IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

IOT Based Heart Monitoring System With Feature Optimization Techniques On ECG Images

[1]Shruti Mehra, [2]Dr.Sandeep Kumar

[1]M. Tech CSE (Data Science), [2]Associate Professor

[1,2]Computer Science and Engineering, (SSET)

[1,2]Sharda University, Greater Noida, India

***Abstract*-**In this paper we tried to demonstrate IOT based heart monitoring system with feature optimization techniques on (ECG image) dataset where we simulate the project using Arduino Uno and AD8232 heart sensor and pulse sensor and by using feature optimization techniques and feature extraction techniques on ECG image dataset for improving the accuracy and performance where it will reduce number of computations and time complexity. In this HOG feature extraction used for extracting the relevant features and eliminating the rest of features which are not important and by using PCA we only select the principal component of image to improve its accuracy by reducing the dimensions**.**

***Keywords*—** IoT, ECG Images, Heart Monitoring, Feature Optimization, Machine Learning, Classification.

1. Introduction

In present scenario in the world of full stress now a days heart disease is becoming a major cause of concern disease which is a crucial to pay adequate attention for it. Cardiovascular diseases (CVDs) which leads to premature deaths even in young generation. Early detection of heart disease by the use of ECG Signals and rapid heart rate calculation and many other like abnormal heart beat rhythms these are crucial to detect in early stage of it and of heart health are crucial to prevent fatal. Electrocardiogram (ECG) signals provide valued information regarding the electrical activity or electrical signals of the heart, and the use of these wearable ECG devices allows for continuous heart monitoring outside of hospital settings to monitor the heart beat 24*7. However, the large volume and complexity of the ECG data pose challenges in processing and classification.

IoT-based systems provide a capable solution for real-world applications, remote heart monitoring by continuously transmitting ECG data. There are some Recent advances in deep learning and image processing which incorporates the use of the ECG images for heart disease classification. However, raw ECG image data often includes noise and irrelevant features, which can worsen classification performance. This paper proposes an IoT-based heart monitoring system that uses ECG images and incorporates feature optimization techniques to boost the detection accuracy of heart diseases on Svm classifier.

The Internet of Things (IoT) plays a vital role in modern heart monitoring systems by permitting real-time, constant tracking of a patient's heart health, like from wearable devices such as smartwatches, chest straps, and ECG patches, pulse monitor, heart rhythm monitor. IoT allows for the persistent monitoring of vigorous signs like heart rate, ECG, blood pressure, and oxygen saturation. These are devices collect and transmit data wirelessly to mobile applications or cloud platforms or even not transmitting but only viewing and recording, allowing healthcare professionals to remotely monitor patients, specially those who are elderly, improving from operation, or active in remote areas. One of Important advantage of these IOT in heart monitoring is its capability to provide early warnings by detecting irregularities, abnormality and sending instant alerts to doctors or family members, potentially preventing serious medical emergencies such as heart attacks. The data collected is stored in the cloud, where it can be analyzed over time to identify trends, improve diagnosis accuracy, and personalize treatment plans. IoT systems also integrate seamlessly with electronic health records (EHRs), telemedicine platforms, and emergency services and which creates a interdependent healthcare ecosystem. Some advanced systems which offer computerized responses, such as adjusting treatments based on real-time readings or notifying emergency services in case of a critical health event. IoT improves the efficiency, accuracy as well as reduces the time complexity and responsiveness of heart monitoring systems, making them a vital component of modern healthcare.

2. Literature survey

The rapid evolution of Internet of Things (IoT) technology has brought significant advancements in healthcare, particularly in early disease detection and continuous patient monitoring. Researchers have explored how deep learning, optimization techniques, and IoT frameworks can enhance medical diagnostics and patient care. This literature review summarizes key contributions in this field while highlighting the strengths and limitations of the technologies used.

[1] developed a heart disease detection model designed for IoT-enabled Wireless Body Area Network (WBAN) systems. The focus of their work was to ensure that AI-driven medical decisions remain interpretable and reliable. The main advantage of using this is the model improves faith in automated diagnostics by making its predictions more transparent, and limitation is also there as the system may struggle with real-time processing due to its computational demands.

[2, 4] presented an IoT-powered diabetes detection system that utilizes deep learning and dimensionality reduction techniques. Their approach improves data processing efficiency, resulting in higher diagnostic accuracy. Advantage of it as the model effectively identifies diabetes at an early stage while reducing unnecessary data complexity. Limitation Large datasets are required for training, and real-time implementation may pose challenges.

[3] demonstrated a protected healthcare outline with the collaboration of IoT (CIoT) with a deep recuperator neural network and long short-term memory (LSTM). This system arranges security while refining analytical accuracy in medical conditions, which consists or it ensures data privacy and effectively manages time-series health data. The computational cost is high, making optimization more complex.

[5] This paper demonstrates and more focused in designing an IoT-based cardiac monitoring platform which not only provides real-time tracking of heart activity. This system is also used for continuously monitors about patients' health and alerts healthcare providers in case of abnormalities. This Real-world data analysis allows early intervention for cardiac patients, which requires stable network connectivity for nonstop monitoring.

[6] Illustrated about heart disease prediction system which is used for modification in neural network within a deep learning framework. In this case the system enhances both prediction accuracy and patient monitoring. The

model adapts well in present scenario of testing for verification of testing of model precision and accuracy. High resource consumption and risk of overfitting could limit practical use.

[7] Illustrated a cloud-based healthcare monitoring system by using a Multi-Scale Self-Organizing Adaptive Neuro-Fuzzy Inference System (MSSO-ANFIS) to diagnose heart disease which using these combined and integrated approach and using IoT with cloud computing, this solution enhances scalability and efficiency, which leads to improved decision-making through the fuzzy inference and is highly scalable. Dependence on cloud infrastructure raises concerns about patient data security and system latency.

[8] Developed an automated heart disease diagnosis system leveraging similarity-navigated graph neural networks optimized using the Leopard Seal Optimization algorithm. This type of advanced methodology is used for enhancement in prediction accuracy while diminishing false alarms. The system provides extremely precise diagnoses with a reduced false-positive rate. High computational power is needed, making it fewer suitable for resource-limited environments.

[9] It demonstrates and more focused on premature heart disease prediction by using feature optimization and deep learning techniques. Which results in low time complexity and computational cost by increasing the accuracy. Their method improves the efficiency of disease recognition while ensuring high accuracy. Optimized feature selection improves processing speed and model efficiency. The model's performance may decline with small or imbalanced datasets.

[10] Applied machine learning algorithms and Monarch Butterfly Optimization for analyzing the data from heart attack patients. Their hybrid methodology shows improvement in classification accuracy in IoT-based healthcare systems. This type of methodology where it focuses on optimization technique that enhances adaptability and classification performance. Which requires careful parameter tuning, which may complicate implementation.

[11] This paper demonstrated the more developed version of an optimized deep learning-based Convolutional Neural Network (CNN) for classification of ECG signals more efficiently. The model supports premature diagnosis and intervention in heart-related conditions. High precision in ECG signal classification aids in premature detection. The model's computational stresses which may restrict its use in real-time or low-resource environments.

3.Methodology

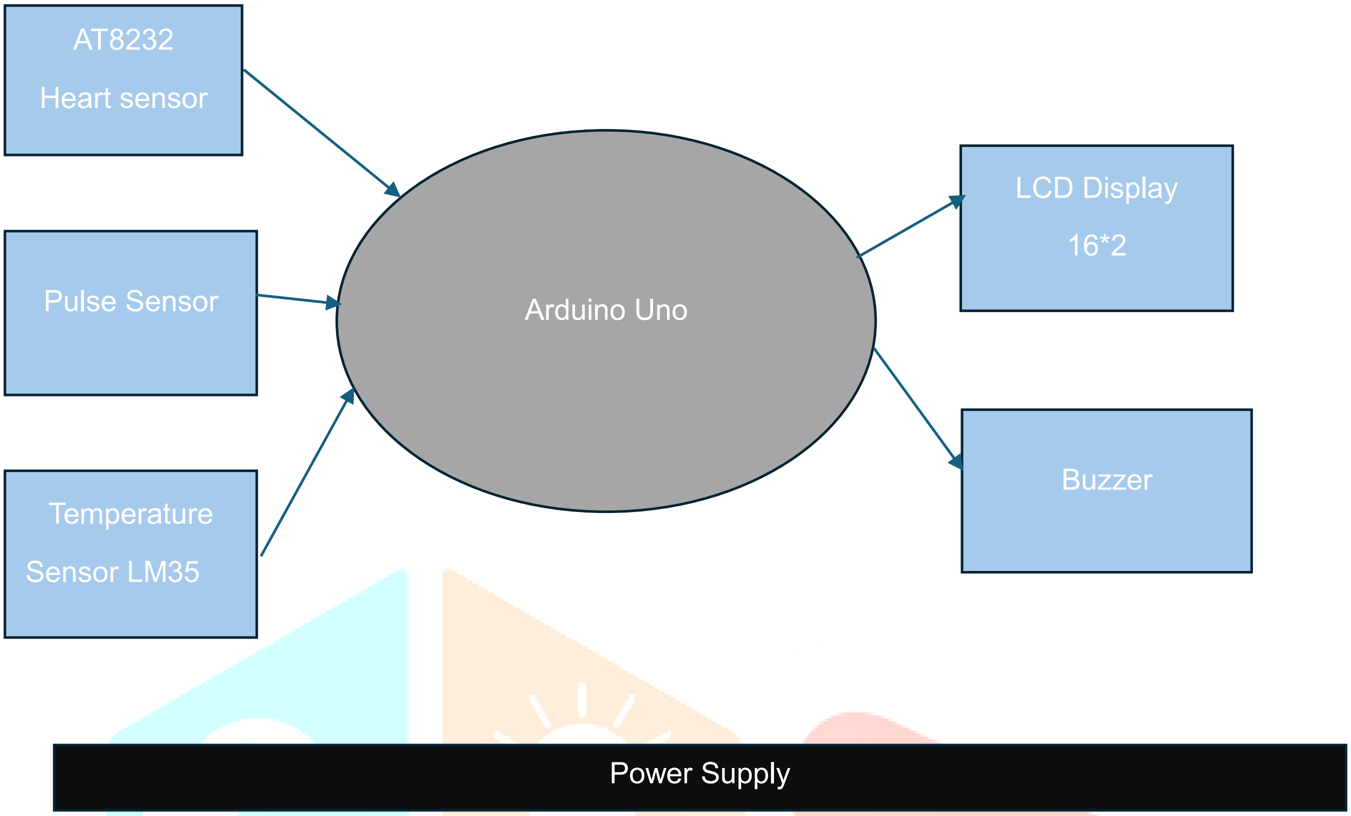


Fig1: Shows block diagram of heart monitoring system

3.1 Sensor Layer

The sensor layer comprises various types of sensors in it. In this paper we have considered 3 sensors in it to predict the ECG signal, pulse count and temperature count i.e, AT8232, Pulse sensor and temperature sensor LM35.These can be broadly discussed below:

AT8232: The **AT8232** is a single-lead heart rate monitoring sensor used to measure ECG (Electrocardiogram) signals. It is widely used in biomedical applications, including fitness tracking, heart health monitoring, and embedded medical systems.

Working Principle

The **AT8232** sensor detects the small electrical impulses generated by the heart during its contraction and relaxation cycles. It amplifies these signals and filters out noise to provide a clear ECG waveform. The sensor typically consists of three electrodes:

Right Arm (RA), Left Arm (LA), Right Leg (RL) (Ground reference)

These electrodes capture the voltage difference created by heart activity and pass it through an **instrumentation amplifier**, followed by filtering and signal conditioning.

Mathematical Representation

The ECG signal can be represented by a summation of various wave components:

$$ECG(t)=P(t)+QRS(t)+T(t)+Noise(t) \quad (1)$$

Where:

P(t): Represents atrial depolarization (P-wave)

QRS(t): Represents ventricular depolarization (QRS complex)

T(t): Represents ventricular repolarization (T-wave)

Noise(t): Represents unwanted interference such as motion artifacts and baseline wander

The **voltage (Vout)** output from the sensor can be approximated using the gain of the instrumentation amplifier:

V out=G·(VLA−VRA) V_{out} = G \c. (V_{LA} - V_{RA})Vout=G·(VLA−VRA) (2)

where **G** is the gain of the amplifier, and **(V_LA - V_RA)** is the differential voltage between the left and right arm electrodes.

(b) Pulse Sensor: Overview & Working Principle

A **pulse sensor** is a photoplethysmography (PPG)-based device used to measure heart rate by detecting changes in blood volume. It typically consists of an **LED** (light-emitting diode) and a **photodetector** that work together to monitor blood flow variations in the skin.

When the heart pumps blood, the volume of blood in capillaries changes, altering the light absorption and reflection. The **pulse sensor** detects this change and converts it into an electrical signal.

(c) LM35 Output Voltage Equation:

The LM35 outputs **10mV per degree Celsius**. The relationship between temperature and output voltage is:

T(°C) =V out(mV)10T(°C) = frac{V_{out} (mV)}{10}T(°C) =10Vout(mV) (3)

or in **volts**:

T(°C) =Vout×100T(°C) = V_{out} \times 100T(°C) =Vout×100 (4)

where:

VoutV_{out}Vout = Sensor output voltage in volts

T(°C)T(°C)T(°C) = Temperature in degrees Celsius

The sensor layer necessary for heart disease classification

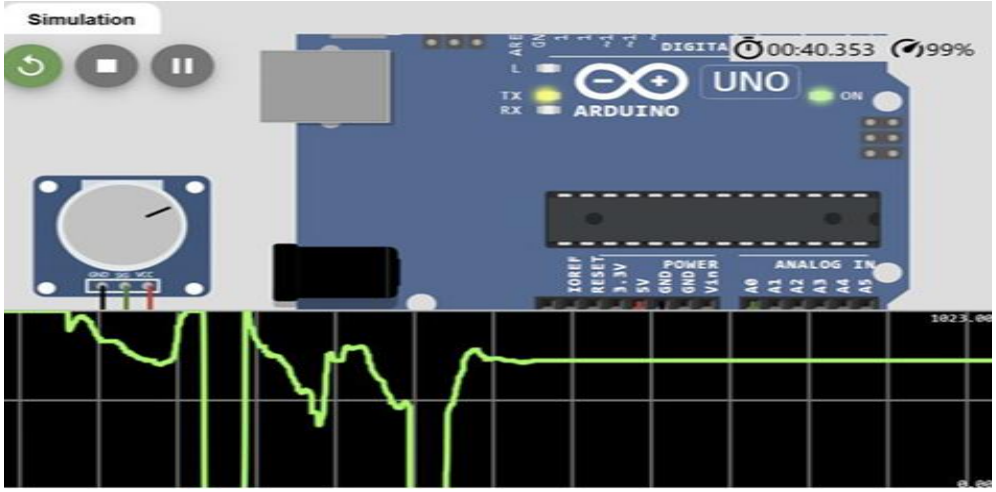


Fig2: Shows the simulation of Arduino uno with potentiometer which mimic the AT8232 ECG signal

3.2. Arduino Uno:

Arduino Uno – Description

The Arduino Uno is a microcontroller board based on the ATmega328P. It is one of the most widely used and beginner-friendly development boards in the Arduino family, designed for electronics projects, automation, and IoT applications. The board features 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button.

It operates at 5V and can be powered via a USB cable or an external power supply (7-12V recommended). The Arduino Uno is programmed using the Arduino IDE, which supports C and C++. Its simplicity, open-source design, and extensive community support make it ideal for both beginners and professionals in embedded systems and electronics prototyping.

The Uno is commonly used in robotics, home automation, sensor monitoring, and DIY electronics projects. It supports a variety of shields and modules, enabling expansion for different applications like wireless communication, motor control, and data logging

4. Feature Extraction Techniques

Feature extraction techniques are crucial part of pre-processing where we require to extract relevant feature ignoring others and these feature extraction methods are of various types like-HOG which is histogram gradient where not only it calculates the magnitude but also it can calculate the orientation or direction of the pixel. In this approach we have used this.

Preprocess of data (64*128)- Dividing the image into 8*8 and 16*16 patches to extract the features specified size (64*128).

2. Calculating gradients (direction **x** and **y**) gradient of every pixel in image forms a pixel matrix. Calculate the change in x and y direction *i.e.*, $G\boldsymbol{x}$ and $G\boldsymbol{y}$ This process will give two new matrices one in x direction and other in y.

3. Calculate magnitude and orientation, by using Pythagoras theorem for each pixel

$$\sqrt{(G\boldsymbol{x})^2 + (G\boldsymbol{y})^2} \tag{5}$$

And orientation or direction as

$$\tan(\emptyset) = \frac{Gy}{Gx} \tag{6}$$

Where

$$\emptyset = \tan^{-1}(\frac{Gy}{Gx}) \tag{7}$$

4. Calculate histogram of gradients in 8*8 cells

5. Normalize gradients in 16*16 cell as given below:

$$V = [a_1, a_2, a_3, \dots, a\_36] \tag{8}$$

$$K = \sqrt{a_1^2 + a_2^2 + \cdots + a_{36}^2} \tag{9}$$

Then the Normalized vector is given by

$$\overline{V} = \frac{a_1}{K}, \frac{a_2}{K}, \dots, \frac{a_{36}}{K} \tag{10}$$

4.3 Dimensionality Reduction

Dimensionality reduction techniques, such as Principal Component Analysis (PCA), are applied to reduce the number of features while preserving essential features. This is the easiest method when compared to other dimensionality reduction techniques. These methods help reduce the computational complexity of the model and improve processing speed, which is crucial for real-time applications.It is less effective to noise or outliers. PCA is commonly used in image processing, face recognition, and anomaly detection

5. Machine Learning Models for Classification

The data analysis layer uses machine learning algorithms to classify heart disease based on optimized ECG images. The following machine learning models are used:

- **Support Vector Machine (SVM):** SVM is a powerful supervised learning algorithm that can classify data points in a high-dimensional feature space. It is used for binary classification, such as determining whether a person has a heart condition or not.

These models are trained on the optimized features extracted from the ECG images to classify the data accurately.

6. System Evaluation

The performance of the proposed IoT-based heart monitoring system was evaluated using a publicly available ECG dataset containing images and labels for heart disease classification. The evaluation metrics used include:

Accuracy: The percentage of correctly classified instances out of the total predictions made by the model.

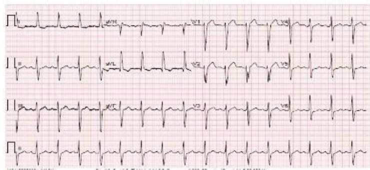
Precision: The ratio of true positive predictions to all positive predictions.

Recall: The ratio of true positive predictions to all actual positive cases.

The system was evaluated with and without feature optimization techniques to assess the impact of optimization on classification performance.

7. Results and Discussion

The experimental results demonstrate the effectiveness of feature optimization in improving the classification performance of the IoT-based heart monitoring system. The application of feature extraction and feature selection techniques led to a significant improvement in classification accuracy, reducing the risk of overfitting and improving generalization.



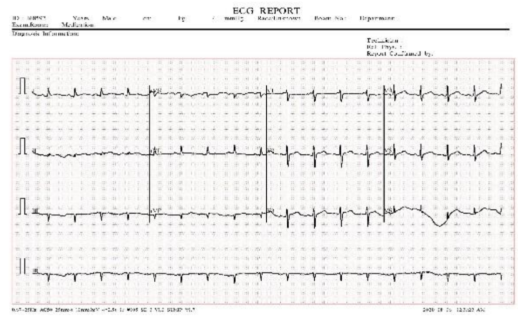
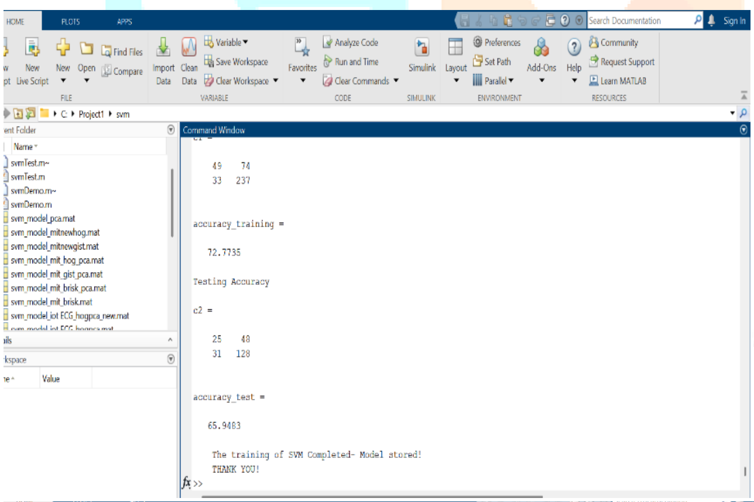


Fig3: Shows Datasets of ECG after covid



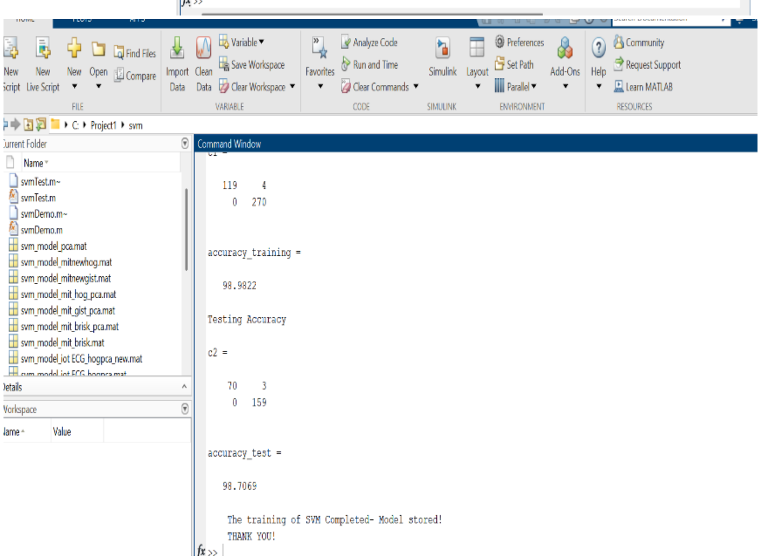


Fig4: Shows the improvement in accuracy after using PCA

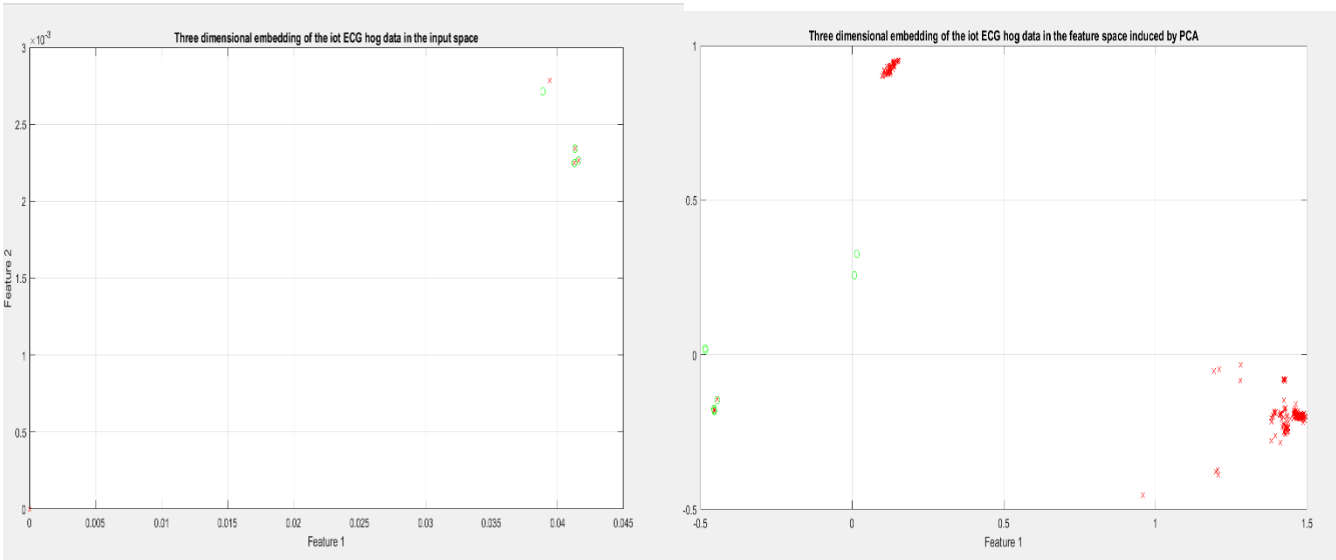


Fig5: Illustrates the plotting in input and feature space after using PCA

The above results show the improvement in accuracy when the data is fed only after feature extraction technique i.e., HOG and with the results that is obtained after using feature extraction with feature optimization i.e, PCA which outperforms in increasing the performance of classifier SVM.

8. Conclusion

This paper demonstrated an IoT-based heart monitoring system on ECG image dataset for classification which integrates feature optimization techniques and feature extraction techniques for the classification of ECG images which has been taken from standard dataset Kaggle to detect heart diseases and improves the accuracy when provided to SVM classifier after application PCA i.e., principal component analysis. This methodology when combined with other real -world data that will prove in premature diagnosis of heart disease, offering a non-invasive and efficient approach to heart disease detection. Feature optimization techniques, including feature extraction, selection, and dimensionality reduction, significantly improve the system's classification accuracy and computational efficiency.

References

[1] Damilola D. Olatinwo; Adnan M. Abu-Mahfouz; Gerhard P. Hancke; Hermanus C. Myburgh, "Interpretable Heart Disease Detection Model for IoT-Enabled WBAN Systems", IEEE Sensors Journal (Volume: 25, Issue: 3, 01 February 2025).

[2] Thavavel Vaiyapuri; Ghada Alharbi; Santhi Muttipoll Dharmarajlu; Yassine Bouteraa; Sanket Misra; Janjhyam Venkata Naga Ramesh, "IoT-Enabled Early Detection of Diabetes Diseases Using Deep Learning and Dimensionality Reduction Techniques", IEEE Access (Volume: 12).

[3] C. Narmatha; S. Manimurugan; P. Karthikeyan, "A Smart CIoT With Secure Healthcare Framework Using Optimized Deep Recuperator Neural Network Long Short-Term Memory", IEEE Internet of Things Journal (Volume: 11, Issue: 6, 15 March 2024).

[4] Thavavel Vaiyapuri; Ghada Alharbi; Santhi Muttipoll Dharmarajlu; Yassine Bouteraa; Sanket Misra; Janjhyam Venkata Naga Ramesh, "IoT-Enabled Early Detection of Diabetes Diseases Using Deep Learning and Dimensionality Reduction Techniques", IEEE Access (Volume: 12).

[5] Sandeep Raj, "An Efficient IoT-Based Platform for Remote Real-Time Cardiac Activity Monitoring", IEEE Transactions on Consumer Electronics (Volume: 66, Issue: 2, May 2020).

[6] Simanta Shekhar Sarmah, "An Efficient IoT-Based Patient Monitoring and Heart Disease Prediction System Using Deep Learning Modified Neural Network", IEEE Access (Volume: 8).

[7] Mohammad Ayoub Khan; Fahad Algarni, "A Healthcare Monitoring System for the Diagnosis of Heart Disease in the IoMT Cloud Environment Using MSSO-ANFIS", IEEE Access (Volume: 8).

[8] V. Sripathi Raja; Ruchira Rawat; Karuna Pandit; Raghu Dhumpati; Vipul Vekariya; S Vijitha, "Automated Heart Disease Diagnosis and Monitoring System Using Similarity-Navigated Graph Neural Networks with Leopard Seal Optimization in IoT Healthcare Applications", 2024 4th International Conference on Sustainable Expert Systems (ICSES).

[9] D Manivannan; N.K Manikandan; S Sathiya Priya; S Bharathi, "A Smart Healthcare Application for Early Heart Disease Prediction: Leveraging Feature Optimization and Deep Learning Techniques", 2024 2nd International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS).

[10] Wahidur Rahman;Md. Abul Ala Walid;S. M. Saklain Galib;Kaniz Rokhsana;Talha Bin Abdul Hai;Mir Mohammad Azad;Mohammad Ali Moni, "Observation of Heart Attack Patients Utilizing Machine Learning with Monarch Butterfly Optimization and IoT", 2023 26th International Conference on Computer and Information Technology (ICCIT).

[11] Sudhanshu Dev; Richa Tiwari; P. R. Rege; A. Thangamani; Yuvraj Parmar; Nishanthi, "Optimized Deep Learning CNN for Efficient Classification of ECG Signals", 2024 IEEE 4th International Conference on ICT in Business Industry & Government (ICTBIG).