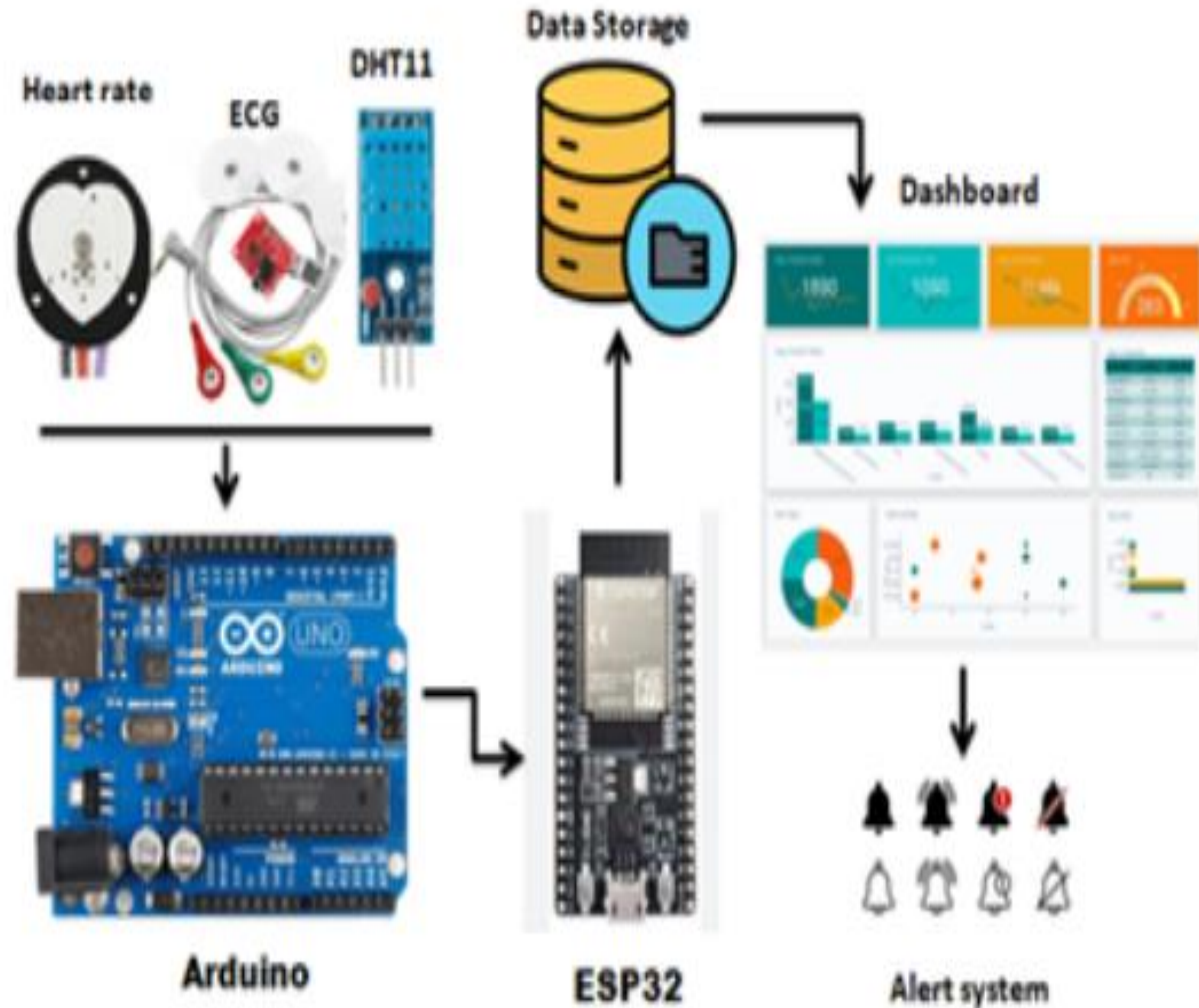


ADAPTIVE IOT-ENHANCED PREDICTIVE HEALTHCARE ECOSYSTEM

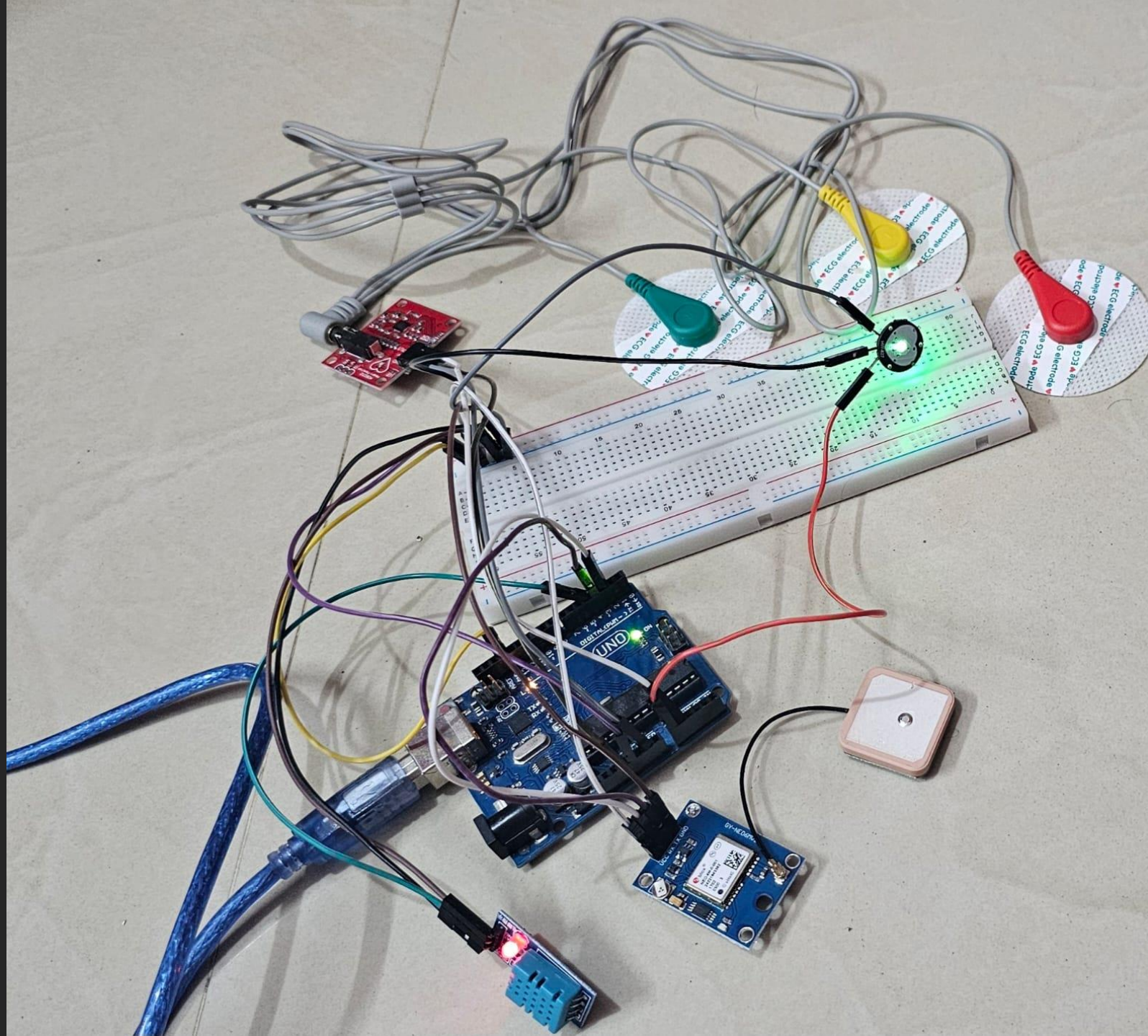
DONE BY : J Verlin Krisha



PROPOSED SYSTEM DIAGRAM:



HARDWARE SIMULATION

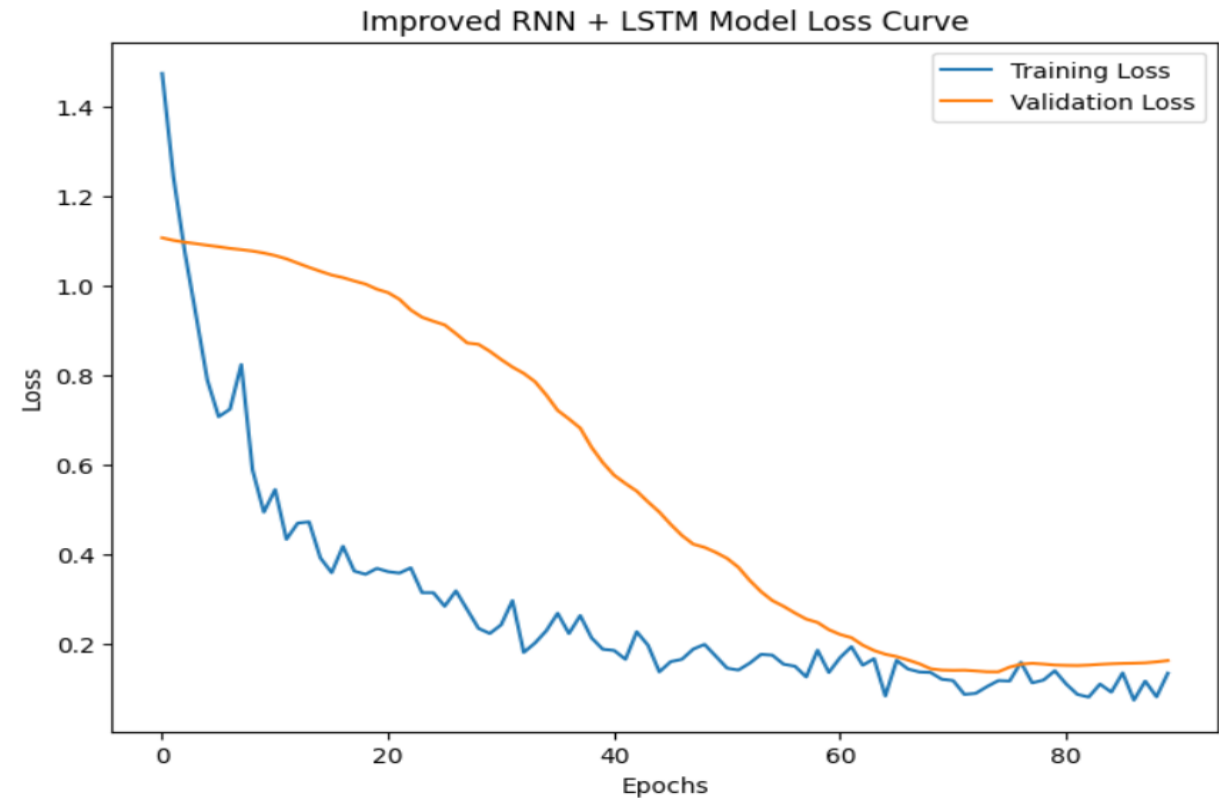
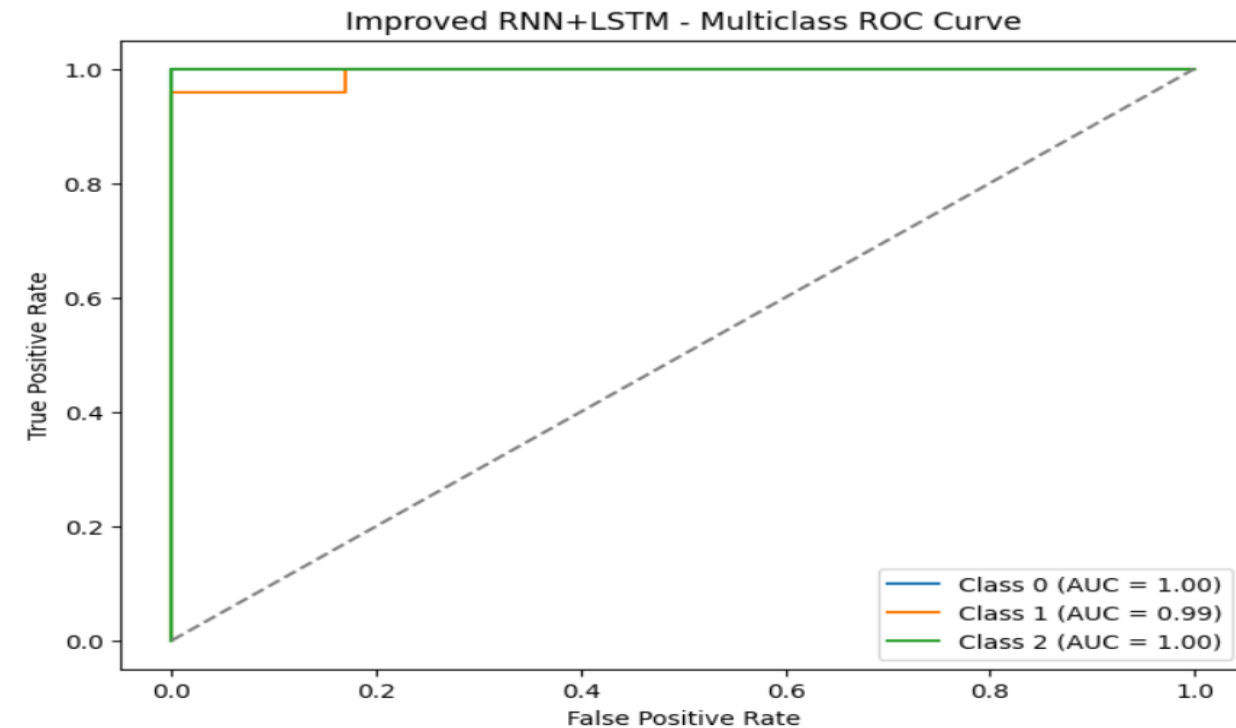


INTEGRATION OF ML MODEL TO THINGSBOARD DASHBOARD

Model used - RNN + LSTM – 97% Accuracy

Epochs – 150

Overall RNN + LSTM Training Accuracy: 0.9679
Overall RNN + LSTM Testing Accuracy: 0.9718
3/3 1s 255ms/step



```
import requests
import json
import time

THINGSBOARD_HOST = "demo.thingsboard.io"
ACCESS_TOKEN = "IwDNmN8XABGIJ2XmmudY"
API_URL = f"http://{THINGSBOARD_HOST}/api/v1/{ACCESS_TOKEN}/telemetry"

# sample payload
payload = {
    "temperature": 36.5,
    "humidity": 45.0,
    "heart_rate": 72,
    "ecg": 0.9,
    "systolic_bp": 125.23,
    "diastolic_bp": 84.39,
    "predicted_status": "Normal"
}

# Send data via HTTP POST request
response = requests.post(API_URL, json=payload)

if response.status_code == 200:
    print("Data sent successfully to ThingsBoard!")
else:
    print(f"Failed to send data. Error: {response.text}")
```

Data sent successfully to ThingsBoard!

Patient Condition: Normal

Temperature: 36.5°C

Humidity: 45.0%

Heart Rate: 72 bpm

ECG Amplitude: 0.9 mV

Estimated Systolic BP: 125.23 mmHg

Estimated Diastolic BP: 84.39 mmHg

Predicted Health Status: Normal

1/1 ————— 0s 42ms/step

Patient Condition: At Risk

Temperature: 38.2°C

Humidity: 55.0%

Heart Rate: 95 bpm

ECG Amplitude: 1.3 mV

Estimated Systolic BP: 136.3 mmHg

Estimated Diastolic BP: 90.99 mmHg

Predicted Health Status: At Risk

1/1 ————— 0s 40ms/step

- Home
- Alarms
- Dashboards
- Entities
- Devices
- Assets
- Entity views
- Gateways
- Profiles
- Customers
- Rule chains
- Edge management
- Advanced features
- OTA updates

Health_Monitoring

Health_Monitoring

Realtime - last 5 minutes

Edit mode

Entities

temperature	Humidity	heart_rate	diastolic_bp	systolic_bp	ecg
36.5	40	72	84	125	1

1 - 1 of 1

Temperature 37 °C

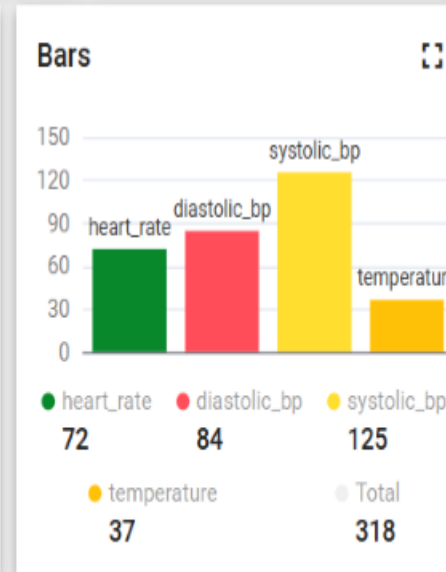
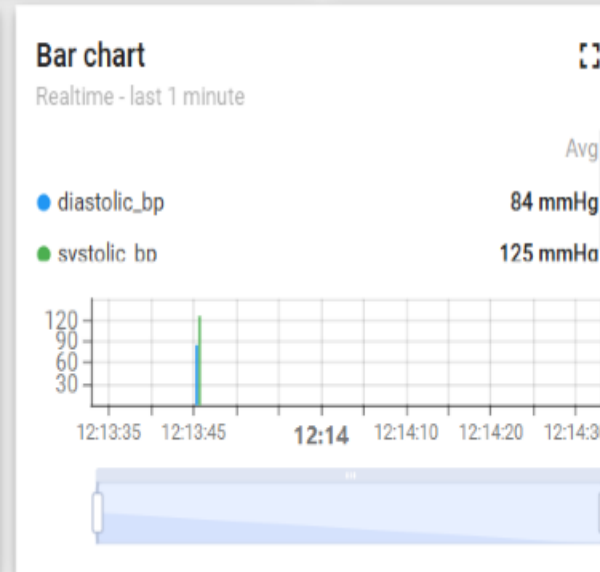
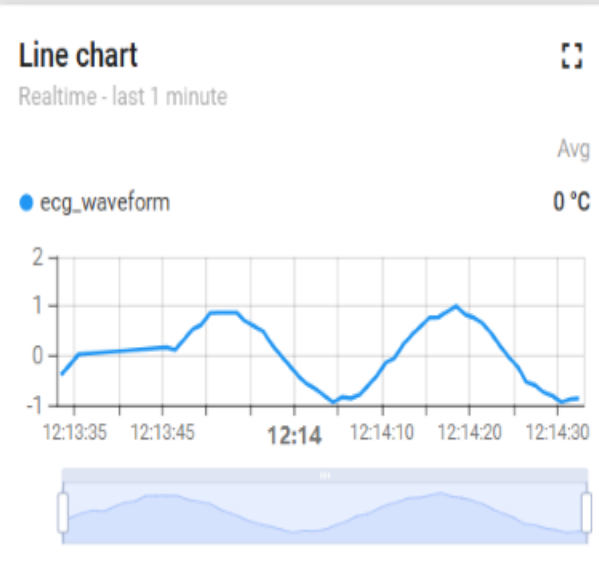
Humidity 40 °C

Alarms

Realtime - last day

diastolic_bp	systolic_bp	heart_rate	Type
No alarms found			

1 - 0 of 0



Unread notification 0

No notifications yet

Predicted Status

Last update just now

Normal

COMPARISON SVM VS RNN+LSTM

SVM

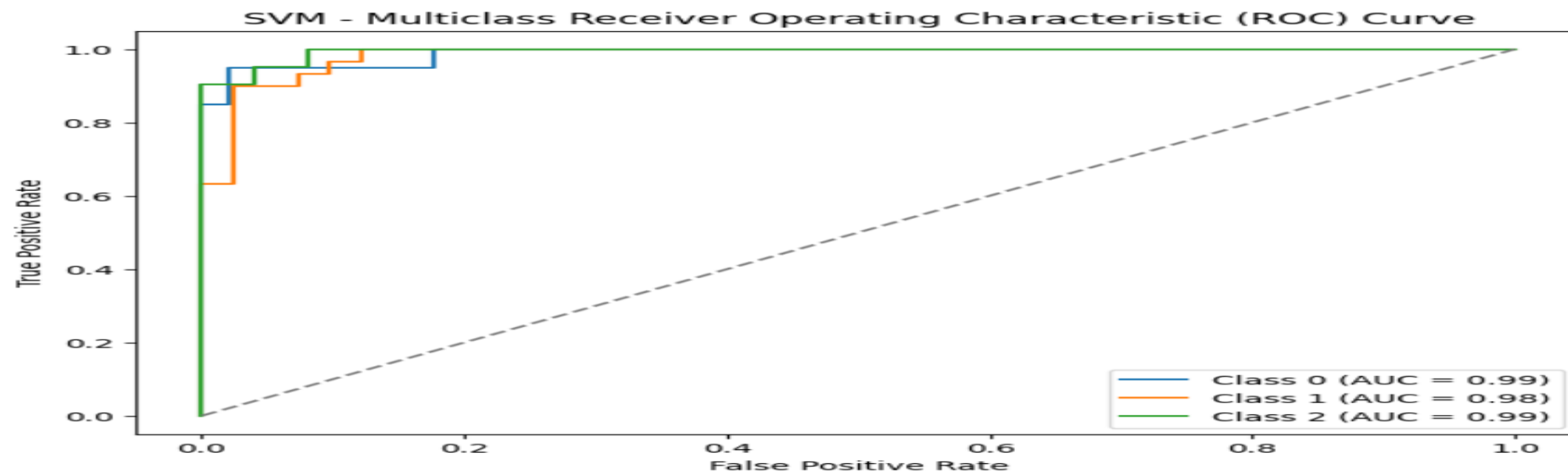
Training Accuracy: 0.9964285714285714

Testing Accuracy: 0.8873239436619719

Best SVM Model: SVC(C=10, gamma=0.1, probability=True)

Classification Report:

	precision	recall	f1-score	support
0	0.90	0.95	0.93	20
1	0.96	0.80	0.87	30
2	0.80	0.95	0.87	21
accuracy			0.89	71
macro avg	0.89	0.90	0.89	71
weighted avg	0.90	0.89	0.89	71

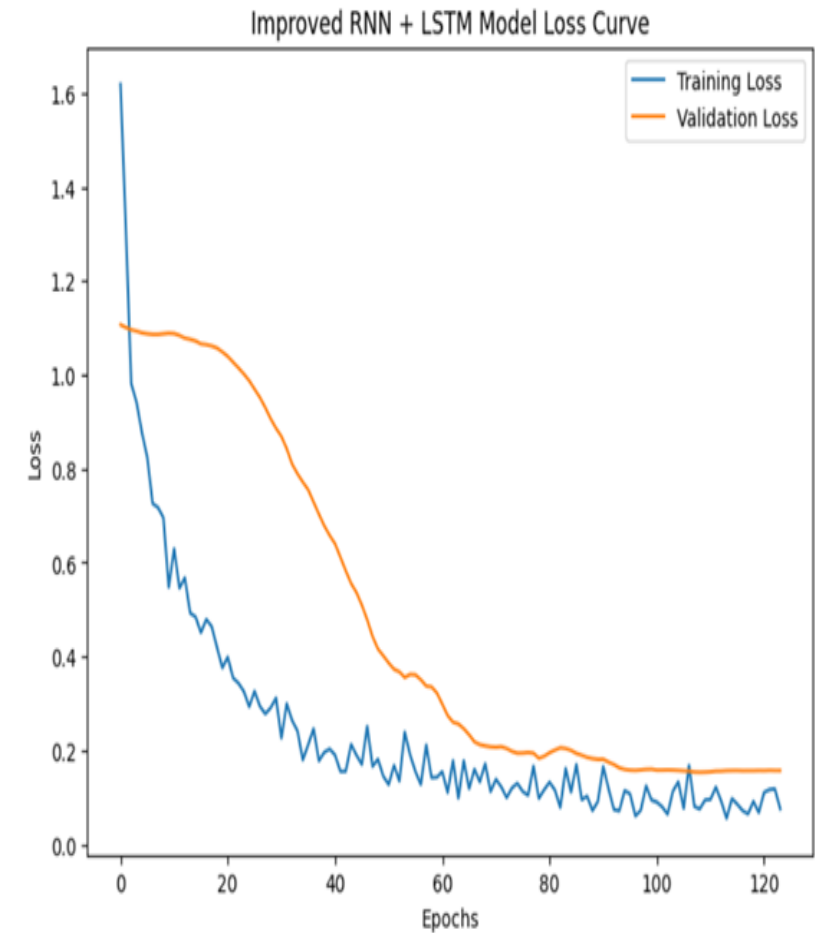
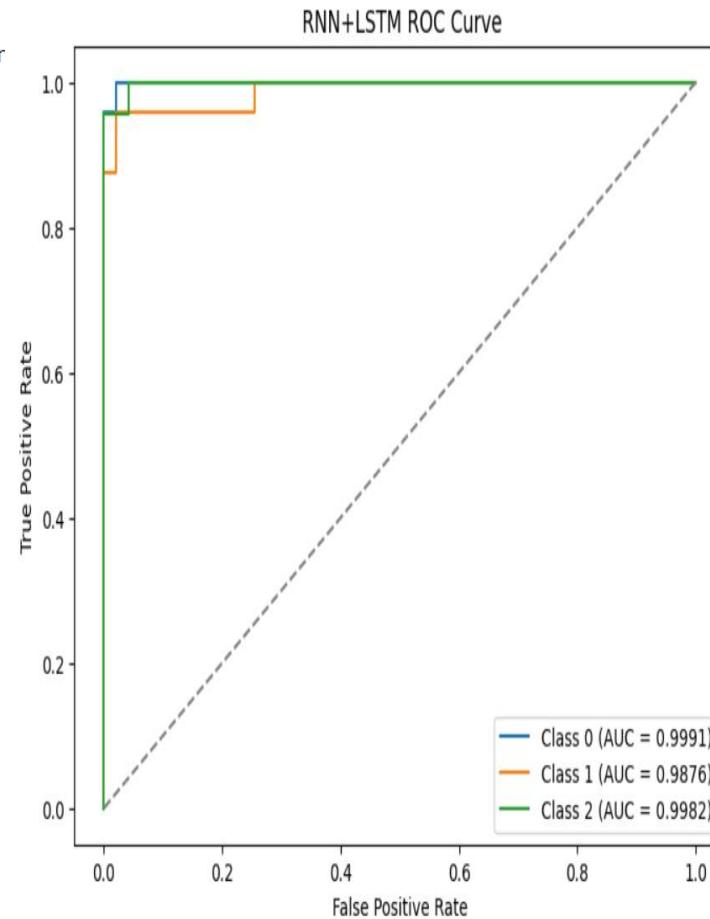
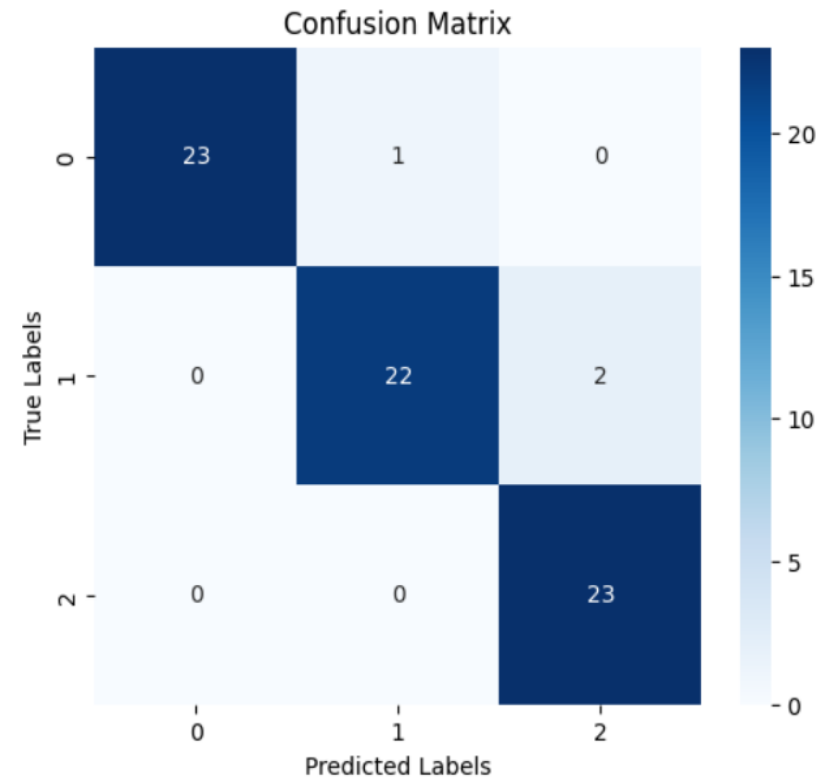


['svm_healthcare_model.pkl']

COMPARISON SVM VS RNN+LSTM

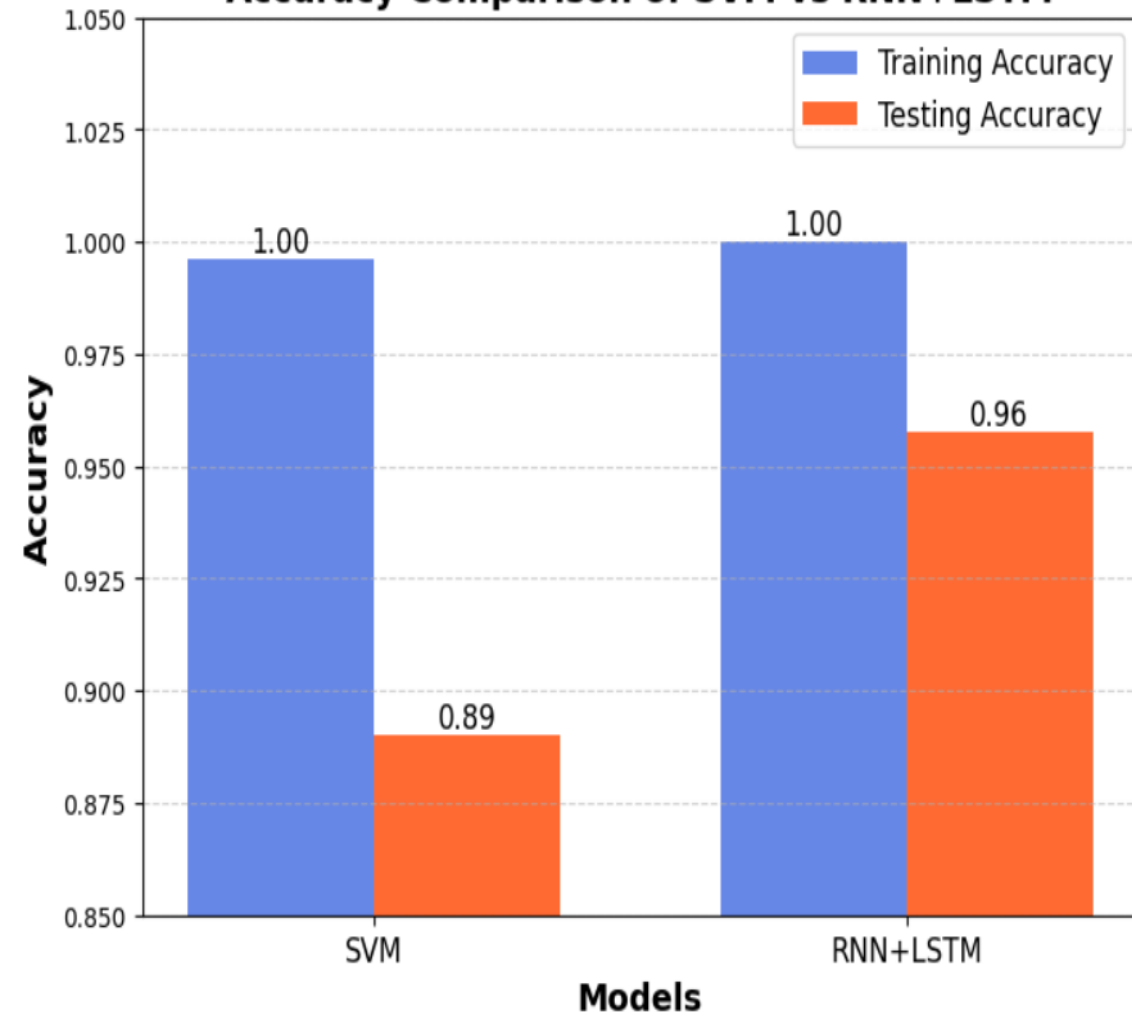
RNN + LSTM

Training Accuracy: 1.0000
Testing Accuracy: 0.9577
/usr/local/lib/python3.11/dist-packages/keras/src/ops/nn.py:907: UserWarning:
warnings.warn(
3/3 ————— 2s 513ms/step

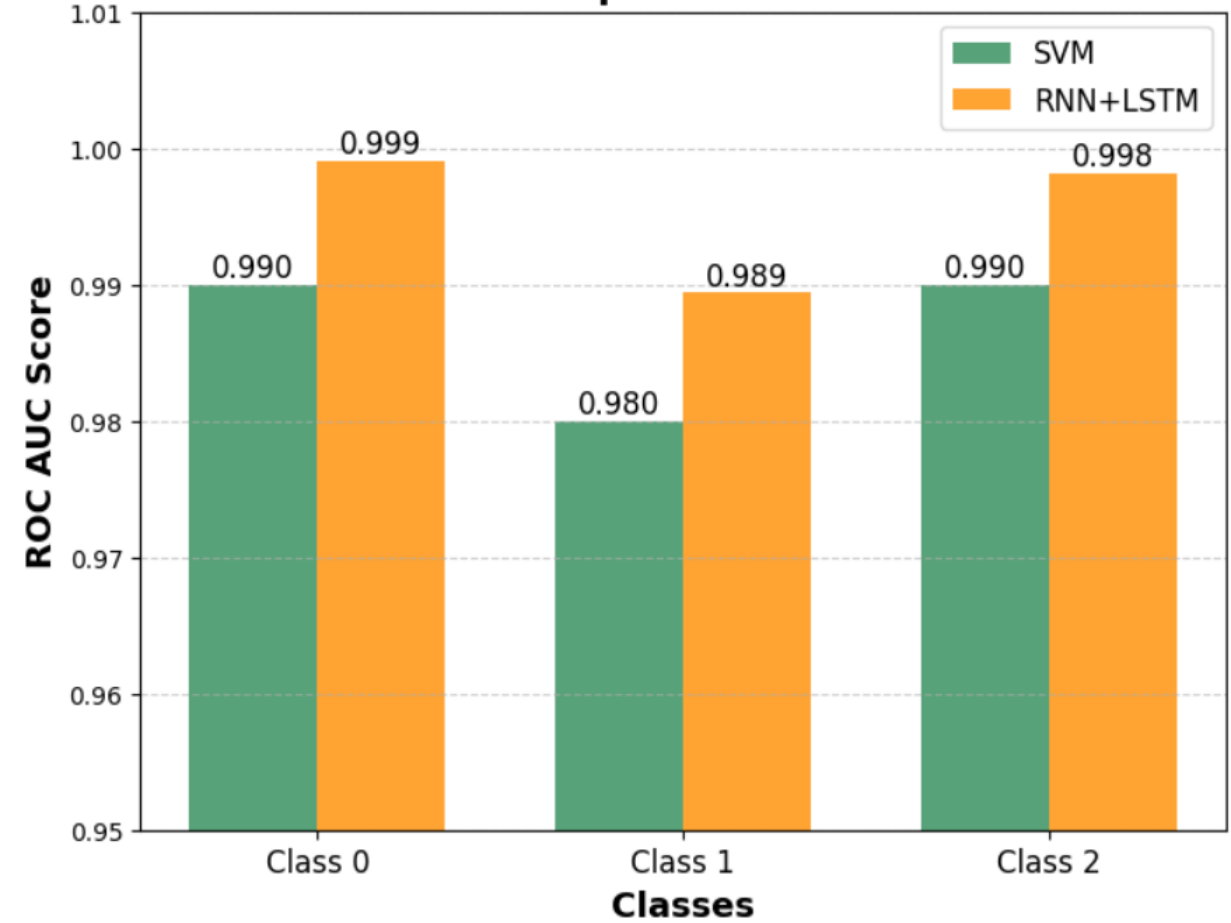


COMPARISON SVM VS RNN+LSTM

Accuracy Comparison of SVM vs RNN+LSTM

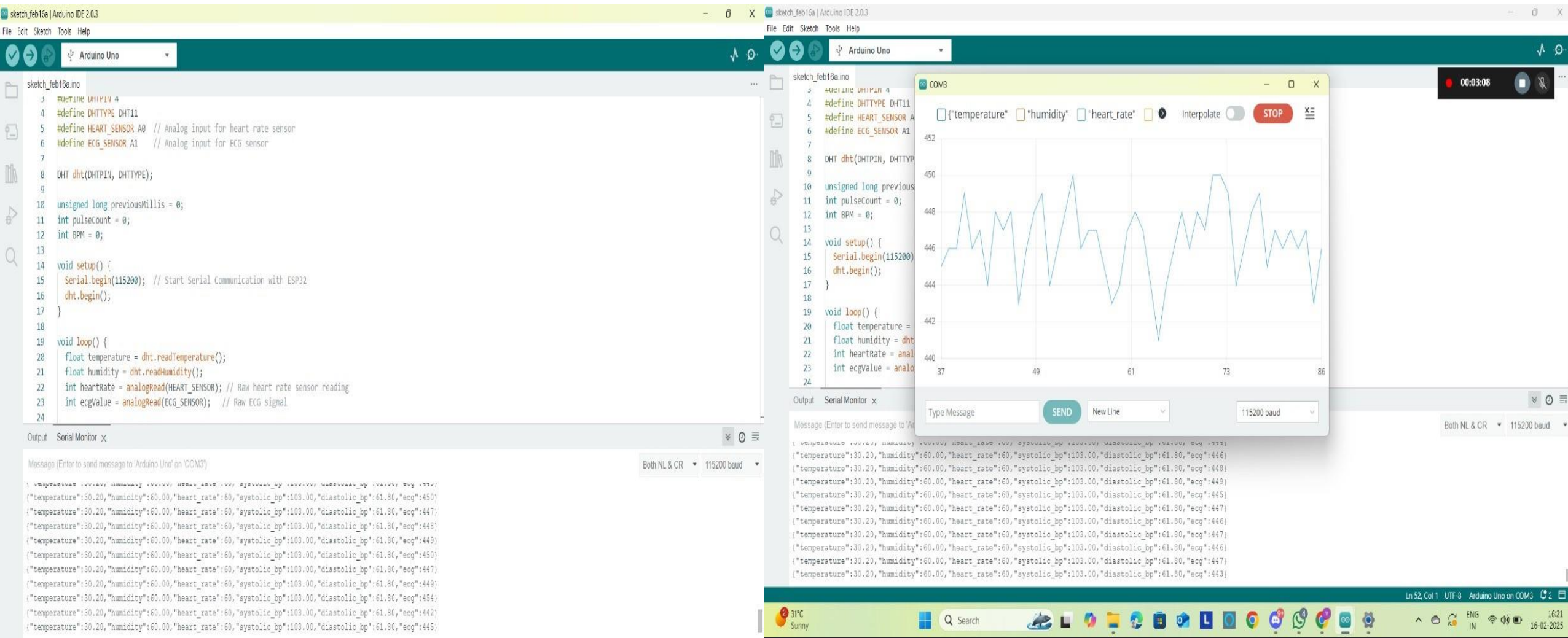


ROC AUC Comparison for Each Class



Best Model for Healthcare System: **RNN+LSTM**

INTEGRATION OF HARDWARE DATA WITH THE THINGSBOARD DASHBOARD





thingsboard_publish.py

C:\Users\verli> Downloads > thingsboard_publish.py > send_data

```
1 import serial
2 import time
3 import paho.mqtt.client as mqtt
4 import json
5
6 THINGSBOARD_HOST = "demo.thingsboard.io"
7 ACCESS_TOKEN = "IwDNmN8XABGIJ2XmmudY"
8 ser = serial.Serial('COM3', 115200, timeout=1)
9 mqtt_client = mqtt.Client()
10 mqtt_client.username_pw_set(ACCESS_TOKEN)
11 mqtt_client.connect(THINGSBOARD_HOST, 1883, 60)
12 mqtt_client.loop_start()
13
14 def send_data():
15     while True:
16         try:
17             if ser.in_waiting > 0:
18                 line = ser.readline().decode('utf-8').strip()
19
20                 if line.startswith("{") and line.endswith("}"):
21                     data = json.loads(line)
22
23                     if "ecg" in data:
24                         ecg_payload = {"ecg": data["ecg"]}
25                         mqtt_client.publish("v1/devices/me/telemetry", json.dumps(ecg_payload))
26                     else:
27                         mqtt_client.publish("v1/devices/me/telemetry", json.dumps(data))
28
29                     print("Published:", data)
30
31                     time.sleep(0.1)
32         except Exception as e:
33             print("Error:", e)
34
35 send_data()
36
```

Command Prompt - python t

```
Published: {'ecg': 451}
Published: {'temperature': 29.8, 'humidity': 67.0, 'heart_rate': 80, 'systolic_bp': 104.0, 'diastolic_bp': 62.4}
Published: {'ecg': 459}
Published: {'ecg': 465}
Published: {'ecg': 465}
Published: {'ecg': 458}
Published: {'ecg': 422}
Published: {'ecg': 451}
Published: {'ecg': 461}
Published: {'ecg': 462}
Published: {'ecg': 450}
Published: {'ecg': 456}
Published: {'ecg': 454}
Published: {'ecg': 418}
Published: {'ecg': 449}
Published: {'ecg': 465}
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Published: {'ecg': 452}
Published: {'ecg': 467}
Published: {'ecg': 468}
Published: {'ecg': 415}
Published: {'ecg': 452}
Published: {'ecg': 457}
Published: {'ecg': 465}
Published: {'ecg': 446}
Published: {'temperature': 29.8, 'humidity': 67.0, 'heart_rate': 80, 'systolic_bp': 104.0, 'diastolic_bp': 62.4}
```


Entities



temperature Humidity heart_rate diastolic_bp systolic_bp ecg

32.4 77 68 62 103 228

Items per page:

10

1 - 1 of 1



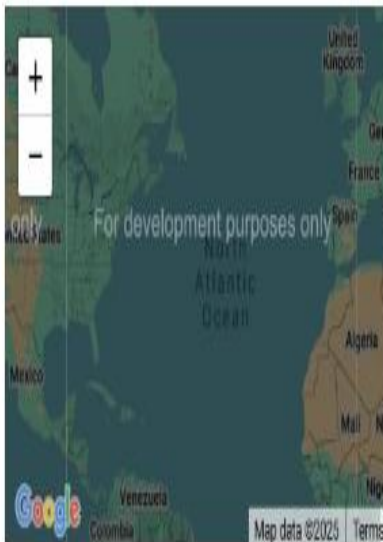
Temperature 32 °C

Humidity 77 g/m³

Predicted Status
Last update 1M ago

Normal

Google Map



Unread notification 99+



Health alert

17 min

Alert! Patient's health condition is abnormal. Please take immediate action.

Rate limits exceeded

47 min

Rate limits for transport messages per device exceeded for 'Health monitorinn'

Health_Monitoring

Health_Monitoring

Realtime - last 5 minutes

Edit mode

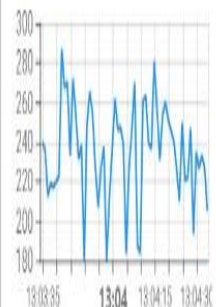


Line chart

Realtime - last 1 minute

Avg

ecg_waveform 235 mV



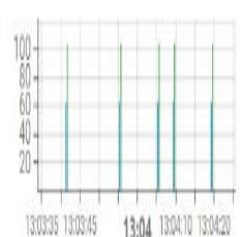
Bar chart

Realtime - last 1 minute

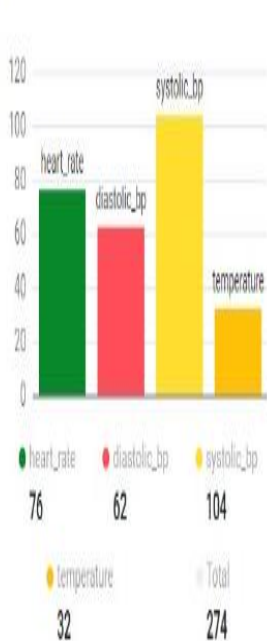
Avg

diastolic_bp 62 mmHg

systolic_bp 104 mmHg



Bars



Unread notification 99+



New alarm 'Critical Temperature'

4 min

Severity: critical, originator: Device 'Health_monitoring'



Critical

Device was added

1 hr

Device 'heart rate' was added by user verlinkrishna@gmail.com



Alarms

Realtime - last day



Created time ↓

Originator

Type

Severity

Status

Assignee



2025-03-20 12:57:29

Health_monitoring

Critical Temperature

Critical

Active Unacknowledged



Unassigned




...

✓


X

NOTIFICATION:


 Notifications Mark all as read

Unread


All


 **Health alert** now




Alert! Patient's health condition is abnormal. Please take immediate action.



Health alert - Health monitoring system Inbox



 ThingsBoard De... 13:55
to me ▾

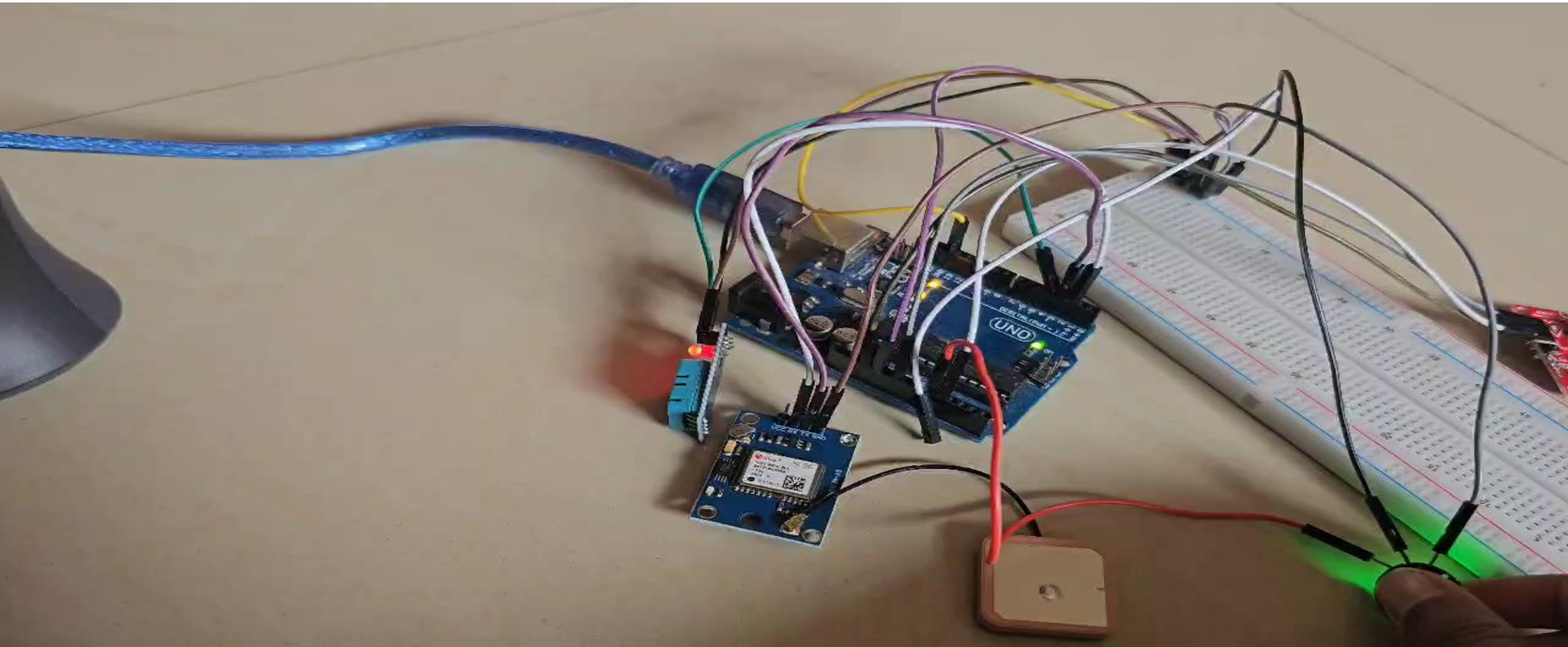
  

Dear Recipient ;

Alert! Patient's health condition is abnormal. Please take immediate action.

RESULT:

HARDWARE SIMULATION VIDEO:



CONCLUSION

The Adaptive IoT-Enhanced Predictive Healthcare Ecosystem successfully addresses critical challenges in current IoT-based healthcare systems, such as **latency, inaccurate anomaly detection, and improves them**. By integrating IoT technologies, advanced machine learning models (RNN + LSTM), and explainable AI techniques, the system achieves:

- Real-time monitoring of vital health parameters using IoT-based wearable sensors.
- Improved predictive accuracy for anomaly detection through sequential deep learning models.
- Reduced hospital workload through automated early disease detection and remote monitoring capabilities.
- Enhanced robustness and generalization of predictive models through advanced data preprocessing and hyperparameter tuning
- The results demonstrate a **high accuracy rate (96%)** for disease detection, validating the effectiveness of the **RNN + LSTM** architecture in processing time-series health data. Furthermore, the integration with the **ThingsBoard** dashboard ensures seamless real-time data visualization and anomaly alerts.

REFERENCES

- [1] S. Mohapatra, A. Sahoo, S. Mohanty, and D. Singh, “Iot enabled ubiquitous healthcare system using predictive analytics,” *Procedia Computer Science*, vol. 218, pp. 1581–1590, 2023.
- [2] P. C. Ingale, S. Nandanwar, and K. Buva, “Enhancing patient care and monitoring using ai and iot in healthcare.”
- [3] M. P. Talawar, H. Pant, M. S. Sayyed, M. S. Tamboli, M. N. Shaik, and M. V. Ganesan, “Predictive maintenance in healthcare iot: A machine learning-based approach.”
- [4] M. M. Khan and M. Alkhathami, “Anomaly detection in iot-based healthcare: machine learning for enhanced security,” *Scientific Reports*, vol. 14, no. 1, p. 5872, 2024.
- [5] M. M. Islam, “Exploring the impact of artificial intelligence in health care,” *Journal of Artificial Intelligence General science (JAIGS)* ISSN: 3006-4023, vol. 2, no. 1, pp. 228–238, 2024.

- [6] S. Shukla, “Real-time monitoring and predictive analytics in healthcare: harnessing the power of data streaming,” *International Journal of Computer Applications*, vol. 185, no. 8, pp. 32–37, 2023.
- [7] B. Paneru, B. Paneru, S. C. Sapkota, and R. Poudyal, “Enhancing healthcare with ai: Sustainable ai and iot-powered ecosystem for patient aid and interpretability analysis using shap,” *Measurement: Sensors*, vol. 36, p. 101305, 2024.
- [8] A. Rahman, T. Debnath, D. Kundu, M. S. I. Khan, A. A. Aishi, S. Sazzad, M. Sayduzzaman, and S. S. Band, “Machine learning and deep learning-based approach in smart healthcare: Recent advances, applications, challenges and opportunities,” *AIMS Public Health*, vol. 11, no. 1, p. 58, 2024.
- [9] S. K. Puli and P. Usha, “Transforming healthcare: Advancements, applications, and future directions of machine learning,” in *2024 10th International Conference on Smart Computing and Communication (ICSCC)*. IEEE, 2024, pp. 502–506.
- [10] N. O. Salim and A. M. Abdulazeez, “Human diseases detection based on machine learning algorithms: A review,” *International Journal of Science and Business*, vol. 5, no. 2, pp. 102–113, 2021.