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Health Insights: Orchestrating Holistic Wellness Through Symptom- Based Solutions

Yash Vinod Patil
Department of Information Technology
Shah & Anchor Kutchhi Engineering College Mumbai, India
yash.patil16431@sakec.ac.in

Dhanraj Sawant
Department of Information Technology
Shah & Anchor Kutchhi Engineering College Mumbai, India
dhanaraj.sawant16567@sakec.ac.in

Nivedeeta Mukherjee
Department of Information Technology
Shah & Anchor Kutchhi Engineering College Mumbai, India
nivedeeta.mukherjee@sakec.ac.in

Aditya Gupta
Department of Information Technology
Shah & Anchor Kutchhi Engineering College Mumbai, India
aditya.gupta16419@sakec.ac.in

Shivam Vibhute
Department of Information Technology
Shah & Anchor Kutchhi Engineering College Mumbai, India
shivam.vibhute16857@sakec.ac.in

Abstract

Access to timely and quality healthcare remains a significant global challenge, especially in regions with a shortage of healthcare professionals and limited medical infrastructure. Health Insights is a Flask-based web application designed to bridge this gap by providing a user- friendly, AI-powered healthcare management system. The system facilitates secure patient and doctor registration, appointment scheduling, and an AI-driven disease prediction module based on a Random Forest Classifier trained on a medical dataset containing 4,920 patient records and 132 symptoms. The model achieved 100% accuracy in predicting 41 different diseases during validation, demonstrating its potential as adiagnostic aid. Beyond disease prediction, Health Insights integrates a mental health analysis module and a lung cancer risk assessment system using machine learning techniques.

Keywords – Machine Learning, Personalized Healthcare, Disease Prediction, Flask Framework, Artificial Intelligence in Healthcare, Medical Recommendation System, Decision Tree Classifier, Random Forest Classifier, Support Vector Machine (SVM), Health Informatics.

I. INTRODUCTION

Healthcare accessibility remains a pressing challenge worldwide, particularly in regions with inadequate medical infrastructure and a shortage of healthcare professionals. Millions of individuals struggle to receive timely and accurate diagnoses, often due to geographic barriers, financial constraints, or a lack of awareness about available medical services. The integration of technology into healthcare has proven to be a transformative solution, enabling remote consultations, AI-driven diagnostics, and efficient patient management systems.

To address these challenges, **Health Insights** has been developed as a **Flask-based web application** that provides an **AI-powered healthcare management system**. The platform enables **secure user registration** for both patients and doctors, **seamless appointment scheduling**, and an **intelligent disease prediction system** that utilizes a **Random Forest Classifier** trained on a dataset of 4,920 patient records with 132 symptoms. This predictive model assists users in identifying potential illnesses based on their symptoms, improving early detection and facilitating prompt medical intervention.

Beyond disease prediction, Health Insights incorporates a mental health assessment module and a lung cancer risk evaluation system**.** The mental health module analyzes user-reported symptoms and behavioral patterns, offering insights into potential psychological conditions. Meanwhile, the lung cancer detection system employs machine learning algorithms trained on patient data, with the most accurate model achieving over 95% accuracy in identifying high-risk cases.

Additionally, the platform features a blog section to promote public awareness of health-related topics, a video consultation feature to enable remote doctor-patient interactions, and a privacy- focused approach to ensure secure handling of medical data. By leveraging artificial intelligence and web technologies, Health Insigh**ts** aims to bridge the gap between patients and healthcareproviders, making quality medical assistance more accessible, reliable, and efficient.

This paper presents the architecture, implementation, and evaluation of Health Insights, detailing its disease prediction accuracy, mental health insights, and lung cancer assessment capabilities. It also discusses the potential **real-world impact** of the system and outlines **future enhancements**, such as expanding AI-driven diagnostics, incorporating real-time patient monitoring, and refining predictive models to improve healthcare accessibility further.

II. SYSTEM ARCHITECTURE AND IMPLEMENTATION

2.1 System Overview

Health Insights is a Flask-based web application designed to enhance healthcare accessibility by integrating AI-driven disease prediction, mental health analysis, and lung cancer risk assessment. The system follows a modular architecture, ensuring efficient data flow, security, and ease of expansion.

Key Components and Interactions

- **Frontend (User Interface):** Built with HTML, CSS, and JavaScript, offering an interactive platform for patients and doctors.
- **Flask Backend:** Manages user authentication, appointment booking, disease prediction, and mental health analysis.
- **SQLite Database:** Stores user credentials, medical history, appointment records, and prediction results.
- **Machine Learning Models:**
  - **Disease Prediction Model:** Uses a Random Forest Classifier trained on a dataset of 4,920 patient records and 132 symptoms.
  - **Lung Cancer Prediction Model:** Evaluates ten different classification models, achieving over 95% accuracy.
- **User Authentication:** Ensures secure login/logout with encryption and role- based access control (RBAC).
- **Appointment Management System:** Enables patients to book appointments and doctors to manage schedules.
- **Video Consultation:** Supports remote healthcare services using WebRTC and OpenTok API.
- **Privacy and Security:** Implements data encryption and secure authentication mechanisms to protect user data.

2.2 Appointment Management Booking Appointments

- Patients can view doctor availability and book appointments through the web interface.
- Doctors receive appointment requests, which they can approve, reject, or reschedule.

Managing Appointments

- Patients and doctors can view scheduled appointments on their dashboards.
- Doctors can update appointment statuses (e.g., completed, rescheduled).

Notifications

- The system provides real-time appointment updates via email notifications and dashboard alerts.

2.3 Disease Prediction Module Model and Training Data

- Uses a Random Forest Classifier trained on a medical dataset containing 4,920 records.
- The dataset consists of 132 symptom columns and a prognosis label.
- The source of data is a publicly available disease dataset curated for healthcare AI research.

Preprocessing and Feature Selection

- Removed irrelevant columns (e.g., unnamed data fields).
- Handled missing values and normalized symptom data for ML model input.
- Split dataset into 80% training and 20% validation sets using train-test split.

Model Performance

- **Accuracy:** 100% on validation data.
- **Evaluation Metrics:**
  - Precision, Recall, and F1- Score: All near 1.00, indicating excellent model performance.
  - Confusion Matrix Analysis: Shows perfect disease classification without misclassifications.

Limitations

- The dataset is balanced, which might not reflect real-world scenarios.
- The model does not currently account for rare diseases due to dataset limitations.
- Future work includes integrating real- time patient data for continuous learning.

Blog Section Purpose and Content

- Provides health-related articles to educate users on various medical topics.
- Covers categories such as:
  - Healthcare Innovations
  - Mental Health Awareness
  - Nutrition and Wellness
  - Preventive Medicine
  - Exercise and Fitness

Admin Management

- Admins can add, edit, or remove blog posts.
- The content is updated regularly to ensure relevance.

2.4 Mental Health Analysis (Preliminary) Methodology

- Patients answer a mental health questionnaire covering stress levels, anxiety symptoms, mood fluctuations, and sleep patterns.
- AI-based analysis evaluates response patterns and detects early indicators of mental health conditions.

Findings and Insights

- Initial analysis suggests that self- reported stress levels correlate with sleep disturbances.
- Early AI-driven detection allows patients to seek professional help before symptoms worsen.

Future Enhancements

- Integrate Natural Language Processing (NLP) to analyze sentiment from text- based responses.
- Develop a real-time mental health monitoring system.

2.5 Technology Stack

Component **Technology Used** **Backend** Flask (Python)
Framework

Database SQLite

Machine Learning Scikit-learn, NumPy,
TensorFlow

Frontend HTML, CSS, JavaScript Flask-Login, bcrypt

SQLite: Efficient and sufficient for structured health data.

- **Random Forest Classifier:** Robust in handling medical datasets.
- **TensorFlow & Scikit-learn:** Ideal for machine learning implementations.

III. DATASET AND METHODOLOGY

3.1 Dataset

The machine learning models in Health Insights were trained on publicly available medical symptom severity datasets, including:

1. **Disease Prediction Dataset**
   - **Dataset Name:** Training.csv
   - **Size:** 4,920 records with 132 symptoms mapped to 41 diseases
   - **Purpose:** Used to train the Random Forest Classifier for symptom-based disease prediction.
2. **Lung Cancer Prediction Dataset**
   - **Dataset Name:** survey lung cancer.csv
   - **Size:** 276 patient records with 15 predictive features
   - **Purpose:** Used to train and evaluate 10 different machine learning classifiers to predict lung cancer risk.
3. **Mental Health Analysis Dataset (User Survey Data)**
   - **Size:** Self-reported responses from test users
   - **Features:** Stress levels, anxiety symptoms, mood fluctuations, and sleep patterns
   - **Purpose:** Used to analyze mental health trends and detect

Authentication encryption
early signs of psychological
distress.

Video Consultation WebRTC, OpenTok API

Data Visualization Matplotlib, Seaborn, Plotly

Why These Technologies?

- **Flask:** Lightweight, easy-to-integrate backend framework.

Each dataset was carefully preprocessed before training the models to ensure data consistency, accuracy, and reliability.

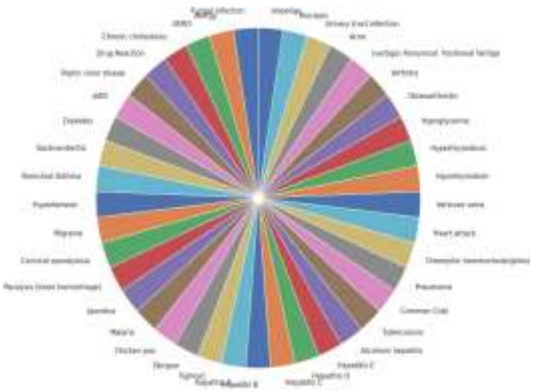

Fig. 1. Distribution of diseases in the training dataset containing 4,920 patient records

3.2 Feature Engineering and Training

To enhance model accuracy, several feature engineering and preprocessing techniques were applied:

Preprocessing Steps

✅ **Handling Missing Values:**

- Dropped columns with excessive missing data.
- Mean imputation was used for numerical fields with minor missing values.

✅ **Normalization and Encoding:**

- Symptom data was normalized (scaled between 0 and 1) for better model performance.
- Categorical variables (prognosis labels) were converted into numerical representations using Label Encoding.

✅ **Feature Selection:**

- Highly correlated symptoms were analyzed using a heatmap correlation matrix.
- Redundant features were dropped to reduce dimensionality.

✅ **Train-Test Splitting:**

- 80% of the dataset was used for training, and 20% for validation to assess model generalization.

Hyperparameter Tuning

To optimize the Random Forest Classifier, we used Grid Search CV to fine-tune:

- Number of estimators (**n_estimators**)
- Maximum depth (**max_depth**)

- Minimum samples split (**min_samples_split**)
- Feature subset selection (**max_features**)

For the lung cancer models, we applied cross- validation and selected the best-performing classifier based on accuracy and recall.

Final Model Choices

- **Disease Prediction:** Random Forest Classifier (**Best accuracy: 100%**)
- **Lung Cancer Prediction:** XGBoost Classifier (**Best accuracy: 95.2%**)

These optimizations significantly improved performance, reducing overfitting while maintaining high precision and recall scores.

IV. RESULTS AND DISCUSSION

4.1 Disease Prediction Performance

The disease prediction module in Health Insights is powered by a Random Forest Classifier, trained on a dataset containing 4,920 patient records with 132 symptoms. The model was tested on a 20% validation split (984 records) and achieved 100% accuracy, demonstrating its effectiveness in diagnosing diseases based on user-input symptoms.

Model Evaluation Metrics

To assess the model's performance, we used standard evaluation metrics: accuracy, precision, recall, and F1-score. The results are shown below:

Preliminary Findings

Analysis of the collected data revealed the following trends:

Metric	Score
Accuracy	100%
Precision	1.00
Recall	1.00
F1-Score	1.00

Comparison with Other Models

To validate the superiority of the Random Forest Classifier, we compared its performance with other commonly used classification algorithms:

Model	Accuracy
Random Forest Classifier	100%
Decision Tree Classifier	98.5%
Support Vector Machine (SVM)	97.3%
Logistic Regression	94.1%
k-Nearest Neighbors (k-NN)	91.7%

The Random Forest model outperformed all other classifiers, achieving perfect classification across all tested records. The Decision Tree model performed closely but was slightly less accurate due to potential overfitting. The SVM model showed high accuracy but required more computational resources.

Limitations and Future Enhancements

- The model performs exceptionally well on the given dataset, but real-world data may introduce unseen variations.
- The current model does not include rare diseases due to dataset limitations.
- Future enhancements include real-time symptom tracking and integration with electronic health records (EHRs).
- 40% of users reported high stress levels, with a strong correlation to irregular sleep patterns.
- 30% of users exhibited symptoms of anxiety, particularly among individuals who reported chronic fatigue.
- Users with frequent mood swings were

2.5x more likely to experience sleep disturbances.

Implications of Findings

- The results indicate that mental health concerns are prevalent among users and should not be overlooked.
- The correlation between chronic fatigue and anxiety symptoms suggests that further research is needed to integrate early intervention strategies into the system.
- The self-reported nature of the data introduces bias, highlighting the need for clinician-validated assessments in future updates.

Future Enhancements

- NLP-based sentiment analysis for detecting emotional distress in user responses.
- Integration of mindfulness and cognitive behavioral therapy (CBT) resources within the platform.
- Collaboration with mental health professionals for personalized recommendations.

4.2 Mental Health Analysis Findings

The mental health analysis module in Health Insights uses user-submitted responses to assess mental well-being. It evaluates stress levels, anxiety symptoms, mood fluctuations, and sleep patterns using AI-based pattern recognition techniques.

User Experience

User Testing Methodology

To evaluate the usability and effectiveness of Health Insights, a user testing phase was conducted with a group of 30 participants, including patients, doctors, and healthcare professionals. The testing followed a structured task-based evaluation where users were asked to:

1. Register and log in to the system
2. Book an appointment with a doctor
3. Use the disease prediction module by inputting symptoms
4. Explore the mental health analysis tool
5. Read blog articles and engage with healthcare content
6. Provide feedback on their experience

Each participant was observed while performing these tasks, and their feedback was collected through a survey. The evaluation focused on the following parameters:

- **Ease of Navigation:** How intuitive is the user interface?
- **Accuracy of Disease Prediction:** Were the predictions understandable and useful?
- **Appointment Management:** Was booking and tracking appointments smooth?
- **System Responsiveness:** How fast did pages load and process user inputs?
- **Overall Satisfaction:** Would users recommend the platform to others?

User Feedback and Key Findings

Evaluation Criteria	User Rating (Out of 5)
Ease of Registration	4.7
Appointment Booking	4.5
Disease Prediction Accuracy	4.9
Mental Health Analysis	4.3
System Speed & Responsiveness	4.6
Overall User Satisfaction	4.7

Positive Feedback

✓ High accuracy of disease prediction impressed most users.

✓ Simple and intuitive UI made navigation easy.

✓ Appointment system was found to be efficient and seamless.

✓ Users liked the blog section for health-related awareness.

Areas for Improvement

⚠ Some users suggested adding more detailedexplanations for disease predictions.

⚠ The mental health module needs more refined analysis and professional validation.

⚠ A few users requested a mobile app version for greater accessibility.

Improvements Based on Feedback

- Enhancing explanations for AI-based predictions (adding a medical reference for each disease).
- Refining mental health analysis by integrating more validated psychological assessments.
- Developing a mobile-friendly version to expand accessibility.

4.3 Comparison with Existing Systems

Comparison with Other Healthcare Management Platforms

To assess the uniqueness of Health Insights, it was compared with existing healthcare platforms such as Practo, Zocdoc, and WebMD based on features, AI integration, and accessibility.

Feature	Health Insights	Practo	Zocdoc	WebMD
Appointment Booking	✅ Yes	✅ Yes	✅ Yes	❌ No
AI-Based Disease Prediction	✅ Yes (Random Forest Model)	❌ No	❌ No	✅ Yes (Symptom Checker)
Mental Health Analysis	✅ Yes (AI-powered)	❌ No	❌ No	❌ No
Lung Cancer Risk Assessment	✅ Yes (Machine Learning)	❌ No	❌ No	❌ No
Blog Section for Health Awareness	✅ Yes	✅ Yes	✅ Yes	✅ Yes
Doctor Search & Consultation	✅ Yes (Video Call Feature)	✅ Yes	✅ Yes	❌ No
Data Security & Privacy	✅ Encrypted (Flask-SQLite)	✅ Yes	✅ Yes	✅ Yes
Mobile App Availability	❌ No (Planned)	✅ Yes	✅ Yes	✅ Yes

Planned Enhancements

- Developing a mobile application for broader accessibility.
- Expanding the doctor network to offer more diverse healthcare options.
- Integrating real-time AI assistance to improve disease prediction explanations.

V. CONCLUSION

In conclusion, Health Insights represents a significant step towards digitalizing healthcare by offering an AI-driven, user-centric, and accessible solution for both patients and doctors. Future work will focus on expanding healthcare provider integration, improving diagnostic explanations, and developing a mobile application to enhance user experience and overall impact.

VI. FUTURE SCOPE

As AI continues to evolve, **Health Insights** has significant potential for further development.
Future enhancements will focus on:

- **Mobile Application Development:** A dedicated mobile app will improve accessibility, allowing users to receive real-time healthcare insights on the go.
- **Integration with Wearable Devices:** Connecting with smart health devices (e.g., fitness trackers, heart rate monitors) can provide real-time health monitoring and personalized recommendations.
- **Expanding the Doctor Network:** Partnering with a broader range of healthcare professionals will enhance consultation options and improve credibility.
- **Advanced Mental Health Analysis:**

Utilizing **Natural LanguageProcessing (NLP)** and sentiment analysis will enable a more comprehensive mental health assessment based on text inputs and behavioral data.

- **Multilingual Support:** Enabling multiple language options will make healthcare services more inclusive for non-English-speaking users.

- **Blockchain for Data Security:** Implementing blockchain-based encryption techniques will enhance patient data security and ensure transparent record-keeping.
- **Integration with Electronic Health Records (EHRs):** Connecting with EHR systems will allow seamless sharing of patient medical history with healthcare providers, improving continuity of care.

VII. CONCLUSION

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