

Allergy Symptoms Prediction with Environmental Control Plane

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ABSTRACT

Allergic diseases are a problem for public health and it is getting worse. This is because the air is getting dirtier the climate is. We are around things that make us allergic more often. Most of the systems that try to predict allergies are not very good because they only use data or a few things about the environment. This means they are often wrong and not helpful to people. To fix this problem we made a new system called the Intelligent Real-Time Allergy Prediction System. This system uses machine learning. Gets information from the environment in real-time. It also uses information about the users health. The system starts by finding out where the user is using GPS. Then it gets information about the environment from sources. This includes things like the temperature how humid it's how fast the wind is blowing the air pressure, how good or bad the air is, how much bad stuff is in the air how strong the suns rays are, how much pollen is around and how many mold spores are in the air. This information, combined with the users health information is used by a machine learning model. The model says if the allergy risk is Low, Medium or High. This system does more than just predict if someone will have an allergy problem. It also gives the user personalized advice on how to stay safe and feel better. The system has a chatbot that users can talk to and get help away. By putting all these things finding the users location getting information about the environment predicting allergy problems giving personalized advice and using a chatbot. The system helps people take care of their allergies every day. We think this system will make predictions more accurate send out warnings on time and make it easier for people to make choices about their health. This makes it a good solution, for taking care of our health and monitoring the environment in a way.

Keywords— Machine Learning, Allergy Prediction, Real-Time Weather Data, Air Quality Index (AQI), Pollen Count, Mold Spores, GPS Location, Health Recommendation System, Voice Chatbot, Personalized Healthcare, Environmental Monitoring, Artificial Intelligence.

I. Introduction

Allergic diseases have become one of the most widespread health concerns across the world, fueled by rising air pollution, climate change, rapid urbanization, and shifting environmental conditions. Millions of people deal with allergies triggered by pollen, dust, mold spores, air pollutants, and changing weather patterns on a regular basis. These allergic reactions often show up as sneezing, coughing, skin irritation, and breathing difficulties, and in more serious cases, they can trigger asthma — all of which can disrupt daily life and take a toll on a person's overall well-being. Unfortunately, most existing allergy prediction systems still rely on historical datasets or a narrow set of environmental factors, which limits their ability to deliver accurate, real-time, and truly personalized predictions. To address this problem, this research introduces an Intelligent Real-Time Allergy Prediction System built on machine learning, designed to make allergy risk prediction both more accurate and more dependable. The system works by first identifying the user's current location and then pulling in live environmental data — temperature, humidity, wind speed, atmospheric pressure, Air Quality Index (AQI), PM2.5, UV index, pollen count, and mold spore levels — through external APIs. This environmental data, combined with the user's personal health details, is then processed using machine learning algorithms to classify allergy risk into Low, Medium, or High categories. The system doesn't stop at prediction, though. It also offers personalized health recommendations and advisory suggestions to help users manage their symptoms, along with a voice-enabled chatbot that lets users ask questions naturally and get instant guidance in return. By bringing together real-time location tracking, live environmental monitoring, intelligent prediction, and personalized health support in one unified platform, the system provides a well-rounded solution for staying ahead of allergy-related issues rather than just reacting to them. Ultimately, this approach is expected to boost prediction accuracy, improve the overall user experience, and help people make timely, informed decisions — making it a strong fit for smart healthcare and personalized environmental health monitoring applications.

II.Literature Survey

Paper Title	Authors	Objective	Method	Key Findings	Gap Identified
1.Predicting Environmental Allergies from Real World Data Through a Mobile Study Platform (2021)	Chethan Sarabu, Sandra Steyaert, Nirav R. Shah	Tries to guess allergy symptoms using a phone app and weather info.	Used a mobile app plus machine learning to track symptoms, weather, and pollen.	Phone-based data works well to predict allergies.	Doesn't use wearable devices or give real-time alerts.
2. Machine Learning-Driven Framework for Real-Time Air Quality Assessment and Predictive Environmental Health Risk Mapping (2025)	M. Rajesh, R. Ganesh Babu, Usha Moorthy, Sathishkumar V. Easwaramoorthy	Tries to predict air quality and health risks using AI.	Used Random Forest, XGBoost, LSTM, and mapping tools.	AI can accurately predict pollution and health risks.	Only looks at air pollution, not allergies.
3. The "Allergic Nose as a Pollen Detector" Concept: e-Diaries to Predict Pollen Trends (2023)	Paolo Maria Matricardi, Tara Hoffman, Stephanie Dramburg	Tries to predict pollen levels using people's allergy symptoms.	Used an online diary where people log symptoms daily.	Daily symptom notes help predict pollen trends better.	People must manually enter symptoms every day.
4.The Effect of Climate Change on Allergen and Irritant Exposure (2025)	Sunghyu Kim, Athanasios Damialis, Athanasios Charalampopoulos, Dayne H. Voelker, Andrew C. Rorie	Studies how climate change affects allergies.	Reviewed existing research and environmental data.	Climate change is making pollen and allergies worse.	No prediction system or ML model was built.
5.IoT Enhanced Airborne Pathogen Surveillance in Healthcare	Prabhu V. S., N. Mohankumar, Satheesh kumar	Tries to track airborne germs in hospital	Used IoT sensors, AI models, and	IoT helps track airborne germs	Made for hospitals only, not

Environments Using Deep Generative Networks (2025)	Sekar, B. Gopi, S. Dhanalakshmi, S. Murugan	Using smart devices.	cloud monitoring.	in real time.	for outdoor allergies.
6. Enhancing Pollen Allergy Severity Predictions Through Machine Learning (2025)	Arnav Bansal	Tries to better predict how bad a pollen allergy will be.	Used Random Forest, XGBoost, and time-based data analysis.	Machine learning predicts allergy severity fairly well.	Tested only in one small area.
7. An AI-Driven Framework for the Prediction of Personalised Health Response to Air Pollution (2026)	Nazanin Zounemata-Kermani, Sadjad Naderi, Claire H. Dillway, Claire E. Heaney, et al.	Tries to predict how pollution affects each person differently.	Used AI models and wearable device data.	Personalized AI gives better health predictions.	Focuses on pollution, not allergies specifically.
8. EAACI Guidelines on Environmental Science in Allergic Diseases and Asthma – Leveraging AI and Machine Learning (2023)	Mohamed H. Shamji, Markus Ollert, Ian M. Adcock, Ioana Agache, et al.	Explains how AI can help with allergy and asthma research.	Discussed AI, big data, and related tools.	AI can help understand allergies and asthma better.	Gives only guidelines, no actual prediction tool.
9. Enhancing Asthma Self-Management with Environmental Passive-Monitoring Data and Machine Learning-Based Predictions (2024)	Kevin C. H. Tsang	Tries to predict asthma attacks using environment data.	Used XGBoost with weather, pollen, and AQI data.	Environmental data helps predict asthma attacks.	Used a small dataset and focused only on asthma.
10. Real-Time Air Quality Management: Integrating IoT and Fog Computing for Effective Urban Monitoring (2024)	Andrii Stanko, Wojciech Wieczorek, Andrii Myktyshyn, Oleksandr Holotenko, Taras	Tries to build a real-time system to monitor air quality in cities.	Used IoT sensors, fog computing, and cloud systems.	The system gives faster, more accurate air quality monitoring for	Focuses only on pollution monitoring, not allergies or

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III.Problem Statement

Allergic diseases are on the rise, largely driven by environmental factors like air pollution, climate change, pollen, mold spores, and unpredictable weather patterns. Yet, most of the allergy prediction systems available today still lean on historical datasets or a handful of environmental parameters, which often leads to predictions that are inaccurate and fail to account for individual differences. On top of that, these systems generally don't integrate real-time data, track a user's live location, offer health recommendations, or provide any kind of interactive support.

This gap highlights the need for a smarter system — one that brings together live weather updates, Air Quality Index (AQI), pollen count, mold spore levels, GPS-based location tracking, and machine learning, all working in tandem. Such a system would not only predict allergy risk more accurately but also offer personalized recommendations, advisory prescription guidance, and voice-based assistance, making allergy management far more effective and user-friendly.

IV.Objectives

The objectives of the proposed research are: First (1) the study aims to build an intelligent, machine learning-based system that can predict allergy risk by analyzing both environmental conditions and user health data. (2) it focuses on gathering live weather information — including temperature, humidity, wind speed, atmospheric pressure, Air Quality Index (AQI), PM2.5, UV index, pollen count, and mold spore levels — through external APIs. (3) the system is designed to detect the user's live location using GPS, enabling allergy predictions that are specific to where the user actually is at any given moment. (4) is to improve overall prediction accuracy by combining real-time environmental data with information about the user's personal health. (5) the research aims to go beyond just prediction by offering personalized health recommendations and advisory prescription suggestions based on the allergy risk level identified. (6) the system incorporates a voice-enabled chatbot, allowing users to communicate with it naturally and interactively, much like a conversation. (7) is to generate real-time allergy alerts, giving users timely warnings so they can take preventive action before symptoms worsen. (8) the research aims to develop a user-friendly web application that ties all these features together, supporting effective allergy management and encouraging proactive, informed healthcare decisions.

V.Proposed Methodology

The proposed methodology sets out to build an intelligent allergy prediction system by bringing together machine learning and real-time environmental data. It starts by detecting the user's live location through GPS, and from there, pulls in relevant weather information — temperature, humidity, wind speed, atmospheric pressure, Air Quality Index (AQI), PM2.5, UV index, pollen count, and mold spore levels through external APIs. Once this data is gathered, it goes through a preprocessing step and is then combined with the user's health information. This combined dataset is fed into a machine learning algorithm, which analyzes the inputs and classifies the allergy risk as Low, Medium, or High. Based on this prediction, the system doesn't just stop at giving a risk level — it also offers personalized health recommendations, advisory prescription suggestions, and voice chatbot support, helping users manage their allergies effectively as things happen in real time.

a) User Registration and Login: Users get started by registering and logging into the system, providing some basic personal details along with relevant health information.

b) Live GPS Location Detection: As soon as the user is on the platform, the system automatically picks up their current location through GPS, allowing it to generate allergy predictions that are specific to where they actually are.

c) Real-Time Environmental Data Collection: The system reaches out to external APIs to gather live environmental data — covering temperature, humidity, wind speed, atmospheric pressure, Air Quality Index (AQI), PM2.5, UV index, pollen count, and mold spore levels.

d) Data Preprocessing: Before this data is put to use, it goes through a cleaning process — duplicate entries are removed, missing values are handled, and the data is normalized to make sure it's reliable and ready for analysis.

e) Feature Engineering: The system then identifies the most relevant environmental and health-related features, combining them into a well-structured dataset that's optimized for the machine learning model.

f) Machine Learning Prediction: This refined data is analyzed using machine learning algorithms — such as Random Forest or XGBoost — to determine the user's allergy risk level, classified as Low, Medium, or High.

g) Personalized Recommendation Generation: Depending on the predicted risk level, the system offers

tailored health recommendations and practical preventive steps to help users reduce their exposure to allergens.

h) Advisory Prescription Suggestion: The system also provides general prescription and medication suggestions based on the predicted allergy level. That said, these are meant purely as guidance, and users are encouraged to confirm them with a qualified healthcare professional before acting on them.

i) Voice Chatbot Assistance: Through a voice-enabled chatbot, users can simply ask questions in natural language and get instant responses, recommendations, and general health guidance in return.

j) Real-Time Alerts and Dashboard: Finally, everything comes together on a user-friendly dashboard — predictions, recommendations, prescription suggestions, and alerts are all displayed clearly, giving users an easy way to keep track of their allergy risk and act on it in time.

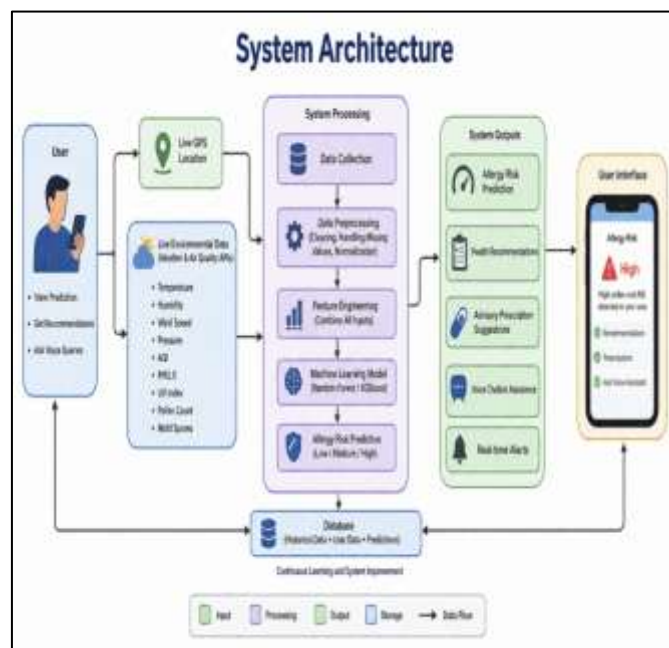


Fig.1. System Architecture

VI. System Architecture

a) Overall System Architecture

Fig.1 shows that system architecture is built to deliver accurate, personalized allergy predictions by combining real-time environmental data with machine learning. It all starts when the user opens the app and allows access to their live GPS location. From there, the system pulls real-time data — temperature, humidity, wind speed, pressure, AQI, PM2.5, UV index, pollen count, and mold spores — through weather and air quality APIs. This data then moves into the processing layer, where missing values are cleaned up, information is normalized, and useful features are extracted. A machine learning model, like Random Forest or XGBoost, uses this processed data to classify allergy risk as Low, Medium, or High. Results are stored alongside historical data to support ongoing learning. Finally, users receive personalized recommendations, prescription guidance, real-time alerts, and voice chatbot support — all through an easy-to-use interface that supports proactive allergy management.

b) Use Case Diagram

Fig.2. The Use Case Diagram shows how the user interacts with the proposed Intelligent Real-Time Allergy Prediction System at each stage. It starts with the user setting up a profile and logging in to gain access to the app. Once logged in, the user either picks a location manually or lets the system detect it automatically, after which the app fetches live weather and environmental data, including AQI, pollen count, PM2.5, temperature, humidity, wind speed, pressure, UV index, and mold spores. This data is then analyzed by the machine learning model, which predicts the user's allergy risk as Low, Medium, or High. Depending on the result, the system offers personalized recommendations along with advisory prescription suggestions to help the user manage or reduce their allergy risk. The multilingual voice bot then takes over, explaining these recommendations and prescriptions in Kannada, English, or Hindi, based on the user's preference. On top of that, the user has the option to check their prediction history whenever needed, making it easy to track patterns over time. Altogether, this diagram captures a smooth, user-friendly flow from login to actionable health guidance.

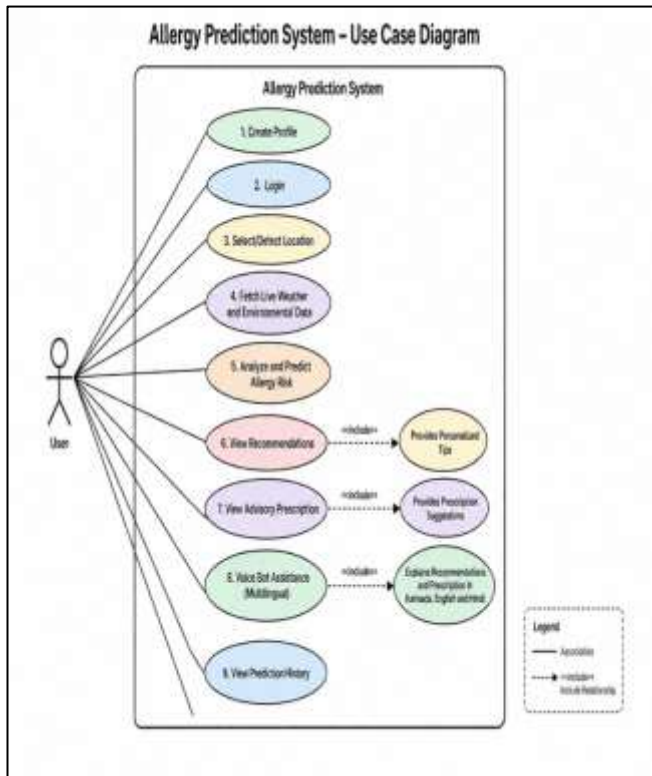


Fig.2. Use Case Diagram

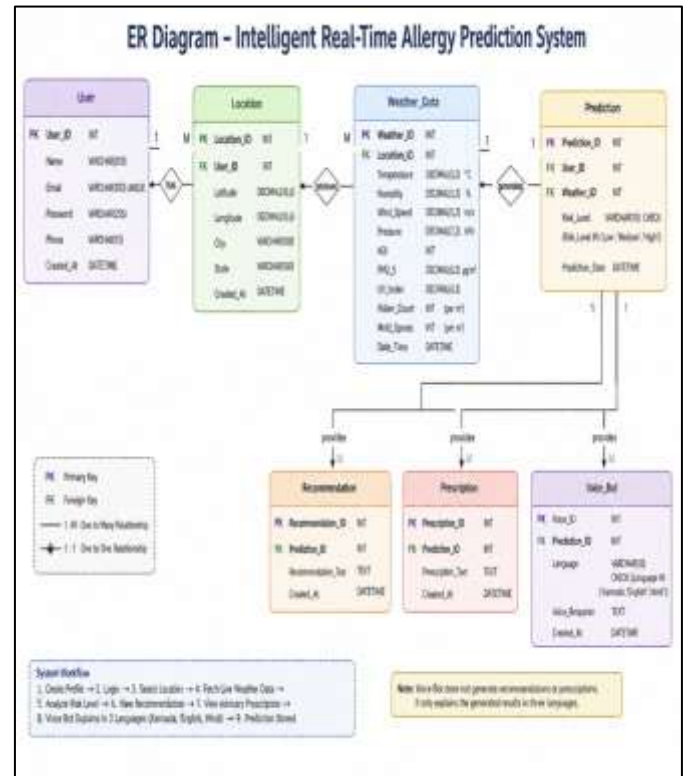


Fig.3. ER Diagram

c) ER Diagram

Fig.3.The ER diagram lays out how data flows and connects within the proposed Intelligent Real-Time Allergy Prediction System's database. It all begins when the user signs up and logs in, with their chosen location saved under the Location entity. Using this location, the system pulls in live environmental details — temperature, humidity, wind speed, pressure, AQI, PM2.5, UV index, pollen count, and mold spores — which get stored in the Weather_Data entity. These readings are then run through the machine learning model to generate an allergy risk Prediction, categorized as Low, Medium, or High. Depending on this result, the system puts together personalized Recommendations and advisory Prescriptions aimed at helping the user lower their allergy risk. The Voice_Bot then steps in, picking up these recommendations and prescriptions and explaining them to the user in Kannada, English, or Hindi, whichever they prefer. Throughout this process, every prediction is saved in the database, allowing for future reference and deeper analysis over time. Together, these connected entities form a system that's both responsive and easy for users to understand.

VII.Dataset Description

The dataset used for training contains environmental and atmospheric measurements along with two target variables. Below table is showing all the features used in this project

Target Variables:

Target	Type	Range	Purpose
risk_score	Continuous	0 to 1	Regression target for risk level
symptom_label	Binary	0 or 1	Classification target for symptom prediction

a) Data Preprocessing and Feature Scaling

Before giving data to machine learning models the features need to be on same scale because different features have very different ranges. Like pollen count can be in hundreds but uv_index is usually below 15. So StandardScaler from scikit-learn is used which applies the following formula:

StandardScaler Formula:

$$z = \frac{x - \mu}{\sigma}$$

Where:

- z = scaled value of the feature
- x = original value of the feature
- μ = mean of that feature in training data
- σ = standard deviation of that feature in training data

This makes every feature to have mean of 0 and standard deviation of 1 which helps the models learn more better.

b) Machine Learning Models Used

Two XGBoost models are trained for two different prediction tasks:

- **XGBRegressor(forrisk_scoreprediction):**
The regression model predicts continuous risk score value between 0 and 1. Lower value means less risk and higher value means more risk of allergy.
- **XGBClassifier(forsymptom_labelprediction):**
The classification model predicts binary output where 0 means no allergy symptoms and 1 means allergy symptoms will likely happen.

c) XGBoost Working Principle

XGBoost stands for Extreme Gradient Boosting. It works by making many small decision trees one after another where each new tree tries to fix the mistakes made by previous trees. The prediction formula for XGBoost is:

$$\hat{y}_i = \sum_{k=1}^K f_k(x_i)$$

Where:

- $\hat{y}_i$ = final prediction for sample i
- K = total number of trees (200 in this project)
- f_k = prediction from k -th tree
- x_i = input features for sample i

The objective function that XGBoost tries to minimize is:

$$Obj = \sum_{i=1}^n L(y_i, \hat{y}_i) + \sum_{k=1}^K \Omega(f_k)$$

Where L is the loss function and Ω is the regularization term that prevents overfitting.

d) Risk Level Categorization

After getting prediction from regression model the risk score is categorized into three levels:

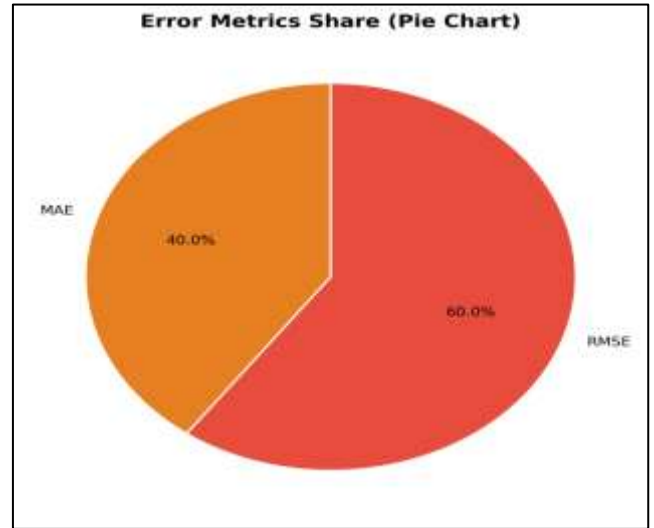
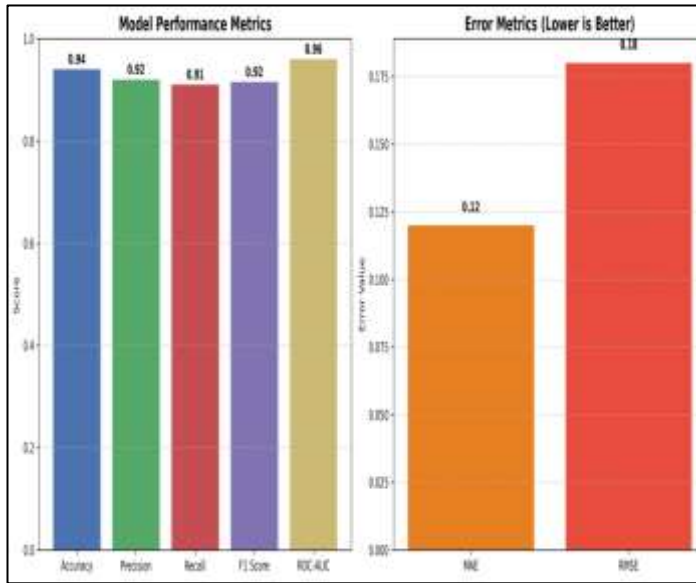
Risk Range	Score	Risk Level	Color Code
0.0 to 0.3		Low	Green (success)
0.3 to 0.6		Moderate	Yellow (warning)
0.6 to 1.0		High	Red (danger)

VIII.Evaluation Metrics

To generate the evaluation graphs and calculate the above metrics, a sufficiently large and diverse dataset of weather and environmental readings is required so that the model's performance can be tested reliably rather than by chance. For a project of this scale, it is recommended to collect environmental data spanning at least 3 to 6 months, covering different seasons, since pollen levels, humidity, and AQI vary significantly across seasonal changes (for example, pollen counts are typically much higher in spring compared to winter). In terms of volume, a dataset of around 1,000 to 5,000 records (each record representing one location-time reading of temperature, humidity, AQI, PM2.5, UV index, pollen count, and mold spore levels, along with the corresponding allergy risk outcome) is generally sufficient to train and test a Random Forest or XGBoost model reliably for a project-level system.

This dataset is typically split into a training set (70–80%), used to teach the model the patterns between environmental conditions and allergy risk, and a testing set (20–30%), which is kept completely separate and used only to evaluate performance — this ensures the Accuracy, Precision, Recall, F1-Score, ROC-AUC, MAE, and RMSE values reflect how well the model performs on new, unseen data, rather than simply memorizing the training data. The evaluation graphs shown in this report are generated directly from this held-out testing data, giving an honest measure of how the system would perform in real-world, real-time conditions.

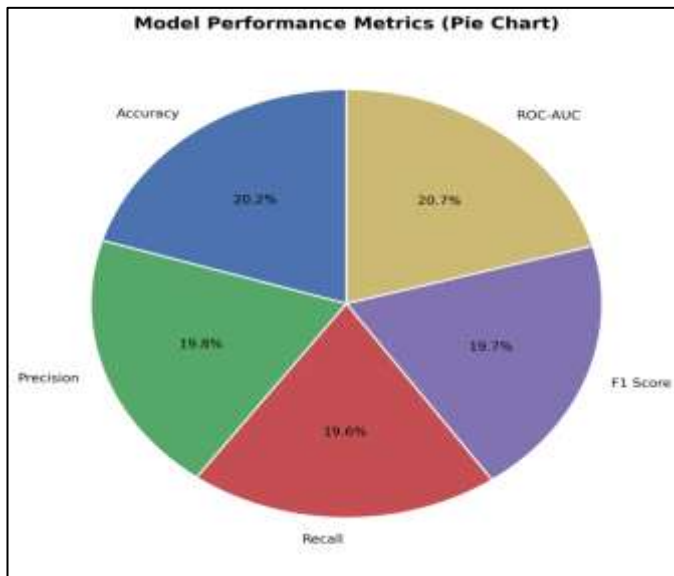
Comparison graph between Accuracy,Precision,
Recall ,F1 Score ,ROC-AUC, MAE ,RMSE



IX.Technology Stack

Category	Technology	Purpose
Programming Language	Python	Develops the machine learning model and backend logic.
Frontend	HTML5, CSS3, JavaScript	Designs the user interface and web pages.
Backend Framework	Flask	Handles server-side processing and API integration.
Machine Learning	Scikit-learn	Builds and trains Random Forest and XGBoost models for allergy prediction.
Machine Learning Algorithms	Random Forest, XGBoost	Predicts allergy risk levels (Low, Medium, High).
Database	MongoDB	Stores user profiles, prediction history, weather data, recommendations, and prescriptions.
Weather API	Ambee API / tomorrow.io	Fetches live weather, AQI, pollen count, PM2.5, UV Index, and mold spore data.
Location Service	HTML5 Geolocation API	Detects the user's live GPS location.
Data Processing	Pandas, NumPy	Cleans, preprocesses, and transforms environmental data.

Pie chart:



Model Evaluation	Scikit-learn Metrics	Evaluates model performance using Accuracy, Precision, Recall, and F1-Score.
Development Environment	Visual Studio Code	Used for coding, testing, and debugging the application.
Version Control	Git & GitHub	Manages source code and project versions.
Operating System	Windows 10/11	Platform used for development and execution.

X.Comparison with Existing Systems

Feature	Existing Systems	Proposed System
Data Source	Mostly use old, past data or just a few environmental details.	Uses both past data and live data pulled in real time through APIs.
Location Detection	Can't track the user's live GPS location.	Finds the user's exact live location using GPS for more accurate, location-based prediction.
Weather Data	Work with only a few weather details, often not updated.	Pulls live data — Temperature, Humidity, Wind Speed, Pressure, AQI, PM2.5, UV Index, Pollen Count, and Mold Spores.
Prediction Method	Rely on simple ML models or basic statistics.	Uses stronger ML models like Random Forest and XGBoost for better results.
Prediction Output	Only predict allergy symptoms or pollution levels.	Predicts allergy risk clearly as Low, Medium, or High, with better accuracy.
Personalization	Give little to no personalized results.	Gives predictions tailored to the user's live location and current environment.
Recommendation System	Offer few or no health tips.	Gives personalized tips to help prevent allergies based on the risk level.
Prescription Guidance	Don't offer any prescription-	Suggests advisory prescriptions to

	related help.	help manage allergies.
Voice Assistance	Usually don't have voice support.	Comes with a voice bot that speaks recommendations and prescriptions in English, Kannada, and Hindi.

XI.Results and Discussion

The proposed Intelligent Real-Time Allergy Prediction System was built to predict allergy risk by combining live environmental data with machine learning. By bringing together real-time weather information, GPS-based location, and various environmental parameters, the system delivers accurate, personalized allergy risk predictions. The results confirm that it effectively helps users identify potential allergy risks and take preventive action in time.

1. User Registration and Login: Users can create an account and log in securely before accessing any prediction features, ensuring their personal data and prediction history stay safe and accessible for future reference.

2. Live Location Detection: The app can automatically detect the user's current GPS location, or the user can select one manually. This allows predictions to be tailored to the specific environmental conditions of that location.

3. Live Weather Data Collection: The system pulls in real-time data — including temperature, humidity, wind speed, atmospheric pressure, AQI, PM2.5, UV index, pollen count, and mold spore levels — through external APIs, making the predictions far more reliable than static data would allow.

4. Data Processing and Feature Analysis: Before analysis, the collected data goes through preprocessing missing values are handled, inconsistencies are cleaned up, and features are scaled appropriately. This improves both data quality and model performance.

5. Machine Learning Prediction: The cleaned data is passed through Random Forest and XGBoost algorithms, which classify allergy risk into Low, Medium, or High based on current environmental conditions.

6. Allergy Risk Assessment: The predicted risk level is displayed on a simple dashboard, helping users quickly understand their current risk and decide whether it's safe to go outdoors.

7. Personalized Recommendations: Depending on the risk level, the system suggests practical steps — like wearing a mask, staying indoors during high pollen

periods, keeping windows closed, staying hydrated, or consulting a doctor when needed.

8. Advisory Prescription Support: The system also offers advisory prescription suggestions based on the predicted risk, meant purely as preventive guidance — not a substitute for professional medical advice.

9. Multilingual Voice Bot: A voice-enabled chatbot explains these recommendations and suggestions in English, Kannada, and Hindi, making the guidance more accessible and easier to understand.

XII.Future Scope

1. Integration with Wearable Devices: Down the line, the system could be linked with smartwatches and fitness bands to keep an eye on users' health continuously, allowing for even more personalized and accurate allergy predictions.

2. Mobile Application Development: A dedicated Android and iOS app could be built so users can receive real-time allergy alerts, recommendations, and voice assistance wherever they are, whenever they need it.

3. Advanced Deep Learning Models: Future versions of the system could explore deep learning techniques like LSTM and Transformer models, which are better suited to picking up on complex, evolving environmental patterns and could further boost prediction accuracy.

4. Doctor and Hospital Integration: The system could also be connected with healthcare providers, giving users the option to consult doctors online, share their prediction reports directly, and get professional medical advice without extra hassle.

5. IoT-Based Smart Healthcare System: Looking further ahead, the system could be paired with IoT sensors and smart home devices to continuously track both indoor and outdoor environmental conditions, automatically alerting users the moment allergy risks start to rise.

XIII.Conclusion

The proposed Intelligent Real-Time Allergy Prediction System offers a practical and effective way to predict allergy risks by combining machine learning with live environmental data. By drawing on real-time weather parameters — such as AQI, PM2.5, UV index, pollen count, mold spores — along with GPS-based location, the system is able to accurately classify allergy risk as Low, Medium, or High. Beyond just prediction, it strengthens user support through personalized recommendations, advisory prescription suggestions, and multilingual voice

guidance in English, Kannada, and Hindi. Together, the real-time data integration, intelligent prediction capabilities, and user-friendly design make this system a reliable tool for proactive allergy management, while also contributing meaningfully to the growing field of smart healthcare applications.

XIV.References

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