical records from paper charts to electronic health records (EHRs), health data management has undergone disruptive transitions to provide more accurate and better patient care and make qualitative use of these records. This shift is underpinned by the advancement in information technologies that led to the development of several notions of health data management systems [1].

This paper focused on specific applications of RL in robotics and healthcare. The article also presents a science mapping analysis on RL research publications. It shows an increase in RL publications over the years and identifies frequently used keywords in this field [2].

AI techniques, particularly reinforcement learning (RL), are becoming increasingly important in healthcare due to the growth of big data and advanced algorithms. RL is distinct from other ML methods because it learns through trial and error interactions with its environment, rather than needing explicit instructions or a perfect model of the environment. RL has the potential to improve healthcare by allowing for personalized treatment plans that take into account individual patient characteristics and responses. Additionally, RL can find optimal treatment policies without requiring a complete understanding of the underlying biology, which is often difficult in healthcare. There have already been many successful applications of RL in healthcare, with more to come in the future [3].

Here the application of Artificial Intelligence (AI) and the Internet of Things (IoT) in healthcare. AI can be used to analyze data from wearable and other medical devices to provide better diagnoses and treatment plans. IoT devices can be used to collect data from patients, such as heart rate and blood pressure. This data can then be used by AI to provide real-time feedback and monitoring. There are also concerns about data privacy and security. However, the article concludes that the benefits of AI and IoT in healthcare outweigh the challenges [4].

ML has also been recently applied to accelerate testing and response during the COVID-19 pandemic. This research differentiated between Artificial Intelligence (AI), ML, and deep learning. AI is the umbrella term that refers to any computerized intelligence. ML is a subfield of AI that uses algorithms to solve problems without needing specific programming. Deep learning is a more complex form of ML that uses artificial neural networks to process data [5].

Various other applications of ML can be used on health industry to handle large amount of data. This all had been done to make the better medical decisions and also for rise in the accuracy. These all challenges can be easier by the help of various tools, algorithms and framework provided by the machine learning [6].

Another paper stated that Symptom checkers use a medical knowledge base and an inference engine to diagnose diseases based on a patient's symptoms. The goal is to be accurate, but online checkers are limited by the amount of information they can get from a patient. There are two main requirements for a good symptom checker: high accuracy and good user experience. To achieve good user experience, a checker should ask as few questions as possible while still getting enough information for an accurate diagnosis [7].

The healthcare industry is generating massive amounts of data that needs to be analyzed and managed effectively. Machine learning (ML) techniques are being used to analyze this data and improve healthcare in a number of ways Healthcare informatics is the field that deals with storing, retrieving, and using medical data. This data is crucial for solving problems and making decisions in healthcare Machine learning is particularly well-suited to healthcare because it can find complex patterns in large datasets. This data can be used to identify diseases, discover new drugs, predict epidemics, and provide personalized treatments [8].

ML has the ability to predict multiple diseases by enabling more accurate and personalized diagnoses, earlier interventions, and more effective treatments. However, there are also challenges and limitations to this approach, including the need for diverse and representative data, the risk of bias in algorithms, and the need for transparent and ethical implementation. ML is one of the fastest growing areas of computer science with several applications. It is the process of extracting useful information from a large set of data. ML techniques are used in various fields such as medical diagnostics, marketing, industry and other scientific fields [9].

ML algorithms are used to analyse large amounts of medical data, including clinical symptoms and imaging features. This data is used to train AI models to perform tasks such as diagnosing diseases, interpreting medical images, and even developing new drugs. AI has the potential to improve healthcare efficiency and accuracy, but it is important to ensure that AI systems are safe and reliable before they are used in clinical settings [10].

ML is an interdisciplinary field that combines mathematics, statistics, knowledge analytics, and data processing to analyze techniques and algorithms for discovering patterns in data. Supervised learning uses well-labelled data to predict outcomes, while semi-supervised learning uses unlabelled data and reinforcement learning uses trial and error. ML applications, algorithms, techniques, opportunities, and challenges for healthcare are being explored in this emerging technological advancement [11].

In 2020, some authors argue that their findings show that using a recurrent neural network to learn a state representation from sequential data can improve the performance of RL models in healthcare. Current RL models in healthcare don't consider the sequential nature of patient data. They proposed that using recurrent neural networks to encode a sequence of observations into a representation of the patient's state [12].

3. OBJECTIVE:

The objective is to develop a Patient and Doctor Management System (PDMS) with the help of Machine Learning (ML) technique to enhance the overall healthcare system with focus on the following issues:

- Providing a quick medical diagnosis to the patients living in rural areas.
- Easy access to doctors by the patients without any physical appearance.

4. PROPOSED SOLUTION:

This proposed project uses RL algorithm to address the issues in the existing PDMS system. The system uses the following tools:

Optimizing Appointment Schedule and Resource Allocation: Dynamically allocates doctors, paramedical staff members, and equipment to minimize wait times and maximize resource utilization.
Improve patient care and outcomes: Provide AI-powered decision support for diagnosis, treatment, and medication, personalized to each patient's needs and medical history.

5. METHODOLOGY:

The patient and doctor management system (PDMS) will be developed in two stages using the principles of Reinforcement Algorithm (RL):

- A database will be developed.
- The interface will be customized, will be programmed and the specific code will be written.

A sample data set is used to develop a system with five primary modules: appointment management, pharmacy management, healthcare operations management, and doctor's management. A comparative study reveals the system is insufficient for rural areas. A local database is built using RL algorithm for scheduling, resource allocation, and clinical decision support.

- Developing RL algorithm for scheduling, resource allocation and clinical decision support and use of natural language processing (NLP) for easy communication between patient and doctor so also for analysis and report generation.

- Performing Real-time data analysis and decision making with the help of big data analytics.

RL approaches have been successfully applied in a number of healthcare domains to date. Broadly, these application domains can be categorized into three main types: dynamic treatment regimes in chronic disease or critical care, automated medical diagnosis, and other general domains such as health resources allocation and scheduling, optimal process control, drug discovery and development, as well as health management.

6. EXPECTED OUTCOMES:

- Reduced wait time of the patients and improvised health care of patients.
- High level of patient satisfaction.

In PDMS using RL, We implement Q-Learning algorithm, Reinforcement Learning, specifically focusing on the Q-Learning algorithm.

7. USING Q- LEARNING ALGORITHM:

Q- Learning Algorithm: Reinforcement Learning (RL) is a learning process where agents continuously interact and maximize rewards to optimize behaviour in a given environment using Q-values.
Q-learning in RL: Q-learning is a model-free RL algorithm utilized in machine learning and artificial intelligence applications, involving agent observation, interaction with environment, and rewards for new information .
Key Components of Q-learning:

I. Q-values estimate the effectiveness of an action at a state, determined iteratively using the TD-Update rule, as discussed in upcoming sections.

II. An agent transitions between states based on actions and environment, receiving rewards at each step. Terminating states end when no further transitions occur.

III. Temporal Difference or TD-Update: The Temporal Difference or TD-Update rule can be represented as follows:

$$Q(S,A) \leftarrow Q(S,A) + \alpha(R + \gamma Q(S',A') - Q(S,A)$$

This update rule to estimate the value of Q is applied at every time step of the agent's interaction with the environment. The terms used are explained below:

- S – Current State of the agent.
- A – Current Action Picked according to some policy.
- S' – Next State where the agent ends up.
- A' – Next best action to be picked using current Q-value estimation, i.e. pick the action with the maximum Q-value in the next state.
- R –Current Reward observed from the environment in Response of current action.
- γ(>0 and <=1): Discounting Factor for Future Rewards. Future rewards are less valuable than current rewards so they must be discounted. Since Q-value is an estimation of expected

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rewards from a state, discounting rule applies here as well.

- α: Step length taken to update the estimation of Q(S, A).
- The ϵ-greedy policy is a straightforward method for determining an action's course based on the current Q-value estimates

7.1. Implementation of Q-Learning

A. Defining Enviroment and parameters:

The Q-learning implementation uses a grid world environment with 16 states and 4 actions to reach state 15, learning parameters like learning rate, discount factor, and exploration probability.

```python
import numpy as np

# Define the environment
n_states = 16  # Number of states in the grid world
n_actions = 4  # Number of possible actions (up, down, left, right)
goal_state = 15  # Goal state

# Initialize Q-table with zeros
Q_table = np.zeros((n_states, n_actions))

# Define parameters
learning_rate = 0.8
discount_factor = 0.95
exploration_prob = 0.2
epochs = 1000
```

B. Implement Q-Algorithm :

```python
# Q-learning algorithm
for epoch in range(epochs):
    current_state = np.random.randint(0, n_states)  # Start from a random state

    while current_state != goal_state:
        # Choose action with epsilon-greedy strategy
        if np.random.rand() < exploration_prob:
            action = np.random.randint(0, n_actions)  # Explore
        else:
            action = np.argmax(Q_table[current_state])  # Exploit

        # Simulate the environment (move to the next state)
        # For simplicity, move to the next state
        next_state = (current_state + 1) % n_states

        # Define a simple reward function (1 if the goal state is reached, 0 otherwise)
        reward = 1 if next_state == goal_state else 0

        # Update Q-value using the Q-learning update rule
        Q_table[current_state, action] += learning_rate * \
            (reward + discount_factor *
             np.max(Q_table[next_state]) - Q_table[current_state, action])

        current_state = next_state  # Move to the next state

# After training, the Q-table represents the learned Q-values
print("Learned Q-table:")
print(Q_table)
```

OUTPUT:

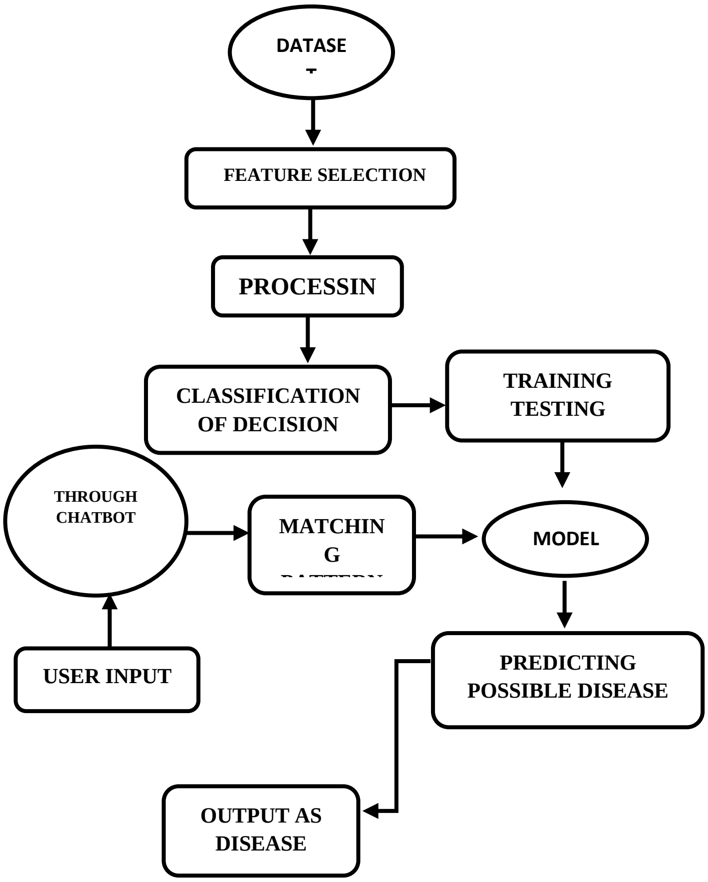
```
Learned Q-table:
[[0.48767498 0.48377358 0.48751874 0.48377357]
 [0.51252074 0.51317781 0.51334071 0.51334208]
 [0.54036009 0.5403255  0.54018713 0.54036009]
 [0.56880009 0.56880009 0.56880008 0.56880009]
 [0.59873694 0.59873694 0.59873694 0.59873694]
 [0.63024941 0.63024941 0.63024941 0.63024941]
 [0.66342043 0.66342043 0.66342043 0.66342043]
 [0.6983373  0.6983373  0.6983373  0.6983373 ]
 [0.73509189 0.73509189 0.73509189 0.73509189]
 [0.77378094 0.77378094 0.77378094 0.77378094]
 [0.81450625 0.81450625 0.81450625 0.81450625]
 [0.857375   0.857375   0.857375   0.857375  ]
 [0.9025     0.9025     0.9025     0.9025    ]
 [0.95       0.95       0.95       0.95      ]
 [1.         1.         1.         1.        ]
 [0.         0.         0.         0.        ]]
```

The Q-learning algorithm is an iterative training method that involves an agent exploring and updating its Q-table, combining received and expected rewards until optimal strategies are learned

8. PROPOSED SYSTEM:

8.1. Method Overview:

The project utilizes machine learning in healthcare to manage appointments, diseases, and medicine, using a decision tree classification algorithm and Kaggle training dataset for accurate diagnoses and timely treatment.



Flow chart [16]

Data Pre-processing: The disease prediction dataset consists of patient-sensitive symptoms, with diseases predicted based on patient records. Symptoms are used as attributes, with 1 indicating the disease and 0 indicating not sensed symptoms.

Classification modelling: The decision tree classification algorithm is used for model building, clustering the dataset based on symptoms and decision tree features. The decision tree classifier is used to predict diseases using a tree structure, utilizing sklearn, pandas, and numpy packages, and is applied to each clustered dataset.

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Text processing: Since we have text data but a machine learning model requires a numerical feature vector, pre-processing is carried out.

Tokenization: in this step, regular text strings are changed into tokens. Word tokenizes translate to lists of words, and sentence tokenizes to lists of sentences. nltk.sent_tokenize (raw) # sent tokens transforms into a series of sentences word tokenize (raw) =nltk.word_tokens .

Lemmatization: Word Net Lemmatizer is imported from NLTK.stem for this purpose. Hence, we will now use lemmas, the real words. We lemmatize our tokens here in our code.

We define a function called Lemtokens, which takes lemmatize tokens as input and returns normalized tokens, a list of words after removing punctuation.

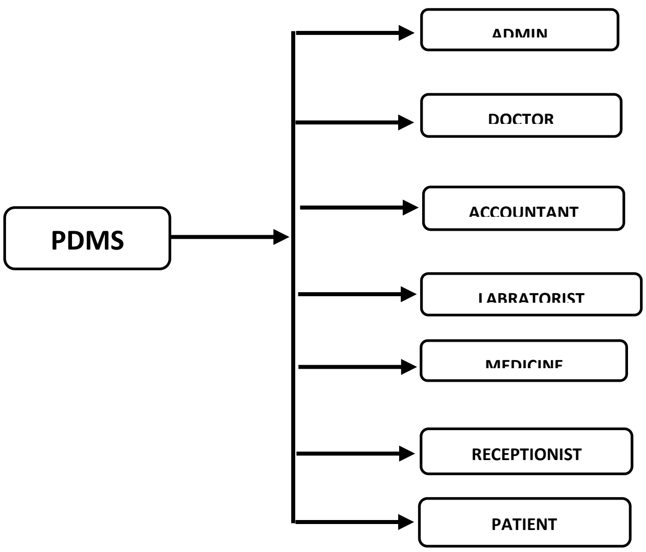
To build a retrieval-based chatbot, a function for inputs and responses is defined, allowing the Chabot to use keyword matching for the system.

The Chabot generates a response from the patient's input using modules like TFidf victories and cosine similarity. The bot uses a decision tree classification model to predict the patient's disease based on their symptoms. The model uses sklearn, pandas, and numpy packages, and the decision tree classifier is applied to each dataset.

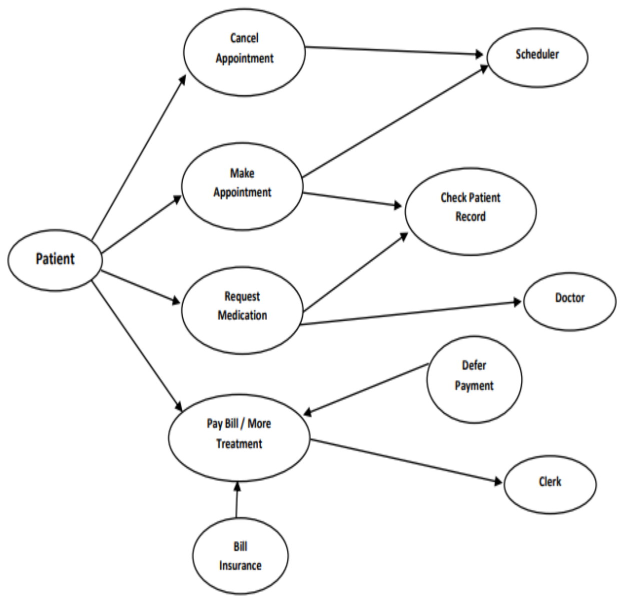
8.2. Background of PDMS:

The Patient and Doctor Management (PDMS) system consolidates a hospital's data and operations into a single platform, encompassing all information processing and storage components, beyond computer systems.

Proposed Model for Patient and Doctor Management System



This software will make it easier to book doctors' appointments, lab test slots, pharmacy services, and health programmes. This system has an admin handling component, which allows administrators to handle users, pharmacy systems, health programme administration, and arranging doctor's appointments and lab testing for their patients. It also describes the user interface and the many models that could be utilised to create software like this.



Use Case Diagram for the Proposed System

A Patient and Doctor Management system is a computer system that facilitates in the efficient execution of the jobs of healthcare practitioners and helps manage information connected to health care. They oversee the data for all healthcare departments, including, customers increases, the system's ability to collect and manage data must improve. A high-end database system is required to store this data. Front-end personnel with greater effectiveness will work on that system. They could overcome this if they were given the proper instructions.

9. CONCLUSION and FUTURE SCOPE

The system will be very much useful for the user in case he/she is unable to go to the hospital or any other clinics and can get doctor's advice. With the application of AI/ML technique accuracy of the treatment can also increase. In future, the system can be enhanced for different types of medical diagnosis tests and online availability of medicine.

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