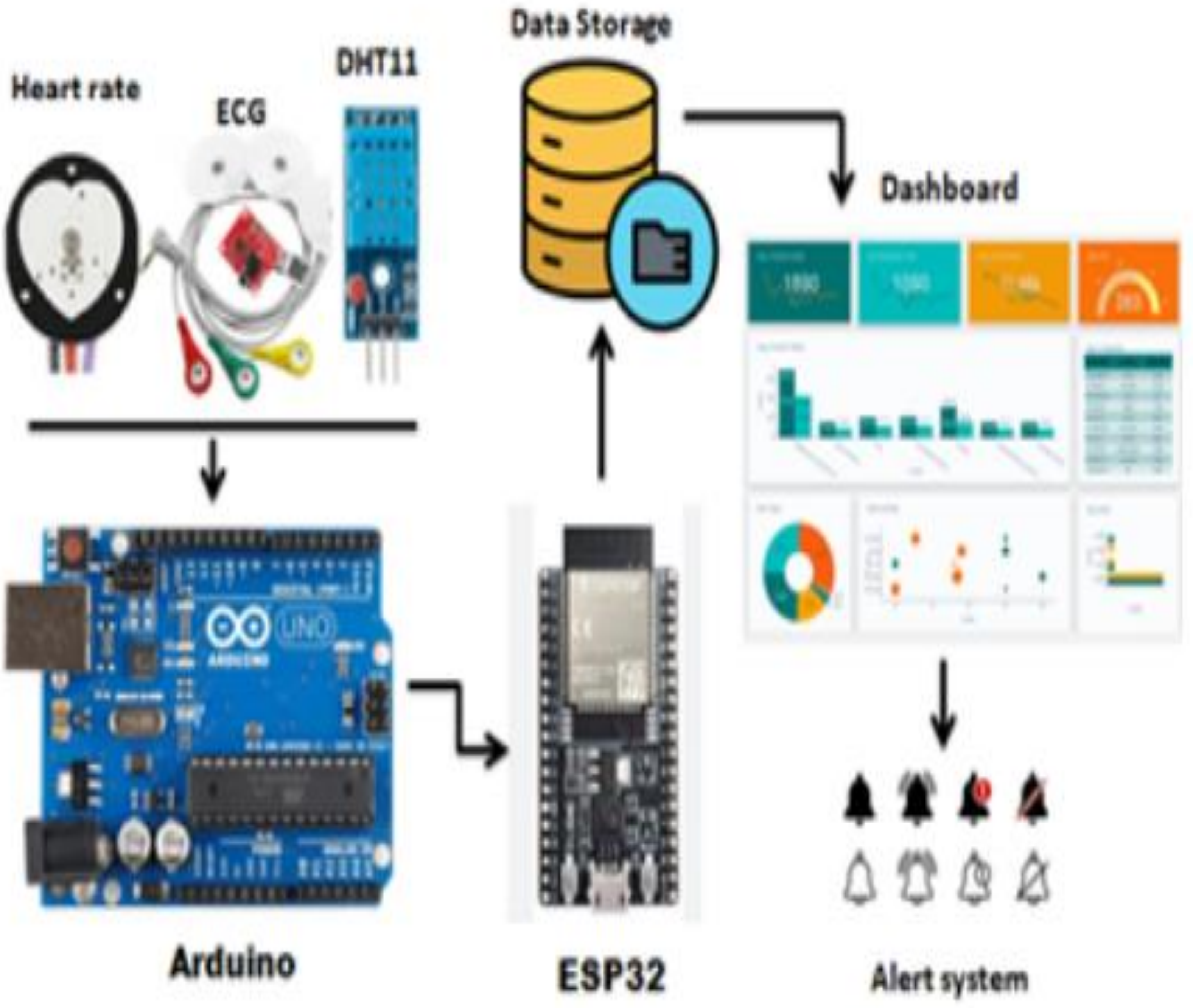
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

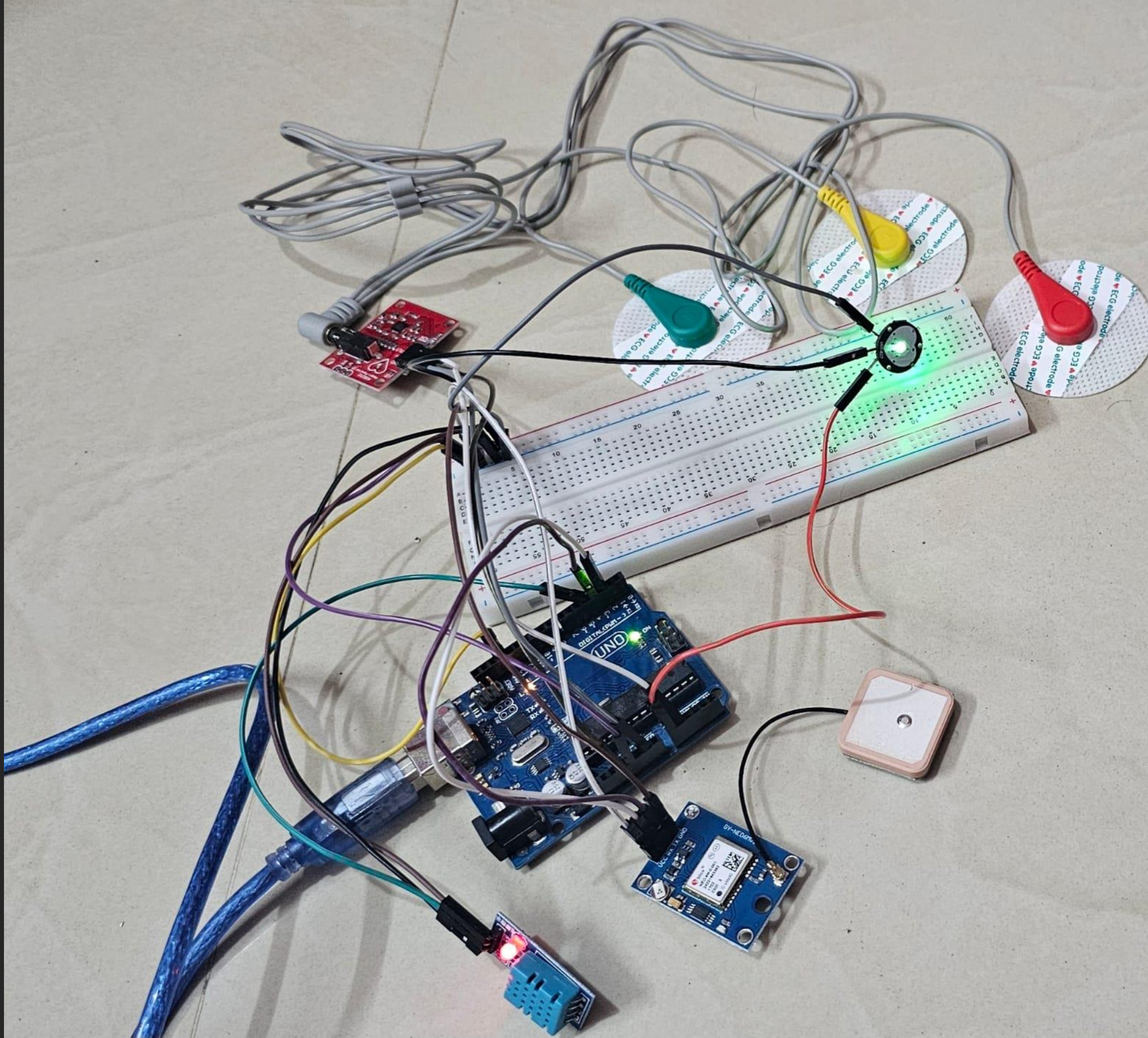
ADAPTIVE IOT-ENHANCED PREDICTIVE HEALTHCARE ECOSYSTEM

DONE BY : J Verlin Krisha

PROPOSED SYSTEM DIAGRAM:



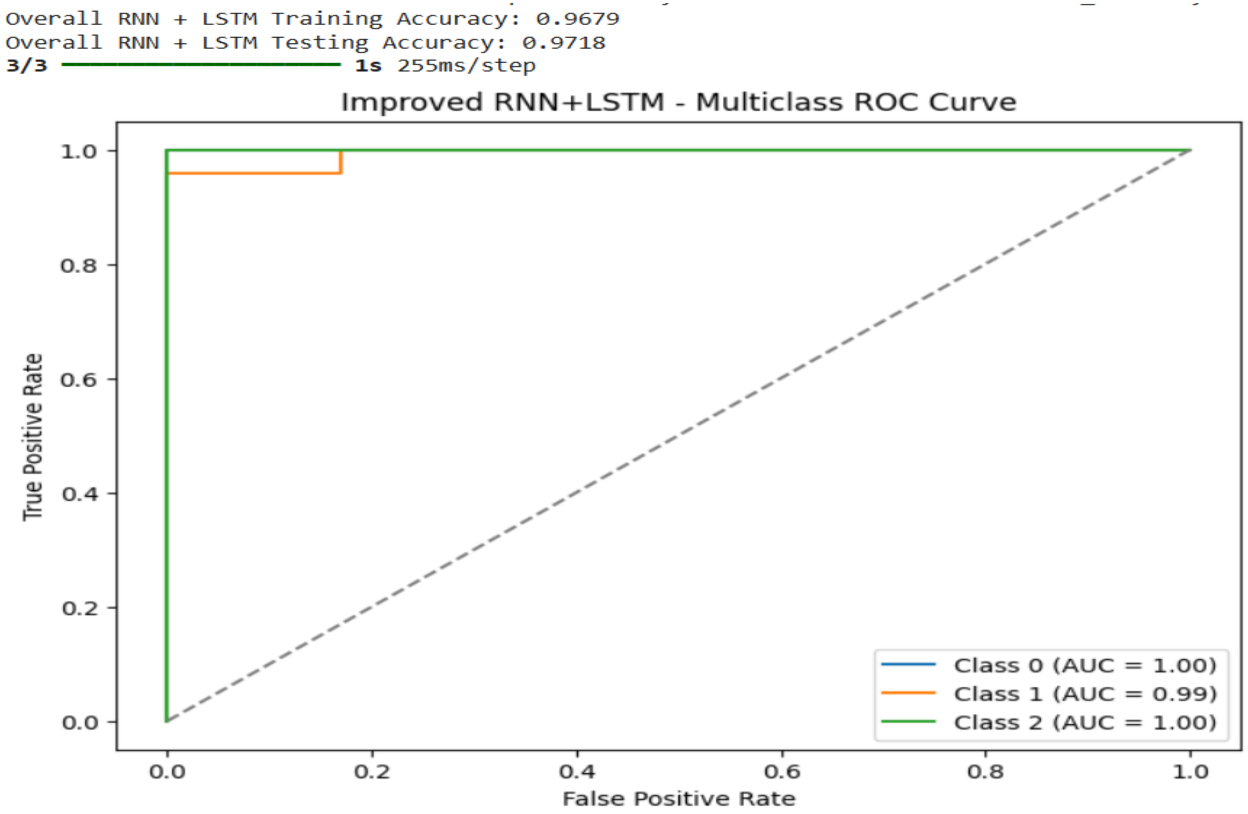
HARDWARE SIMULATION

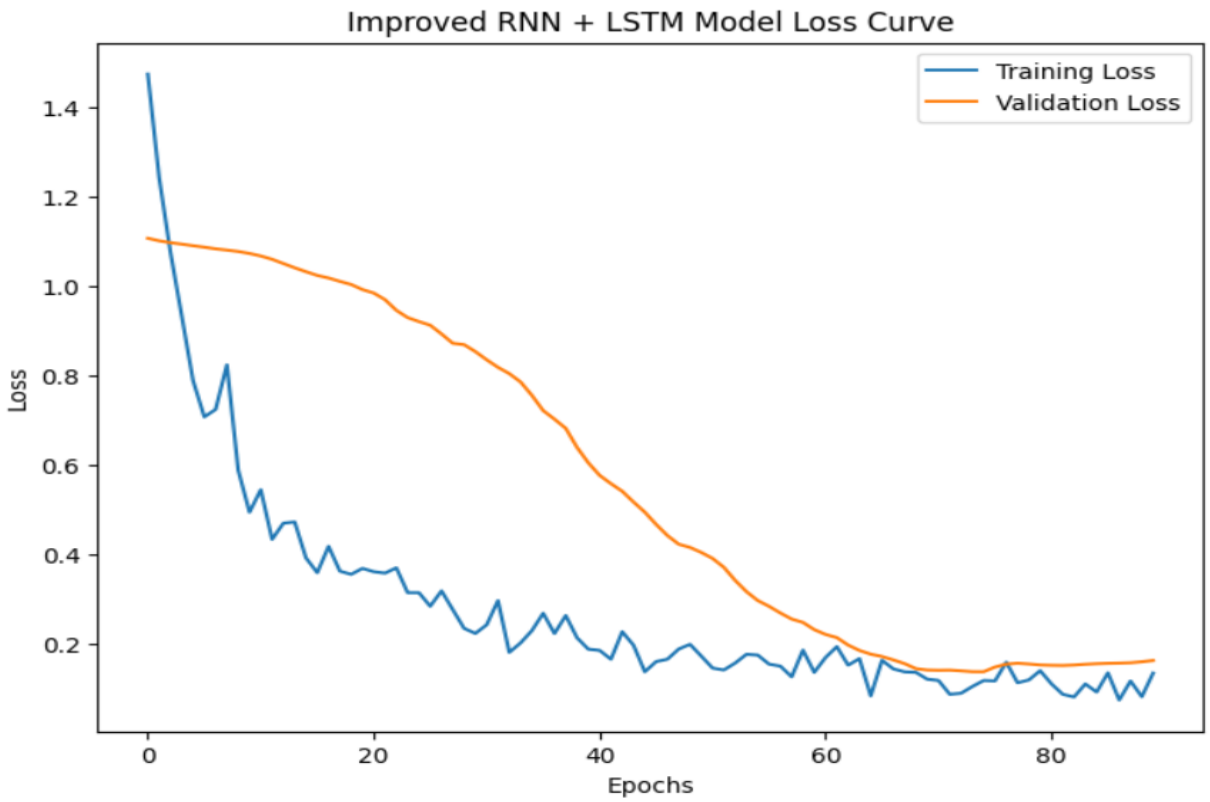


INTEGRATION OF ML MODEL TO THINGSBOARD DASHBOARD

Model used - RNN + LSTM – 97% Accuracy

Epochs – 150



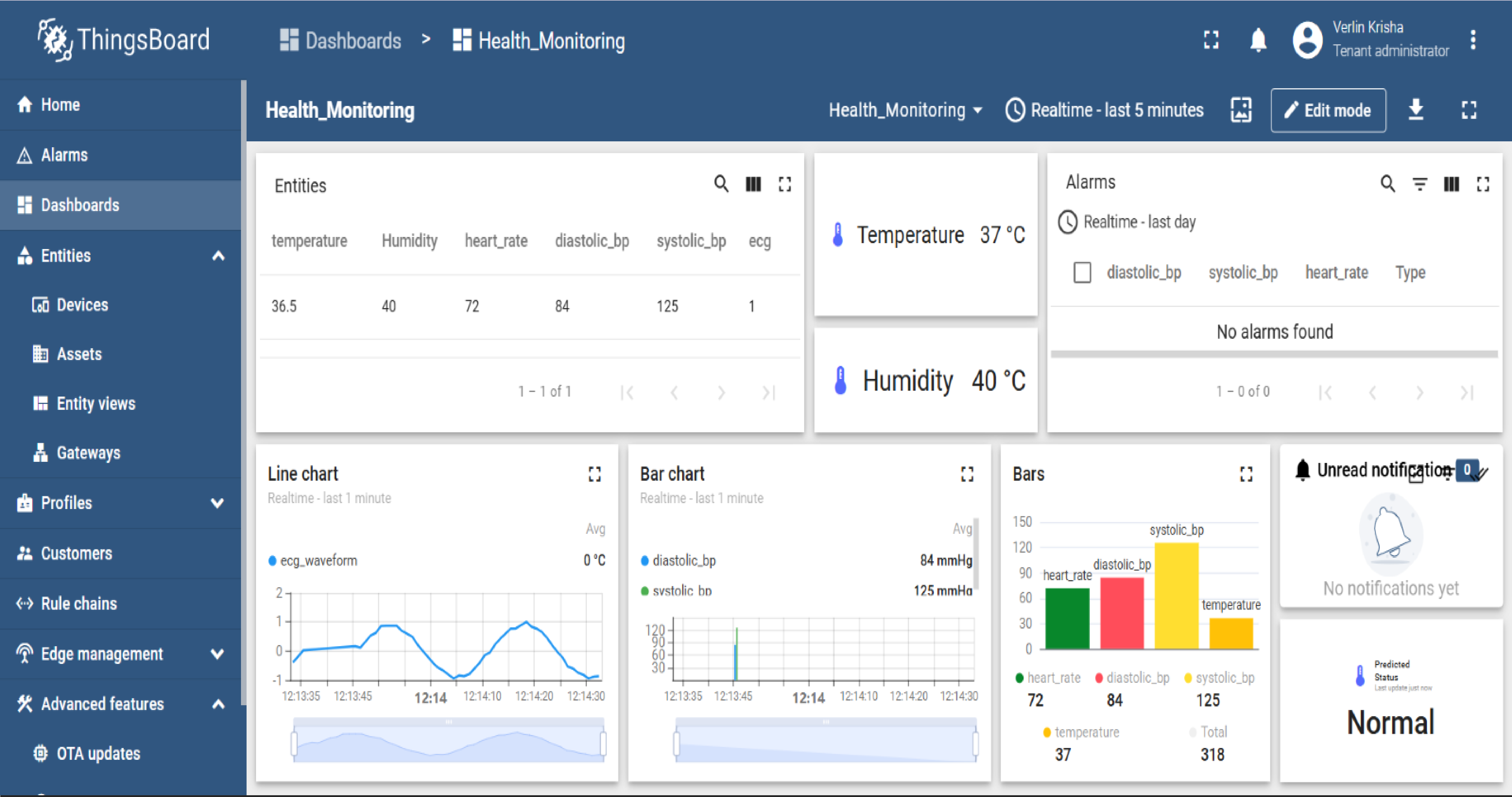


```python
import requests
import json
import time

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
```

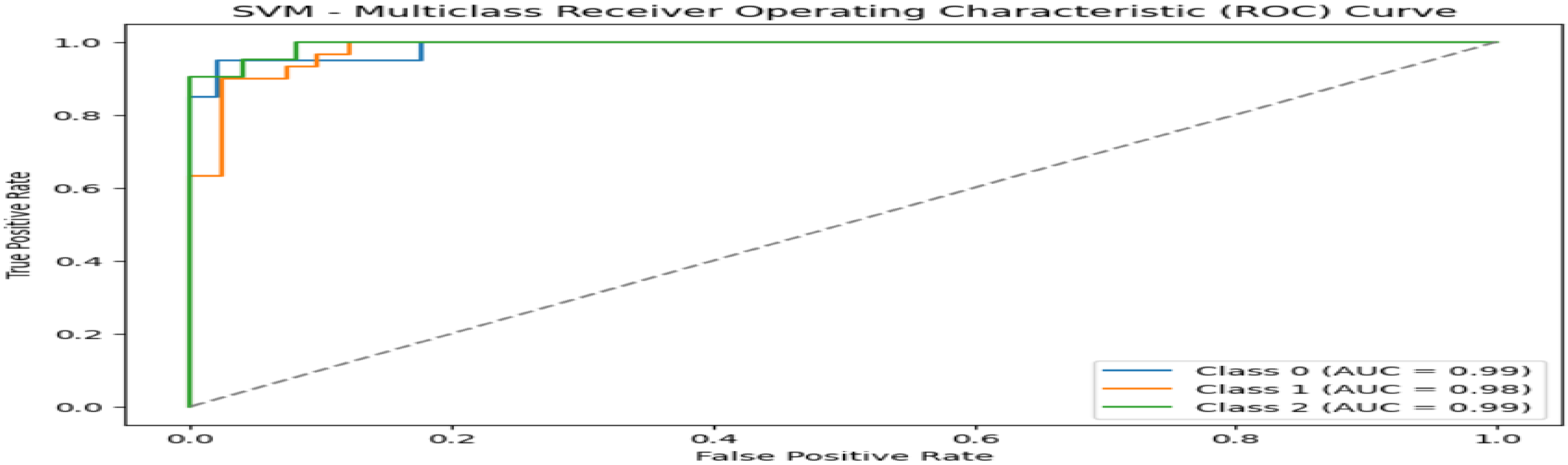
```
Patient Condition: At Risk
 Temperature: 38.2°C
 Humidity: 55.0%
 Heart Rate: 95 bpm
 ECG Amplitude: 1.3 mV
 Estimated Systolic BP: 136.3 mmHg
 Estimated Diastolic BP: 90.99 mmHg
 Predicted Health Status: At Risk
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 40ms/step
```


ThingsBoard
Dashboards > Health_Monitoring
Verlin Krisha
Tenant administrator
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
Line chart
Realtime - last 1 minute
Avg
ecg_waveform 0 °C
12:13:35 12:13:45 12:14 12:14:10 12:14:20 12:14:30
Bar chart
Realtime - last 1 minute
Avg
diastolic_bp 84 mmHg
systolic_bp 125 mmHg
12:13:35 12:13:45 12:14 12:14:10 12:14:20 12:14:30
Bars
heart_rate diastolic_bp systolic_bp temperature
heart_rate 72
diastolic_bp 84
systolic_bp 125
temperature 37
Total 318
Unread notification 0
No notifications yet
Predicted Status
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
```

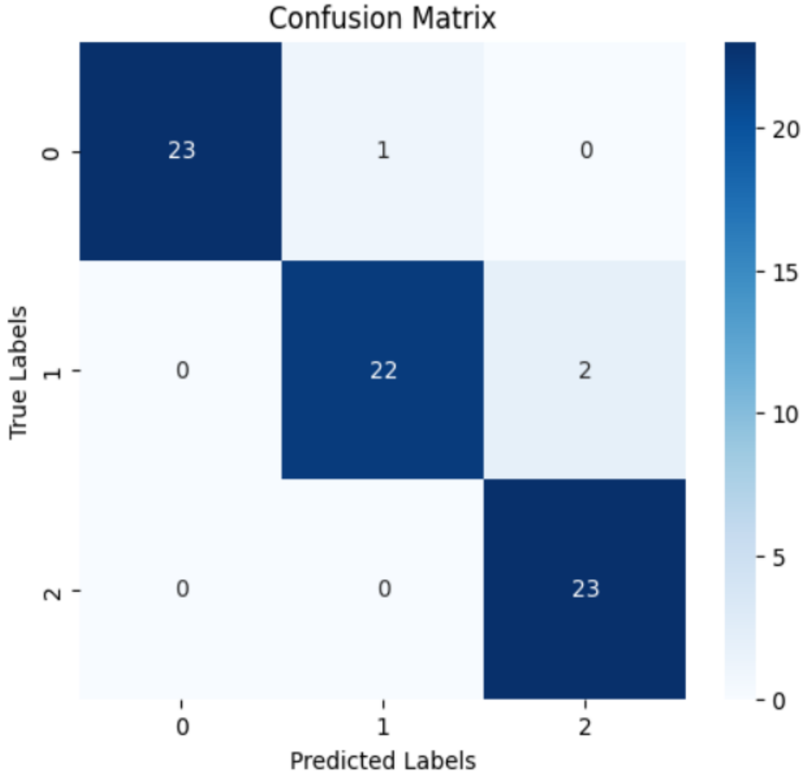


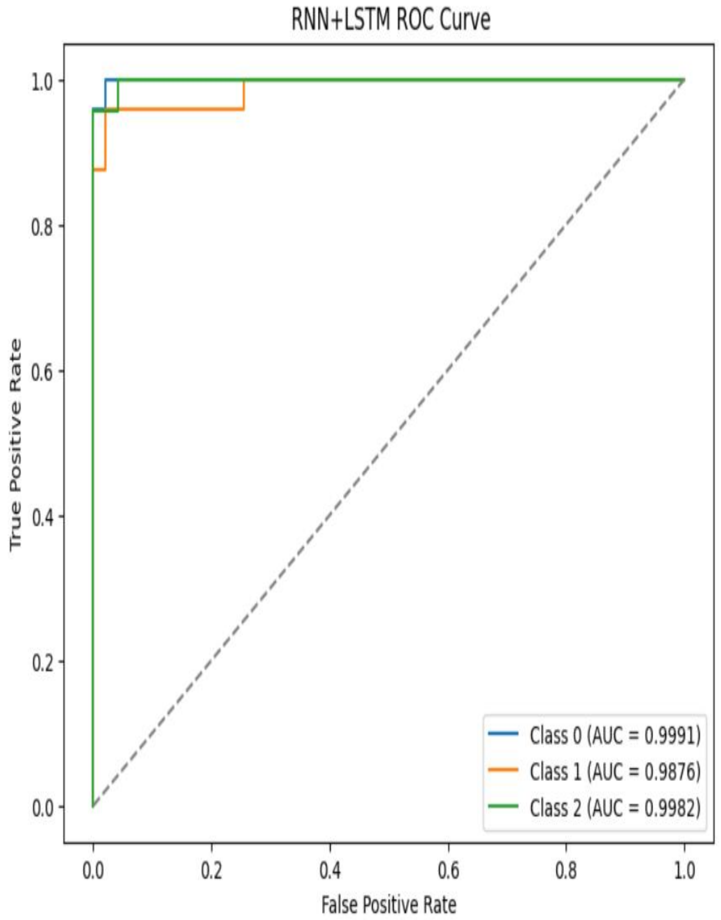

```
['svm_healthcare_model.pkl']
```

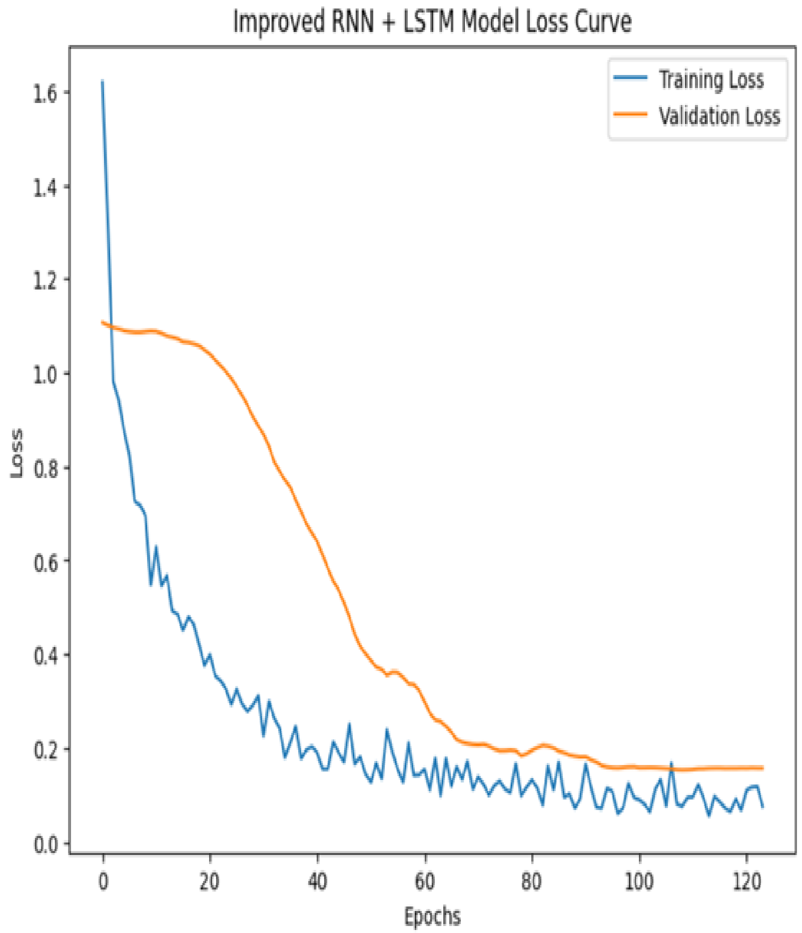
COMPARISON SVM VS RNN+LSTM

RNN + LSTM

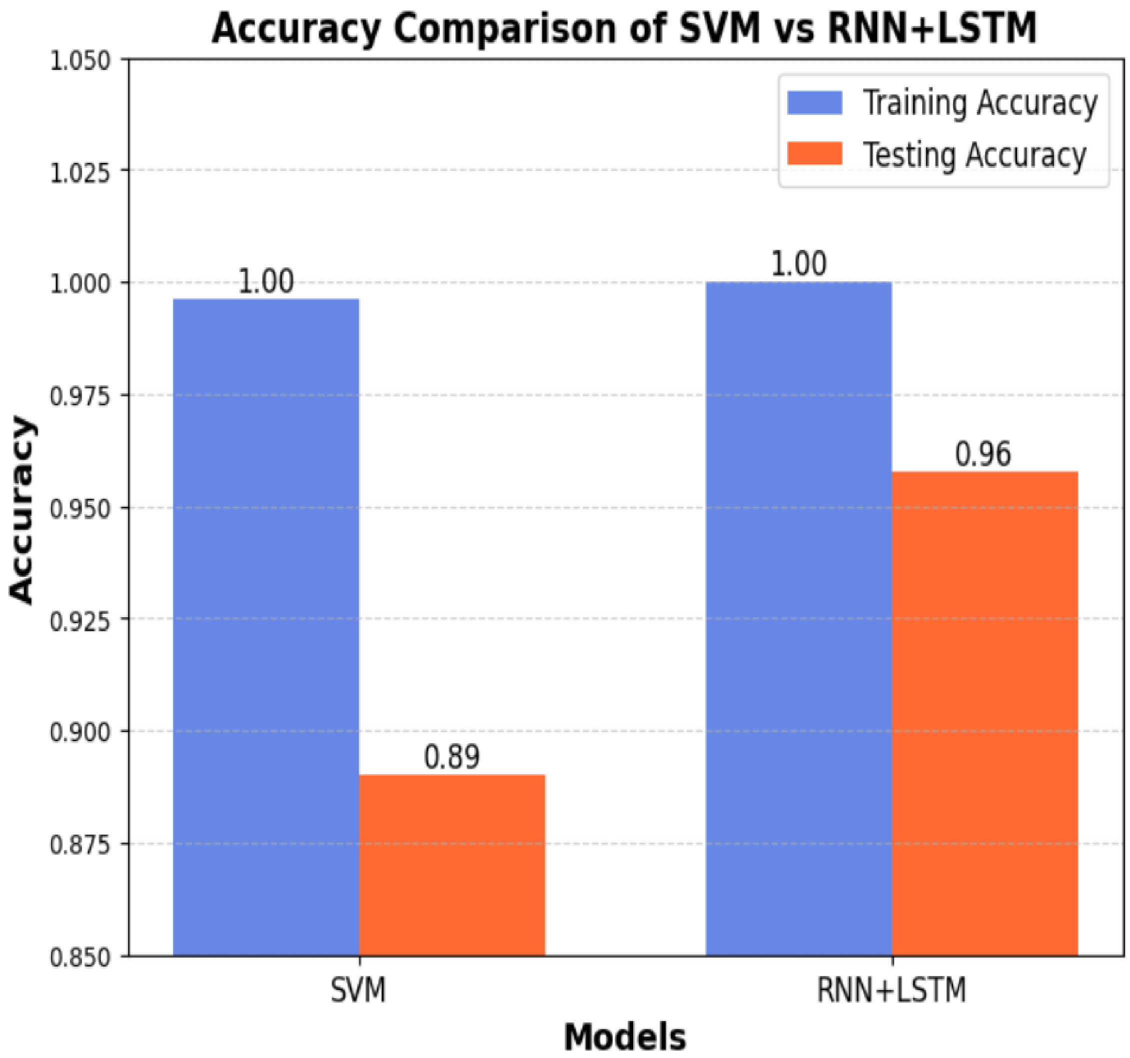
```
Training Accuracy: 1.0000
Testing Accuracy: 0.9577
/usr/local/lib/python3.11/dist-packages/keras/src/ops/nn.py:907: UserWar
  warnings.warn(
3/3 ━━━━━━━━━━━━━━━━━━━━ 2s 513ms/step
```

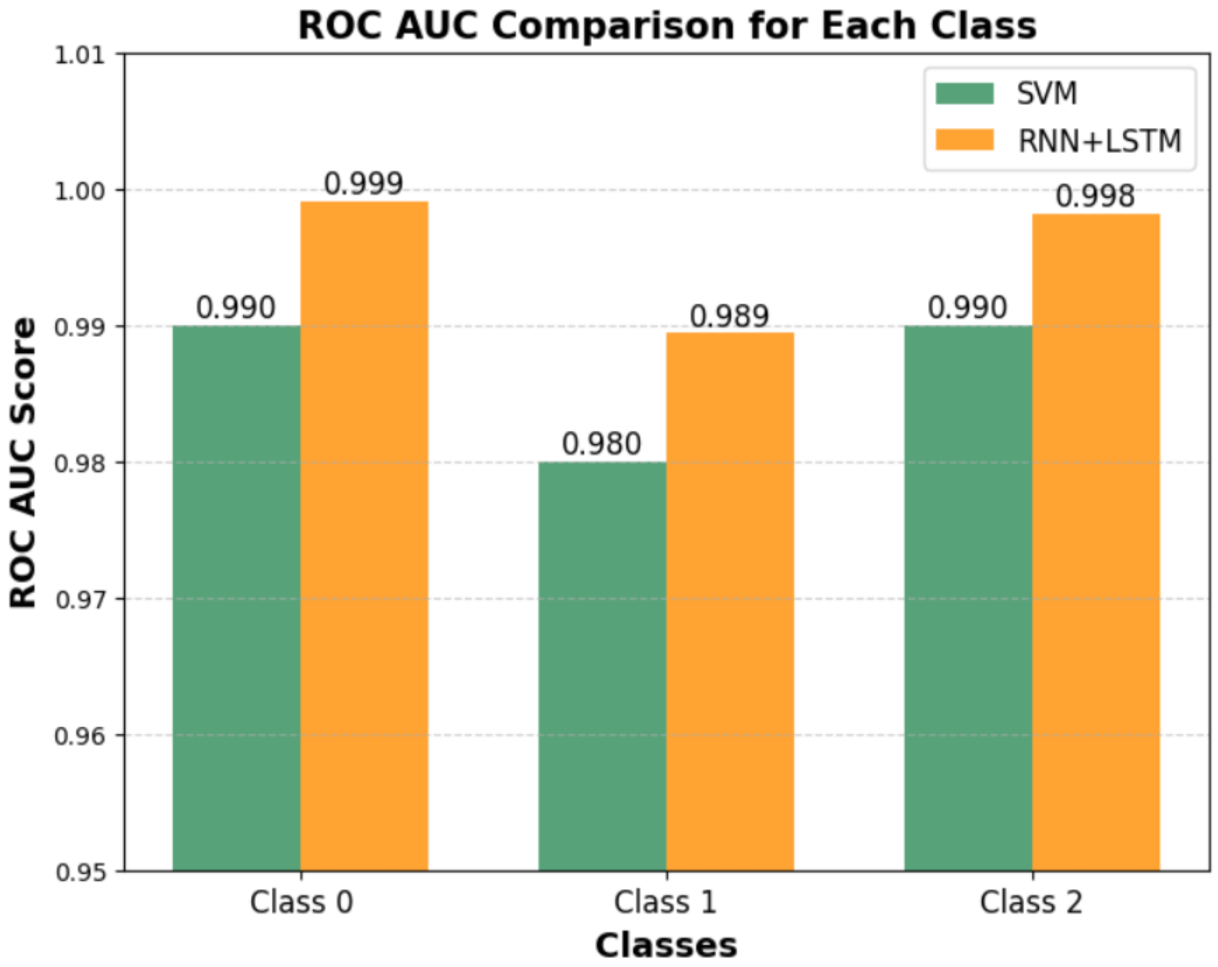






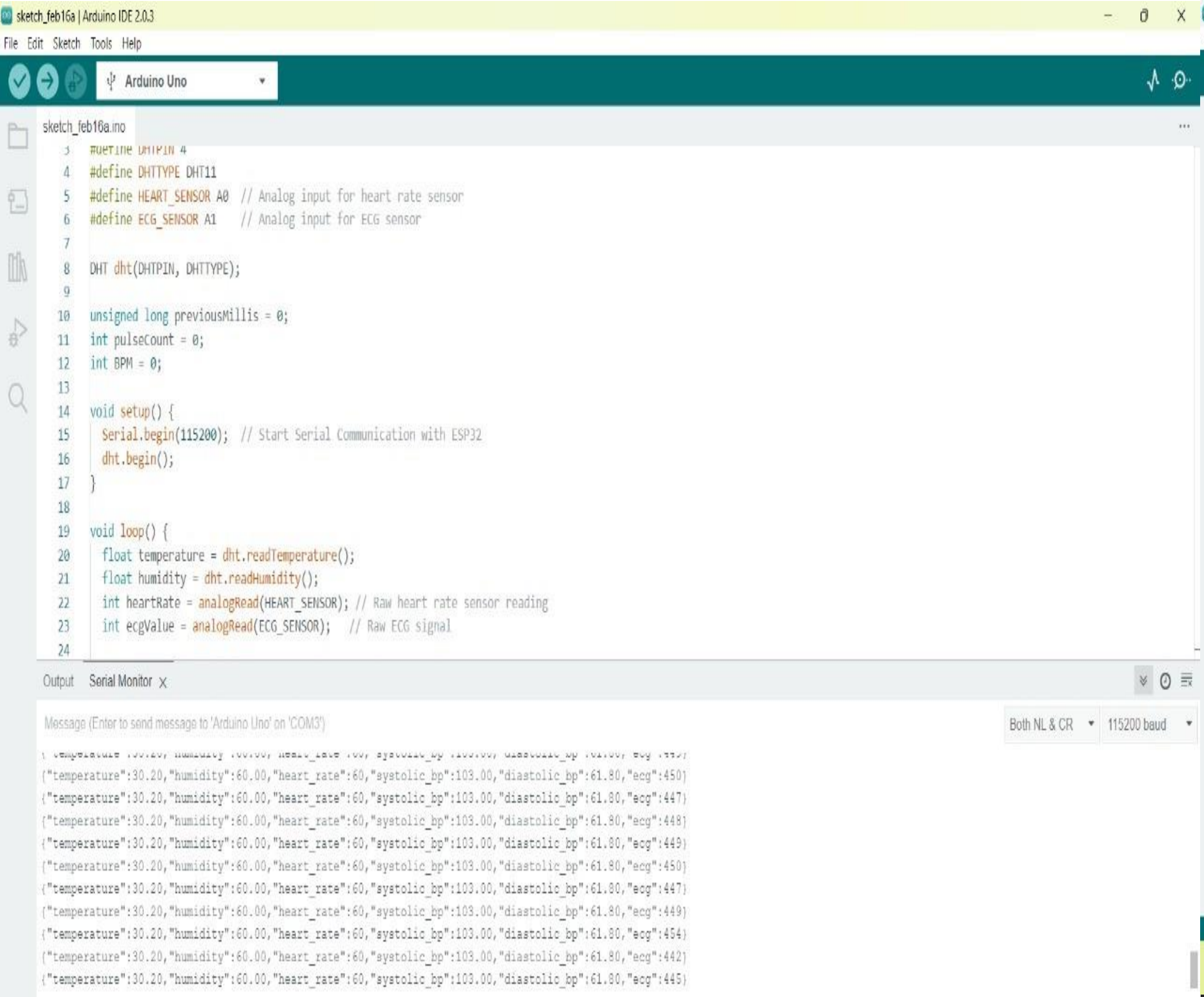
COMPARISON SVM VS RNN+LSTM

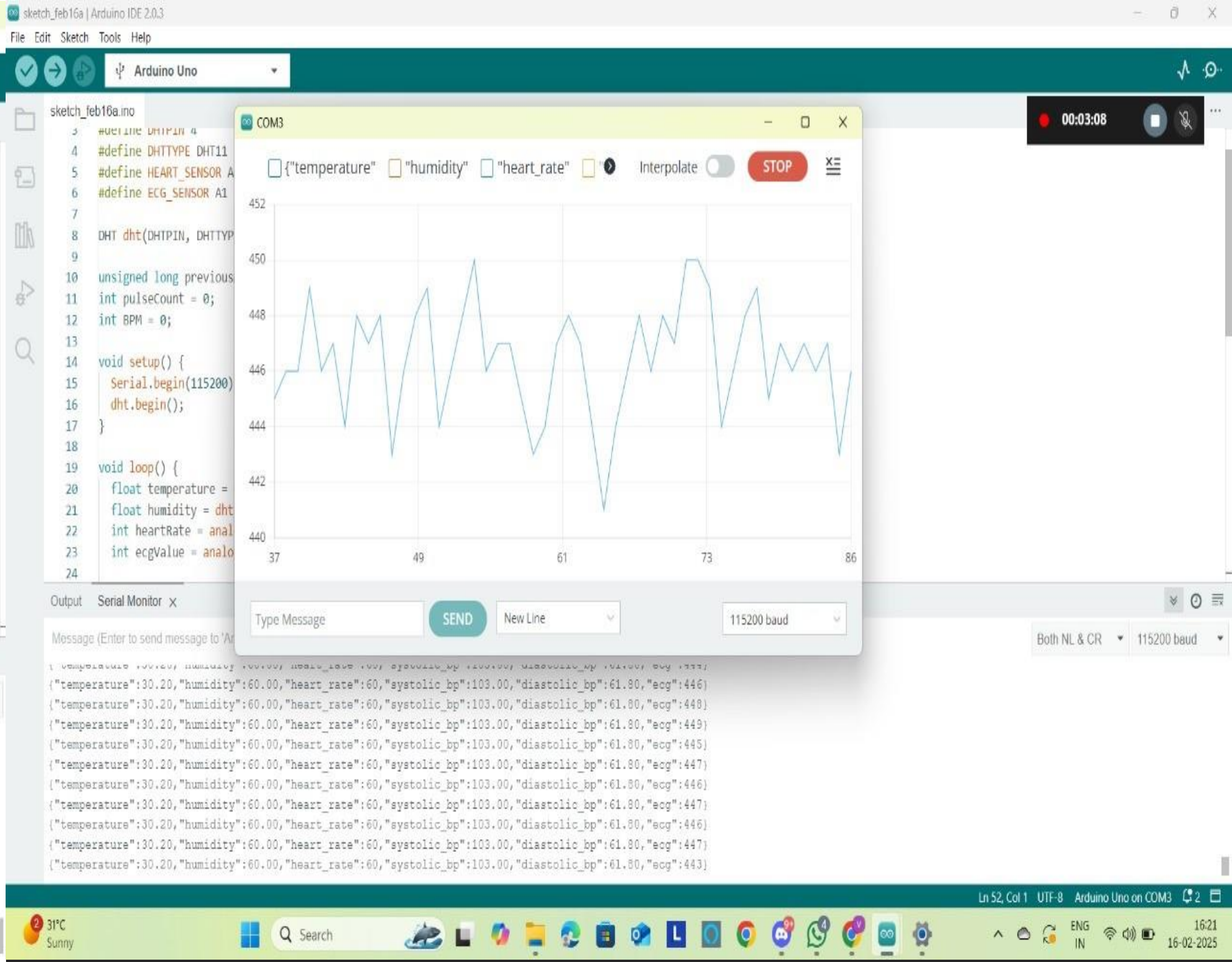




Best Model for Healthcare System: **RNN+LSTM**

INTEGRATION OF HARDWARE DATA WITH THE THINGSBOARD DASHBOARD





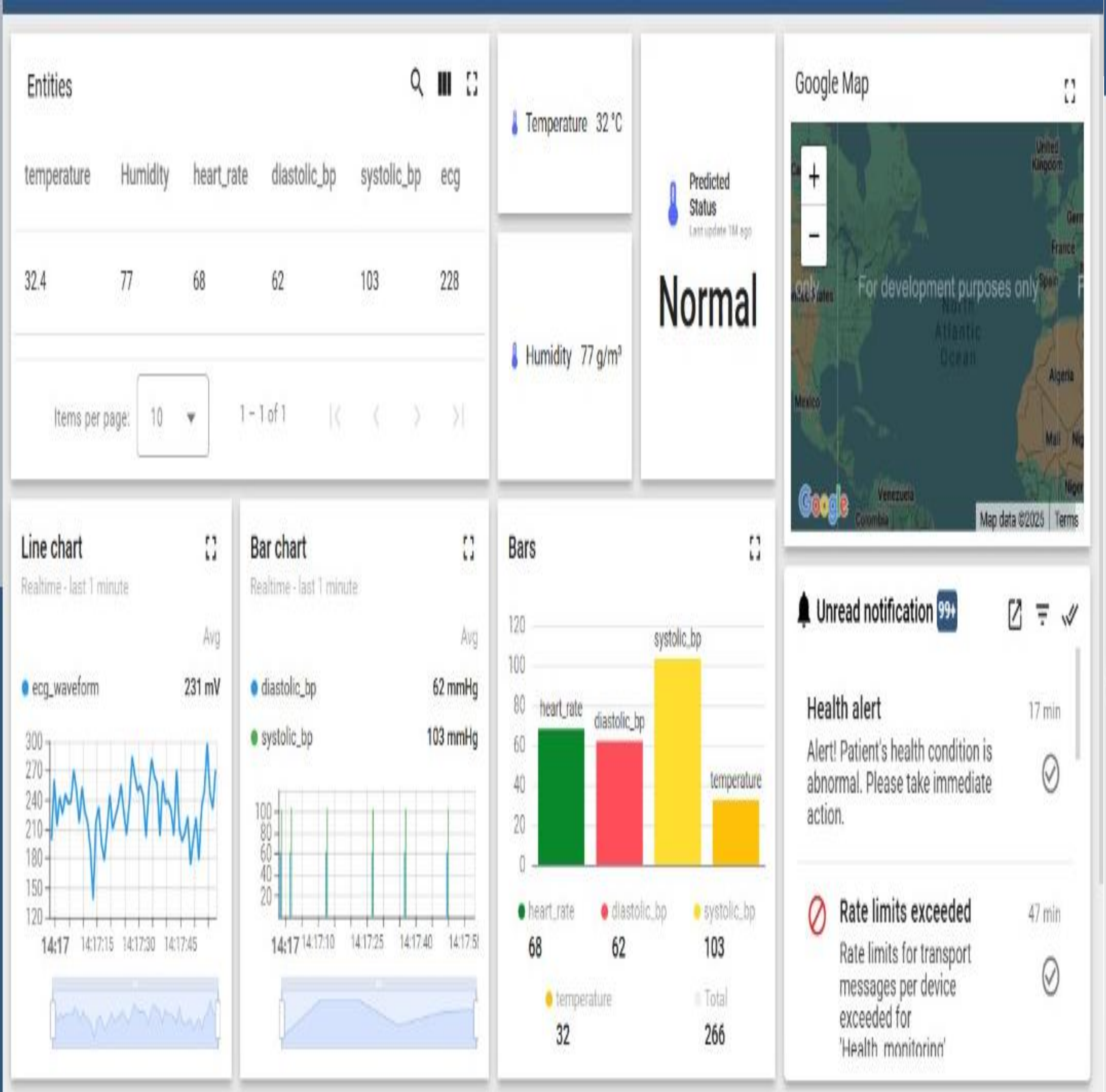
thingsboard_publish.py

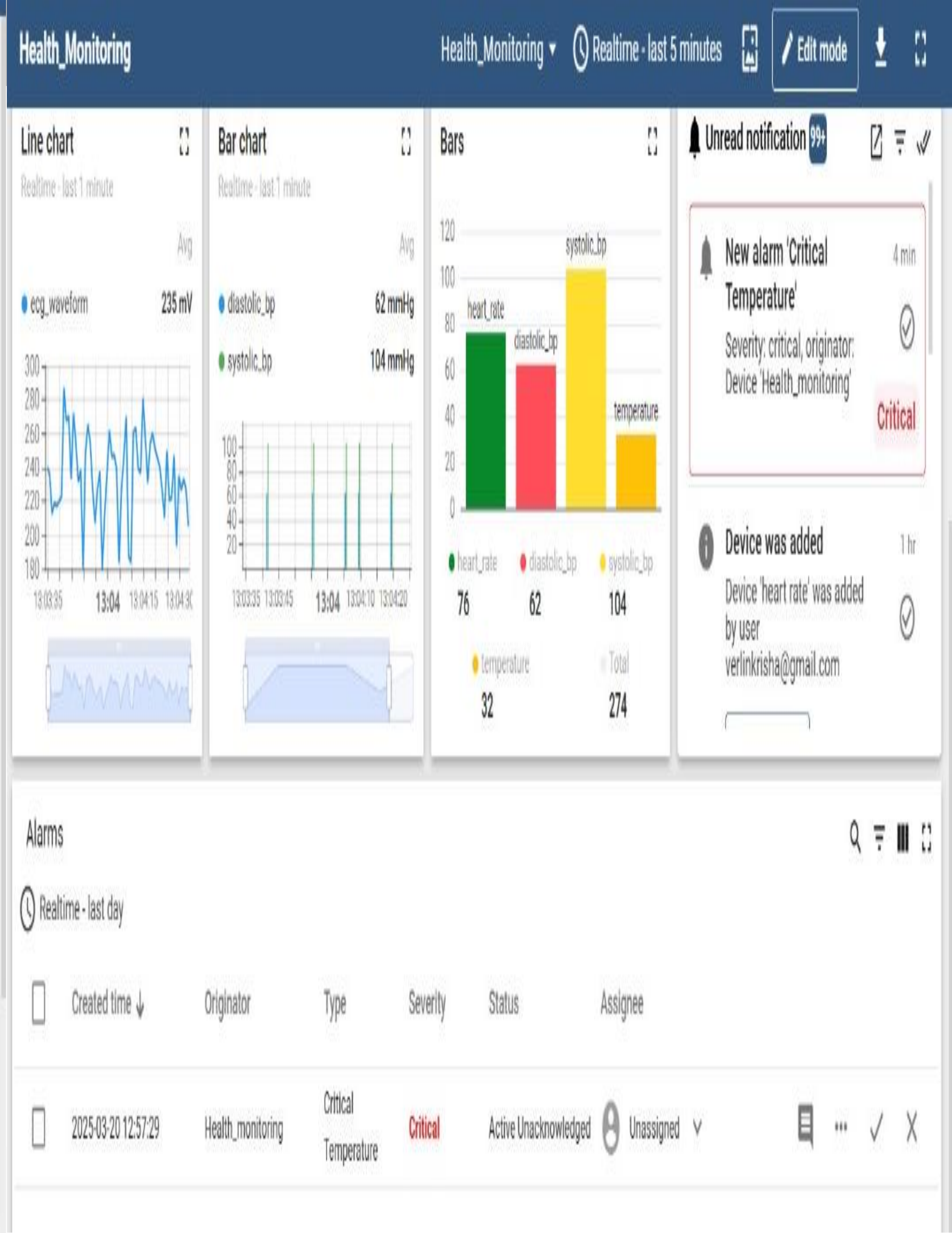
C: > Users > verli > Downloads > thingsboard_publish.py > send_data

```python
import serial
import time
import paho.mqtt.client as mqtt
import json

THINGSBOARD_HOST = "demo.thingsboard.io"
ACCESS_TOKEN = "IwDNmN8XABGIJ2XmmudY"
ser = serial.Serial('COM3', 115200, timeout=1)
mqtt_client = mqtt.Client()
mqtt_client.username_pw_set(ACCESS_TOKEN)
mqtt_client.connect(THINGSBOARD_HOST, 1883, 60)
mqtt_client.loop_start()

def send_data():
    while True:
        try:
            if ser.in_waiting > 0:
                line = ser.readline().decode('utf-8').strip()


                if line.startswith("{") and line.endswith("}"):
                    data = json.loads(line)

                    if "ecg" in data:
                        ecg_payload = {"ecg": data["ecg"]}
                        mqtt_client.publish("v1/devices/me/telemetry", json.dumps(ecg_payload))
                    else:
                        mqtt_client.publish("v1/devices/me/telemetry", json.dumps(data))

                    print("Published:", data)
                time.sleep(0.1)
        except Exception as e:
            print("Error:", e)

send_data()
```

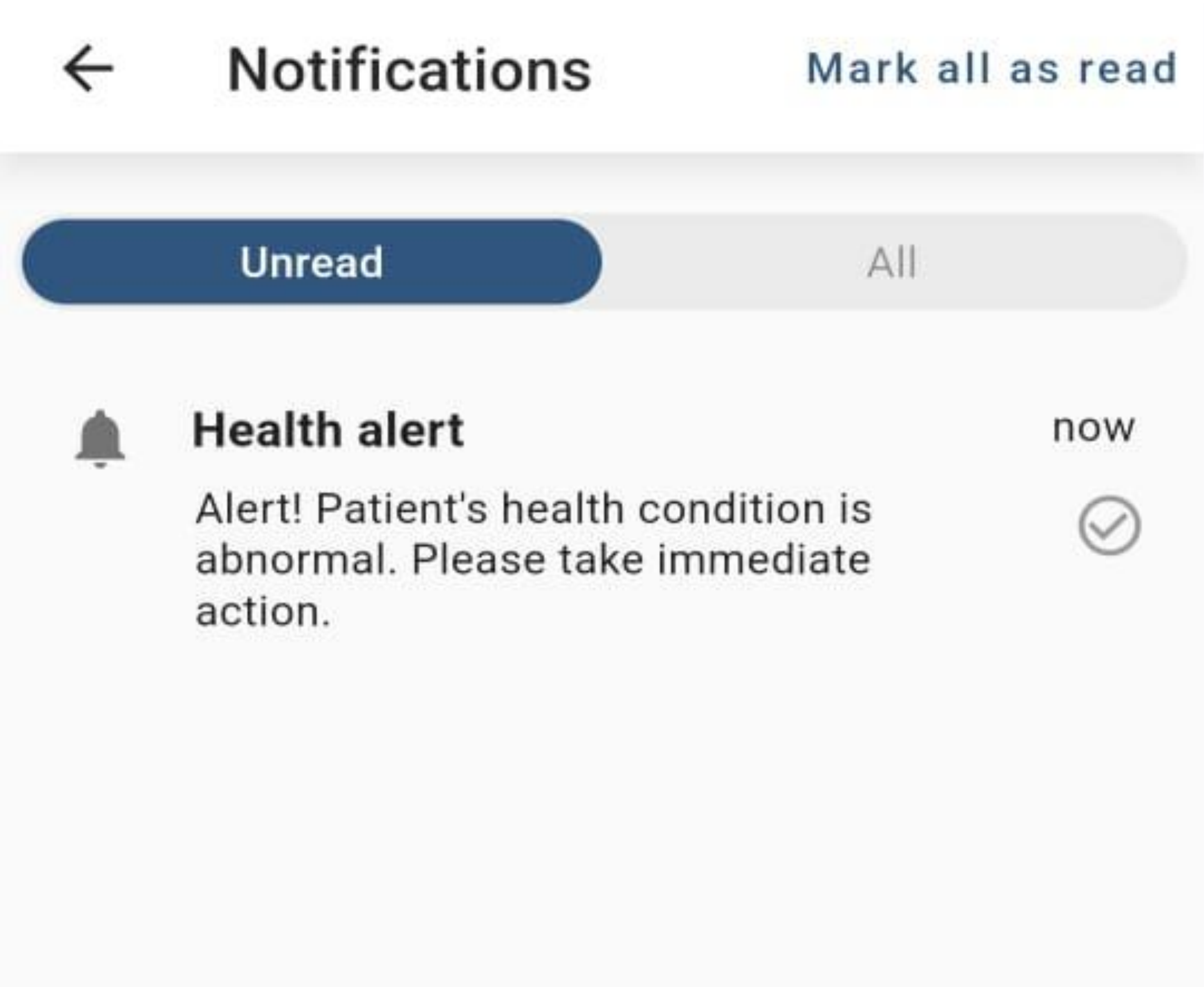
Command Prompt - python t

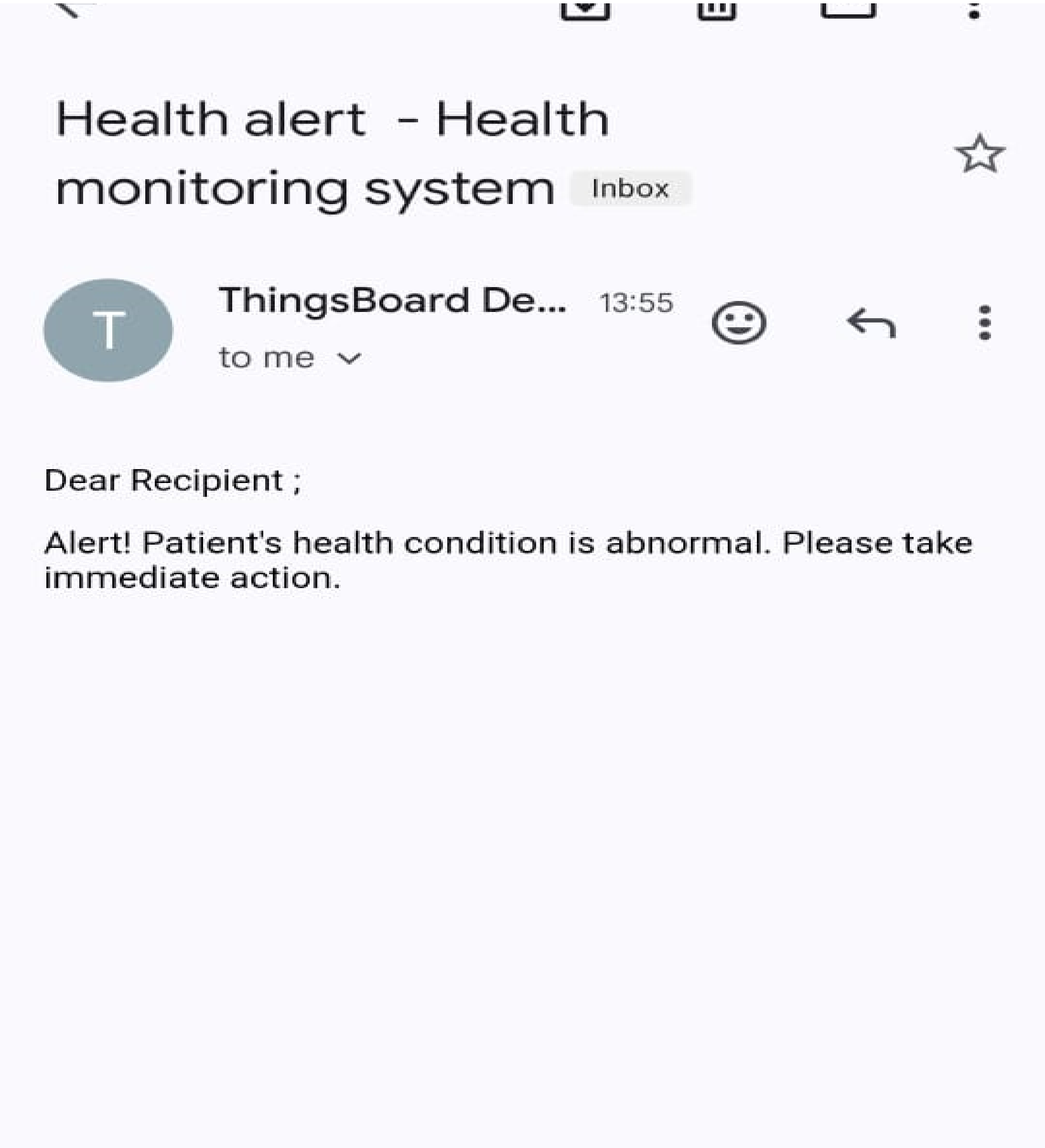
```
Published: {'ecg': 451}
Published: {'temperature': 29.8, 'humidity': 67.0, 'heart_rate': 80, 'systolic_bp': 104.0, 'diastolic_bp': 62.4}
Published: {'ecg': 459}
Published: {'ecg': 465}
Published: {'ecg': 465}
Published: {'ecg': 458}
Published: {'ecg': 422}
Published: {'ecg': 451}
Published: {'ecg': 461}
Published: {'ecg': 462}
Published: {'ecg': 450}
Published: {'ecg': 456}
Published: {'ecg': 454}
Published: {'ecg': 418}
Published: {'ecg': 449}
Published: {'ecg': 465}
Published: {'ecg': 461}
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
Normal
Google Map
For development purposes only
North Atlantic Ocean
Map data ©2025 Terms
Line chart
Realtime - last 1 minute
Avg
ecg_waveform 231 mV
Bar chart
Realtime - last 1 minute
Avg
diastolic_bp 62 mmHg
systolic_bp 103 mmHg
Bars
heart_rate
diastolic_bp
systolic_bp
temperature
heart_rate 68
diastolic_bp 62
systolic_bp 103
temperature 32
Total 266
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_monitoring'


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
heart_rate 76
diastolic_bp 62
systolic_bp 104
temperature 32
Total 274
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 verlinkrisha@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

NOTIFICATION:





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

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