International Research Journal of Engineering and Technology (IRJET) e-ISSN: 23950056
Volume: 12 Issue: 11 | Nov 2025 www.irjet.net p-ISSN: 2395-0072

MedAi: A Multi-Sensor Smart watch and Machine Learning Framework for Real-Time Multi-Disease Prediction

ARJUN M MANOJ

Arjun M Manoj, MSc Computer Science
St. Thomas (Autonomous) College, Thrissur 680001, Kerala, India

---

Abstract - *This review examines the "MedAi" framework, a smart watch-based application designed for the prediction of multiple common diseases using machine learning algorithms. The core objectives include providing early disease vulnerability detection and offering real-time health assistance. The framework comprises three main modules: a prototype smart watch called 'Sense O'Clock' equipped with eleven sensors for bodily data collection, a machine learning model for data analysis and prediction, and a mobile application for displaying results. The study employed various machine learning algorithms, with the Random Forest (RF) algorithm demonstrating the highest accuracy at 99.4% in predicting diseases such as ischemic heart disease, hypertension, and diabetes. This system represents a notable advancement in health information technology, aiming to mitigate the time consuming and expensive nature of traditional doctor visits and pathological tests.*

I. INTRODUCTION

Context & Motivation Healthcare information technology is rapidly advancing, driven by the need for quick illness prediction and medication access, as traditional medical visits and tests are often time-consuming and costly. Globally, prominent diseases like cardiovascular diseases, cancers, respiratory diseases, diabetes, and kidney diseases cause alarming numbers of deaths and contribute to massive healthcare expenditures. Many countries, especially in Asia, struggle to provide adequate health coverage, leading to concerns about diseases like malaria, dengue fever, and typhus. A significant issue is the occurrence of sudden deaths due to undiagnosed illnesses, such as advanced cancer, heart attack, or brain hemorrhage. Routine checkups are recommended, but often hindered by work pressure, family responsibilities, or lack of time. This highlights a critical need for convenient, real-time health monitoring systems that can provide full-time assistance and suggest remedies.

Wearable Health Monitoring The modern era offers technology-driven solutions for healthcare, with health and fitness mobile application downloads increasing significantly. The rapid growth in intelligent wearables, predicted to exceed one billion by 2022, has made real-time health checkups possible. However, many branded smartwatches are expensive and primarily function as fitness trackers, lacking features for analyzing bodily statistics or providing feedback on unusual results for multiple diseases. There is a demand for affordable smart wearables equipped with numerous sensors to monitor bodily statistics and prevent sudden tragedies.

Machine-Learning for Disease Prediction Machine learning (ML) has emerged as a vast and continuously growing field of research for disease prediction. While many existing ML-based prediction systems focus on single diseases, such as heart disease (due to its high death rate), there is a critical need for systems capable of predicting multiple disease vulnerabilities simultaneously. The "MedAi" system addresses this by presenting a smartwatch based prediction framework for twelve common diseases, leveraging various machine learning algorithms to achieve high accuracy.

II. LITERATURE SURVEY

II.1 Smartwatch Monitoring:

hardware, sensors, data challenges Existing smart wearables often fall short in comprehensive disease detection. Many branded smartwatches are expensive and mainly function as fitness trackers, not providing in-depth analysis or feedback for health issues. For instance, Medibot, a medical chatbot for smartwatches, claimed to be the first disease prediction app with a smartwatch, but it only included four sensors, which could bias predictions. In contrast, the 'Sense O'Clock' prototype, central to the MedAi system, is designed with eleven sensors to collect a wider range of bodily statistics, making it more feasible for multi-disease prediction. It aims to be more cost- and power-efficient than smart garments or high-functionality branded watches. Data collection for disease prediction systems is challenging; readily available open-source datasets for all targeted diseases are scarce, and collecting observational data from patients wearing smartwatches is not always feasible. Privacy concerns arise when utilizing third party APIs for data storage, as health related information is sensitive. The accuracy and reliability of smartwatch data for clinical measurements remain an ongoing discussion. Some studies show smartwatches under/overestimate measurements (e.g., blood pressure) and can be affected by rapid acoustic fluctuations in noise monitoring, indicating they are not always ready for clinical usage without systematic bias. While some commercial smartwatches have demonstrated moderate validity for certain parameters like heart rate, their ability to precisely detect medical symptoms is still limited, with notable discrepancies compared to medical-grade instruments.

II.2 ML for Prediction:

algorithms, models, metrics Machine learning has been widely applied in disease prediction, especially for cardiovascular diseases, diabetes, and other conditions. MedAi employs a range of popular ML algorithms, including Support Vector Machine (SVM), Support Vector Regression (SVR),K-Nearest Neighbor (KNN), Extreme Gradient Boosting (XGBoost), Long Short Term Memory (LSTM), Random Forest (RF), Gradient Boosting (GB), and Logistic Regression (LR). For disease prediction, MedAi's experimentation showed that the Random Forest algorithm outperformed others, achieving an accuracy of 99.4%. This compares favorably to other existing systems, for example:

- Arumugam et al. focused on heart disease in diabetic patients with accuracies around 78-90% using decision trees, Naive Bayes, and SVM, whereas MedAi predicts twelve diseases performance.
- Alfian et al.'s system for diabetic patients achieved decent performance but was limited to diabetes prediction.
- Kim's cardiovascular disease prediction model using smartwatch data and three ML methods obtained lower accuracy than MedAi's model.
- Terrada et al.'s MDSS for atherosclerosis prediction achieved a highest accuracy of 94% using ANN, AdaBoost, and DT, which is significantly lower than MedAi's 99.4%.
- Tyagi et al.'s thyroid disease prediction system using SVM, KNN, and decision trees also showed good accuracy, but MedAi includes thyroid diseases among multiple others and uses more advanced methods for a higher score.
- Wang et al.'s chronic kidney disease prediction system using associative classification techniques achieved high accuracy but might not be suitable for other diseases, unlike MedAi's broader scope.
- Ganesan et al.'s IoT and ML-based heart disease prediction model had commendable but relatively average accuracy compared to MedAi. with higher Data preprocessing is a crucial step involving data acquisition, library import, dataset import, missing data handling, data encoding, dataset splitting, and feature scaling. Attribute selection, evaluating twenty attributes to make the best possible prediction, is also vital. The use of 5-fold cross-validation during training and testing helps in hyperparameter optimization and assessing model overfitting.

Performance evaluation metrics used in this study include:

- **Classification:** Accuracy (correct predictions/total predictions), Precision (correct positives/total positive predictions), (correct Recall positives/total actual positives), and F1-Score (harmonic mean of precision and recall).
- **Regression:** Mean Square Error (MSE), Root Mean Square Error (RMSE), and R-Squared (variance explained by input variables).

II.3 Frameworks:

feature comparison, gaps The MedAi system offers a comprehensive framework that integrates a custom smartwatch design, a robust machine learning model, and a mobile application. This integrated approach addresses several limitations identified in previous works:

- **Lack of comprehensive solutions:** Many existing disease prediction systems using wearables, ML, and mobile applications do not offer a comprehensive, simple, and satisfying solution within a single framework. MedAi integrates all three components into one cohesive system.

- **Limited disease prediction scope:** Previous works often predicted a reasonably low number of diseases, even when utilizing wearable technology and ML. MedAi aims to predict twelve different common diseases.

- **Reliance on manual user input:** Several mobile or online applications for health provide predicted results but require manual user input, which is inconvenient and requires users to have medical knowledge or proficiency in English. MedAi, conversely, predicts diseases using real-time data from the smartwatch without user intervention, and its application has a user-friendly UI.

- **Absence of real-time assistance:** Some self-checkup apps extract information from existing datasets, making real-time prediction infeasible. MedAi gathers data in real-time through the smartwatch and provides instant assistance and suggestions. health The broader field of smartwatches in healthcare indicates a need for the development of "medical watches" and "AI-hospital assistants" to improve patient monitoring, appointment scheduling, and medication management, going beyond basic fitness tracking.

III. PROPOSED FRAMEWORK

Architecture- The proposed system, "MedAi," integrates "Artificial Intelligence" and "Medical Technology". Its architecture consists of tightly coupled components:

- **Data Acquisition:** The user wears the prototype smartwatch, "Sense O'Clock," which houses eleven necessary sensors (e.g., ESP32 MCU compatible GPIO pins for body vitals). These sensors collect real-time bodily statistics.

- **Data Transmission:** smartwatch connects The to a smartphone via Bluetooth Low Energy (BLE). BLE is chosen for its power optimization, security, and availability, addressing issues like cost and lack of widespread Wi-Fi connectivity in less developed regions, and privacy concerns with third-party APIs. The serial raw data from the sensors are continuously sent to the mobile application.

• **Preprocessing/Extraction:** Upon receiving serial data, the MedAi Android application sends it to a Flask Rest API for processing. Data preprocessing steps typically involve data cleansing, handling missing values, filtering noise, and feature selection learning outcomes. to optimize

• **Training & Inference:** The Flask Rest API forwards the extracted feature values to the machine learning model for prediction. The model, built using the Random Forest algorithm (identified as the best-performing with 99.4% accuracy), processes the data

• **App UI & Backend:** The prediction response from the ML model is sent back to the API and then displayed on the smartphone screen and in the notification bar. The Android application features a user-friendly interface that allows users to register, view readings, and receive predicted disease risks and suggested remedies. The system is designed to store only minimal, necessary data to alleviate concerns about storage costs and privacy issues associated datasets.

Novelty vs. Existing Work : The "MedAi" framework distinguishes itself through several novel contributions:

• **Multi-Disease Prediction:** Unlike many existing systems that focus on one or a few diseases, MedAi predicts vulnerabilities for twelve distinct common diseases, including ischemic heart disease, hypertension, respiratory disease, hyperthyroidism, hypothyroidism, stroke, myocardial infarction, kidney failure, gallstones, diabetes, and dyslipidemia.

• **Comprehensive Sensor Integration**: The 'Sense O'Clock' prototype smartwatch is designed with eleven sensors, providing more comprehensive data input compared to systems with fewer sensors (e.g., Medibot with four sensors).

• **High Accuracy:** The machine learning model, particularly using the Random Forest algorithm, achieves a noticeably higher accuracy of 99.4%, surpassing the performance of many existing common disease prediction methods.

• **Real-time and Uninterrupted Monitoring:** The system provides full-time, real-time assistance and suggests requisite remedies without requiring continuous manual user input for prediction. This addresses the inconvenience noted in other mobile health applications.

• **Cost and Power Efficiency**: The prototype watch is designed to be cost- and power-efficient compared to expensive branded smartwatches and smart garments.

• **Integrated Framework:** MedAi offers a comprehensive solution within a single framework, encompassing wearable design, an optimized ML model, and a self directed mobile application, which was identified as a gap in prior research.

IV. EVALUATION CRITERIA

The performance of the "MedAi" system, particularly its machine learning model, is rigorously evaluated using standard metrics for both classification and regression analyses.

• **Accuracy:** The ratio of correct predictions to the total number of predictions (TP+TN)/(TP+FP+FN+TN). For MedAi, the RF algorithm achieved
99.4% accuracy on test data for the entire dataset. 10 9 6 5

• **Precision:** The ratio of correctly predicted positives to the total predicted positives (TP)/(TP+FP), effective in lowering false positives.

• **Recall (Sensitivity):** The ratio of correctly predicted positives to the total actual positives (TP)/(TP+FN), useful in reducing false negatives. • F1-Score: The harmonic mean of precision and recall, providing a balanced measure of the model's effectiveness.

• **Latency & Battery Use:** While not explicitly detailed in the evaluation results, the choice of BLE for communication emphasizes power optimization, suggesting consideration for battery life, which is crucial for IoT applications like smartwatches.

• **Usability & User Acceptance:** The "MedAi" application is designed with a straightforward and user friendly UI to ensure comfort and ease of use for people without domain knowledge of other fields. The rapid growth of wearables and health apps suggests a high level of user acceptance technologies. for such The ability to customize the 'Sense O'Clock' enclosure according to user needs also contributes to acceptance.

For regression analysis (used with SVR and LSTM in some cases), Mean Square Error (MSE), Root Mean Square Error (RMSE), and R-Squared are used. The experimentation involved applying eight algorithms to individual disease datasets, which were then amalgamated and subjected to 5-fold cross-validation to assess model performance and optimize hyperparameters.

V. DISCUSSION & FUTURE WORK

Ethics, Privacy, Security

The use of smartwatches for health monitoring raises significant ethical and privacy concerns, especially regarding data theft when using third-party APIs. While MedAi addresses this by storing only a minimal amount of data relevant for evaluation and avoiding third-party APIs for primary data transfer, the broader discussion on the reliability and trustworthiness of smartwatch diagnoses persists. Different smartwatch brands yield varying results, and the opaqueness of their underlying algorithms is can introduce uncertainty about accuracy and reliability. It important to note that most commercially available wearables are marketed for "wellbeing" and are not approved for medical decision-making without extensive clinical studies and regulatory approval, which is a significant barrier.

V.1 Scalability & System Integration

The MedAi framework is designed to predict multiple diseases, demonstrating a degree of scalability in its core functionality. However, integrating such technologies into existing, complex healthcare IT infrastructures poses challenges. Data and AI models would need to be seamlessly integrated and regularly updated to be available at the point of decision-making, while always protecting privacy and data security. V.2 Extensions to More Diseases/Sensors Future research for the "MedAi"

V.2 Extensions to More Diseases/Sensors

Future research for the "MedAi" application framework includes several key areas:

• **Dataset Expansion**: Increasing the size of the dataset will further improve the machine learning model's performance robustness.

• **Smartwatch Production:** Moving from a complete design of 'Sense O'Clock' to its actual production is a future task.

• **Expanded Disease Prediction:** Adding more seasonal diseases to the existing list of prominent diseases is planned.

• **Mobile Application Publication:** The mobile application is intended for publication on the Google Play Store, increasing its accessibility.

• **Refined Measurements:** Future studies may need to use more precise measurement values for certain variables, such as stress index, which was noted as a limitation in other studies due to subjective self-reporting.

• **Disease-Specific Models:** It may be beneficial to construct models that predict each of the twelve diseases individually to understand the differences in influencing factors and better analyze false-negative subjects.

• **Deep Learning Algorithms**: Future studies might consider using Deep Learning algorithms on the pre-processed data for potentially enhanced model performance.

VI. CONCLUSION

The "MedAi" framework represents a significant advancement in preventive healthcare through its innovative integration of smartwatch technology, machine learning, and a mobile application. By designing a comprehensive smartwatch, 'Sense O'Clock,' equipped with numerous sensors, and developing a highly accurate machine learning model (99.4% with Random Forest), MedAi offers a robust strategy for predicting multiple common disease vulnerabilities. The system is designed to provide full-time, real-time assistance, reporting body conditions and suggesting remedies without requiring manual user intervention, thereby overcoming critical limitations of existing solutions. The impact of "MedAi" is profound, promising to greatly reduce the rate of sudden deaths and undiagnosed terminal diseases by alerting users to significant bodily changes. It serves as a valuable aid to medical specialists, empowering individuals to take a more proactive role in managing their health and promoting healthy lifestyles. While challenges related to data accuracy, privacy, and full clinical integration remain, the proposed framework lays a strong foundation for future developments in affordable, energy saving, and user-friendly health monitoring systems. The continuous evolution of such AI-driven wearable solutions is poised to transform contemporary clinical care and enhance long-term preventive strategies.

REFERENCES

[1] D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[2] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[3] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[4] K. Elissa, "Title of paper if known," unpublished.

[5] Global Health and Fitness app Downloads 2020 | Statista. Accessed: Apr. 1, 2022.

[6] igital Around the World—DataReportal—Global Digital Insights. DataReportal-Global Digital Insights. Accessed: Apr. 1, 2022

[7] What Is Sudden Death?. Accessed: Apr. 1, 2022