A Smart IoT and AI/ML Based Device for Quantitative Rasa Analysis in Herbs

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Abstract **– The Ayurasa project conducts scientific evaluation and numerical measurement of crude herb rasa based on the essential Ayurvedic fundamental that guides medicinal plant therapeutic properties. The study analyzes primary and secondary tastes of herbs by measuring their chemical compounds which include glucose, fructose and malic acid alongside tannins, alkaloids together with other phytochemicals. This initiative brings together analyses of modern technology and traditional Ayurvedic knowledge through systems which standardize and measure rasa determination in substances. The proposed method links phytochemical analysis with taste assessment mapping to discover chemical-rasa connections for six Ayurvedic tastes including sweet, sour, salty, pungent, bitter and astringent. Through scientific validation of ancient Ayurvedic principles during this research scientists created a path to develop enhanced herbal medicines that utilize personalized taste-based healthcare.**

Keywords: **AyurRasa, Rasa analysis, taste analysis, Herbal medicine, Taste mapping, Personalized Ayurvedic healthcare, Scientific validation of Ayurveda**

I. INTRODUCTION

Based in the Indian subcontinent Ayurveda remains as a historic medicinal approach that uses a complete understanding of health alongside disease. Within its framework rasa functions as a main principle that determines therapeutic properties through its concept of taste in medicinal substances and herbs. The six basic Ayurvedic rasas of madhura (sweet), amla (sour) and lavana (salty), katu (pungent), tikta (bitter), kashaya (astringent) control both medicinal drug reactions and body physiological processes. Traditionally the identification of rasa used sensory perception as the method despite these methods proving inconsistent across different users.[1][2]

The modern scientific field shows rising interest in combining analytical knowledge systems with traditional practices such as Ayurveda. Ayurasa project responds to this requirement through a comprehensive scientific evaluation of crude herb rasa which utilizes contemporary chemical testing methods. A research objective includes phytochemical analysis through glucose, fructose, malic acid, tannins, and alkaloids detection which strives to connect particular chemical compounds to Ayurvedic taste classification. There is growing interest in the modern scientific community in fusing ancient therapies like Ayurveda with analytical knowledge.[3][4]

This research project aims to develop a scientific model for rasa determination which enables personalized Ayurvedic drug development through taste considerations. Ayurasa merges traditional wisdom with contemporary analytical techniques to build modern standards of personalized herbal medicine creation through ancient Ayurvedic knowledge from the past centuries.

II LITERATURE SURVEY

The rasa concept stands as a fundamental diagnostic tool along with therapeutic application within Ayurvedic literature according to Charaka Samhita and Sushruta Samhita texts which recognize its vital role in assessing herb medication values. The six tastes of Ayurvedic diagnosis known as madhura, amla, lavana, katu, tikta, and kashaya shape as well as monitor doshas (Vata, Pitta, Kapha) which lead to transformations in human body physiology and pathology. The rasa-based classification of herbs has primarily depended on organoleptic evaluations for centuries although this method shows interpretive inconsistency among testers because it relies on personal sensory interpretation.[5]

Scientists have initiated research efforts to merge Ayurvedic traditional knowledge with contemporary scientific evaluation methods throughout the past

few years. Rastogi et al. (2015) alongside Sharma et al. (2017) recommended applying phytochemical analysis for backing up Ayurvedic pharmacology. Their research establishes that herb flavor determinations activate when particular chemical compounds exist in the plant material—like sweet taste results from sugars and sourness is triggered by organic acids and bitterness is generated by alkaloids. The research discoveries provide practical methods to measure taste through chemical indicators.[6][7]

The validation of traditional knowledge relies on reverse pharmacology according to research conducted by Patwardhan et al. (2013). Ayurvedic principles become scientifically explored through the application of spectroscopy and chromatography and metabolomics. Analysts have achieved successful profiling of medicinal plant chemistry through numerous studies even though direct correlations between their findings and Ayurvedic taste categories remain limited.[8][9]

The research project "Ayurgenomics" demonstrated potential in Ayurvedic medicine integration with personalized treatment yet standard rasa evaluation methods are still missing. The study conducted by Singh and Tripathi (2019) created a taste-based classification system through analysis of phytochemicals with high-performance liquid chromatography (HPLC) and established meaningful correlations with the concepts of Ayurvedic rasas. Their research included a restricted set of herbs combined with deficient standard operational procedures.[10][11]

Scientific development requires a standardized methodology to evaluate and measure the phenotypical and genotypical characteristics of rasa. The Ayurasa project facilitates the advancement of this new field by uniting chemical tests with taste mapping along with traditional Ayurvedic methods to create an improved proof-based method for raw herb assessment. The method seeks to improve both the quality and consistency and therapeutic effects of herbal treatments by using evidence-based methods.[12][13]

III. PROBLEMS IN AYURVEDIC TASTE ASSESSMENT

Rasa stands as a fundamental principle in Ayurvedic medicine because practitioners view it as vital for understanding drug behavior in herbs. The technique used traditionally to determine rasa depends mainly on human sensory responses but this approach leads to substantial subjectivity. The ability of healthcare practitioners to perceive taste depends on their personal sensitivity while external factors related to sample testing and environmental elements create inconsistent measurement results. Rasa classification becomes unreliable in reproducible clinical and research conditions due to subjective human perception methods.

A major problem exists because rasa determination lacks standardized quantitative protocols or measurement standards. The Ayurvedic method of taste assessment does not employ standardized measurement methods like modern pharmacological testing which creates barriers for studying relationships between different herbal samples. Herbal compounds contribute to additional evaluation complications because of their intricate chemical composition. The majority of medicinal herbs contain various phytochemical groups including alkaloids along with flavonoids and glycosides and organic acids which potentially generate multiple taste sensations. The chemical compounds in complex mixtures interact with one another which hinders the identification of distinct chemicals that produce single rasas.

Ayurvedic practices have not efficiently integrated contemporary analytical technologies for their implementation. Rasa identification has not been complete with modern assessment tools because traditional methods still lag behind in implementing electrochemical sensing and machine learning and data analytics technology. Inaccurate rasa prediction occurs because machine learning models need extensive high-quality training data which are restricted by the absence of digitized labelled datasets and its values.

A major challenge develops from classifying herbs that exist without sufficient documentation or remain unknown to researchers. The classification of herbs into rasas becomes vague in cases where authors of Ayurvedic texts did not provide information about rasa properties. Addressing unidentified herbal specimens depends on either practical testing approaches or personal assessments because scientific investigation methods remain unavailable to practitioners.

The assessment of rasa in Ayurvedic medicine encounters multiple difficulties because of subjective judgment along with inadequate quantification methods and complex chemical properties and limited technical tools and inadequate data and problems identifying new herbs. The current rasa evaluation methods require an improved scientific framework which upholds Ayurvedic principles by utilizing modern technologies for increasing measurement precision and experimental repeatability.

IV. SYSTEM DESIGN AND COMPONENT DESCRIPTION

Through Ayurasa the project unites electrochemical hardware components with software tools for scientific evaluation and quantitative measurement of crude herb rasa (taste). Electrodes monitor the electrical output of herbal solutions to identify Ayurvedic taste-related phytochemicals along with their quantitative levels. Modern analytical and embedded technologies support the integration of traditional Ayurvedic wisdom present within this system.

1. HARDWARE COMPONENTS:

1.1 RaspberryPi 3

The central processing of Ayurasa system data acquisition and signal processing and control functions operates through Raspberry Pi. This platform is optimal for electrode system interaction and real-time electrochemical analysis because it offers affordability as well as a compact design and supports GPIO signals and runs on the Python framework. The system's networking functionality helps panelists conduct remote monitoring together with data storage operations which enables growth and scalability of the rasa analysis platform.

1.2 Electrode Array

The electrode array including working, reference and counter electrodes serves to detect electrochemical signals that come from herbal extracts. Through these signals the electrode system detects essential herbal compounds linked to Ayurvedic tastes (rasas). The device provides precise assessments of rasa which are both reproducible and without human subjectivity thus supporting the scientific evaluation of Ayurvedic taste classifications.

2. SOFTWARE COMPONENTS

2.1 Hybrid SVM-KNN Model for Taste Detection

Hybrid SVM-KNN Model for Taste Detection A classification system based on the combination of SVM with KNN delivers precise recognition of Ayurvedic rasas. The model uses electrode data-derived electrochemical features for predicting primary and secondary taste types in herbs. This duet between SVM and KNN achieves better taste classification by enabling the separation of classes along with local similarity analysis which increases detection precision.[14][15]

2.2 DCGAN for Synthetic Data Generation

A Deep Convolutional Generative Adversarial Network (DCGAN) serves as the method to generate synthetic electrochemical profiles because of limited dataset sizes. The enhanced model performance and better generalization properties stem from this augmentation particularly for minority rasa category examples.[16]

2.3 Tanimoto Similarity Algorithm for Unknown Herbs

The Tanimoto similarity algorithm functions to determine the possible rasa classification of unidentified herbs. An algorithm compares the unknown chemical makeup of samples against established herb profiles in the system to create similarity scores which suggest possible rasa types and category the new samples.[17]

2.4 Mobile Application

The mobile app through its interface enables data entry that delivers immediate rasa predictions and presents chemical analysis visualizations. Through its user-friendly mobile application the system improves accessibility and enhances user participation with Ayurvedic health guidance.[18]

V. SYSTEM ARCHITECTURE

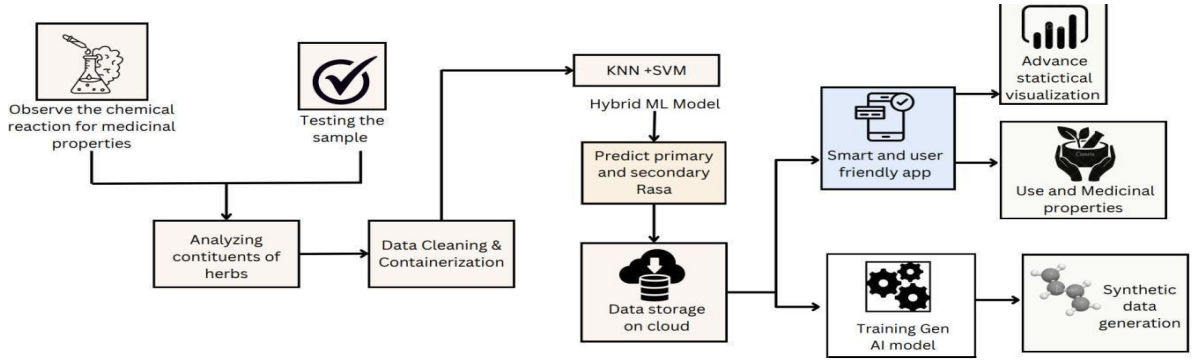

Figure 1: System Architecture

AyuRasa functions as a real-time device which detects Ayurvedic rasa taste by analyzing herbal samples and provides medicinal remedy proposals based on their chemical composition. This implementation provides two interfaces through ReactJS to serve researchers and administrators and a Kotlin-based mobile Android application designed for users. Two connected user interfaces make up the system to allow users both predict results from the analyzes and view detailed clarification of their findings. Through their mobile app users achieve real-time interaction although they gain superior data visualization capabilities and system management functions along with analytics features from their web dashboard. [19][20]

The core part of the system utilizes backend features that merge Firebase for dynamic data management with Flask (Python) for executing machine learning algorithms. The Both user authorization and data synchronization are handled through Firebase Firestore since it serves as the storage system for essential data points containing herbal specimens data alongside monitored sensor readings and user interactions and system-generated pointers. Flask APIs allow the primary and secondary rasa detection models to connect frontend elements with the database through smooth information processing. Users have the option to input their sample readings either through the app or web portal that leads to results being processed in the backend. proposed remedies with low latency times.

The system connects to external hardware as well as software components through its robust API modules. The Spectrometer & Sensor API functions as an instrument connector that retrieves essential taste parameters including pH and conductivity and optical absorbance values for rasa classification accuracy. After extraction the values move to the backend for the ML API to perform rasa classification. provides corresponding herbal remedy suggestions. The notification system based on Firebase Cloud Messaging (FCM) sends prompt alerts which consist of remedy suggestions or sample verification updates to keep users informed. AyuRasa benefits from its architecture because it allows flexible growth and interface capabilities to connect between classical Ayurvedic wisdom and contemporary AI healthcare knowledge. modern AI-driven health insights.

VI. PROPOSED SYSTEM

Ayurasa presents a scientific method using technological advancement to detect crude herb Ayurvedic rasa (taste). A system integration of electrochemical data acquisition with machine learning technology along with synthetic data simulation and mobile application design provides objective scalable analysis for rasa testing.

The system initiates its sequence by configuring the electrode array for testing herbal extracts to obtain electrochemical data. The sensors operate through measuring current and voltage outputs from the herbal solution to identify essential phytochemicals such as glucose, fructose, tannins and alkaloids in their concentrations. A Raspberry Pi serves as an efficient data acquisition and processing unit because of its compact size. Its main function is to control and interface with the electrode array while transmitting data for analytical processes.

The processed electrochemical signals containing valuable data features go into a hybrid machine learning model where Support Vector Machines (SVM) work together with K- Nearest Neighbors (KNN). The predictive model receives chemical patterns to identify herbal samples that belong to any of the six Ayurvedic rasas including sweet, sour, salty, bitter, pungent, and astringent. The

application uses Deep Convolutional Generative Adversarial Networks (DCGANs) for generating training samples because they help improve classification accuracy particularly with insufficient datasets. The model develops better generalization capabilities along with reduced data limitations.

Unknown or unclassified herbs undergo Tanimoto similarity evaluation because the algorithm compares their chemical fingerprints with recorded herbs to determine their nearest rasa match. The implementation enables a basic classification system to operate before performing explicit model training. The mobile application distributes all study outcomes including rasa identification and chemical test findings while presenting a simple user interface to scientific researchers and medical practitioners. The app brings a user-friendly interface that allows live data entry and rasa-based Ayurvedic recommendation visualization.

VII. RESULT ANALYSIS

The result analysis of the given project focuses on evaluating the performance of android application and machine learning model that to classifies Ayurvedic herbs according to their Rasa (taste). Different visualizations are used like confusion matrix, feature importance, ROC-AUC, and training curves were examined to determine model accuracy, feature importance, and prediction reliability. This summary identifies important insights, strengths, and points of improvement in the model's predictions and overall performance.

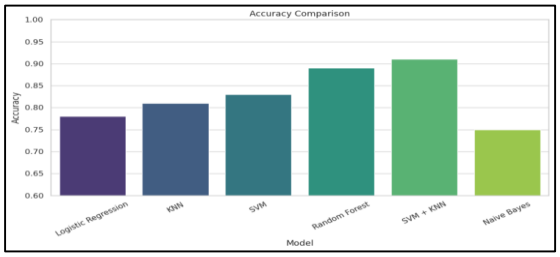

Figure 2: Accuracy Comparison of different ML Models

The training and validation accuracy curves show a smooth, parallel rise in performance across epochs, suggesting that the model is well-regularized and not overfitting. The absence of significant divergence between the training and validation lines indicates that the model generalizes well to unseen data. This is a positive sign of proper model tuning and balanced complexity.

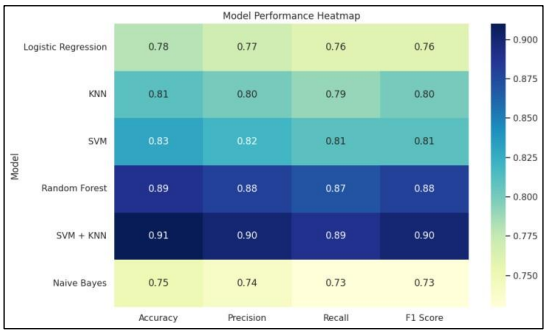

Figure 3: Correlation Heatmap

The correlation heatmap shows that features such as taste, potency (virya), and effect on dosha are very closely linked. This makes sense given the holistic nature of Ayurveda, where different properties often influence each other. There is a strong relationship between features could lead to multicollinearity, which might be improved by using techniques like feature selection or dimensionality reduction to make the model more stable.

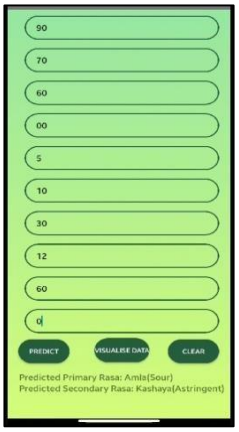

Figure 4: Android Application

This page of the Android app displays a predictive model for classifying and idetifying the primary and secondary Rasas based on multiple input parameters based on the dataset. First the user enter the values and submits the data, the model accurately predicts the Primary Rasa as Amla (Sour) and the Secondary Rasa as Kashaya (Astringent). This indicates that the model is functioning as intended by analyzing the input features and correlating them to Ayurvedic taste classifications, offering a user-friendly and interactive experience for herbal analysis.

VIII. CONCLUSION

The Ayurasa project develops an innovative method to classify Ayurvedic rasa in crude herbs by uniting modern technology with traditional Ayurvedic knowledge. The proposed system monitors

electrochemical data using electrode arrays along with signal processing through Raspberry Pi before performing taste classification by employing hybrid SVM-KNN and DCGAN models for reliable objective scalable detection. The system gains extra analytical power through the implementation of the Tanimoto similarity algorithm for detecting unlisted or undocumented herbs.

The combined approach solves established Ayurvedic taste evaluation problems and enables researchers to create better herbal medicines and tailored healthcare treatments. A mobile application deployment guarantees practical accessibility of the technology to researchers healthcare providers as well as Ayurvedic practitioners. The Ayurasa system undertakes substantial progress in validating Ayurvedic medicine through scientific methods to create future possibilities for traditional health solutions based on data-driven techniques.

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