Stress-Lysis: An IoMT-Enabled Device for Automatic Stress Level Detection from Physical Activities

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Outline of the Talk

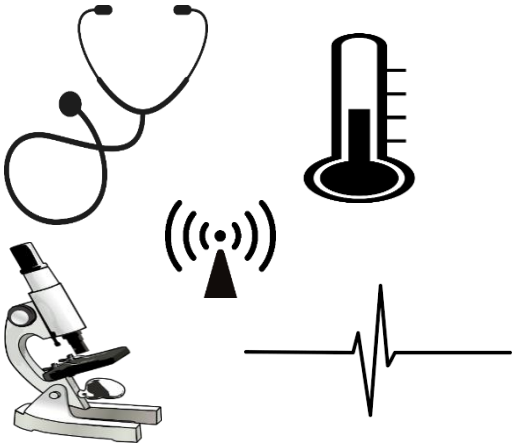
- Introduction
- Novel Contributions
- Stress Detection Approaches: State-of-the-art
- The Proposed IoMT-based Stress Detection System - Stress-lysis
- Consumer Electronic Proof-of-concept Using Off-the-shelf Components
- Conclusions And Future Research

Introduction

✓Internet of Things

- The Internet of Things is a network of devices where each device in the network is recognizable and connected.

✓Internet of Medical Things



- The Internet of Medical Things is a network of medical devices where each device in the network is recognizable and connected.

Introduction

✓Applications of IoT and IoMT

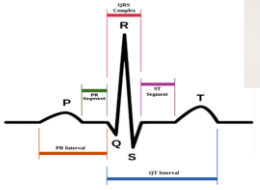
Posture Recognition

Decision Making

Connected Health

Smart Supply Chain

ECG Monitoring System



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Research Motivation

✓Why is Stress an important factor to consider?

When there is an encounter with sudden **stress**, your brain floods your **body** with chemicals and hormones such as adrenaline and cortisol.

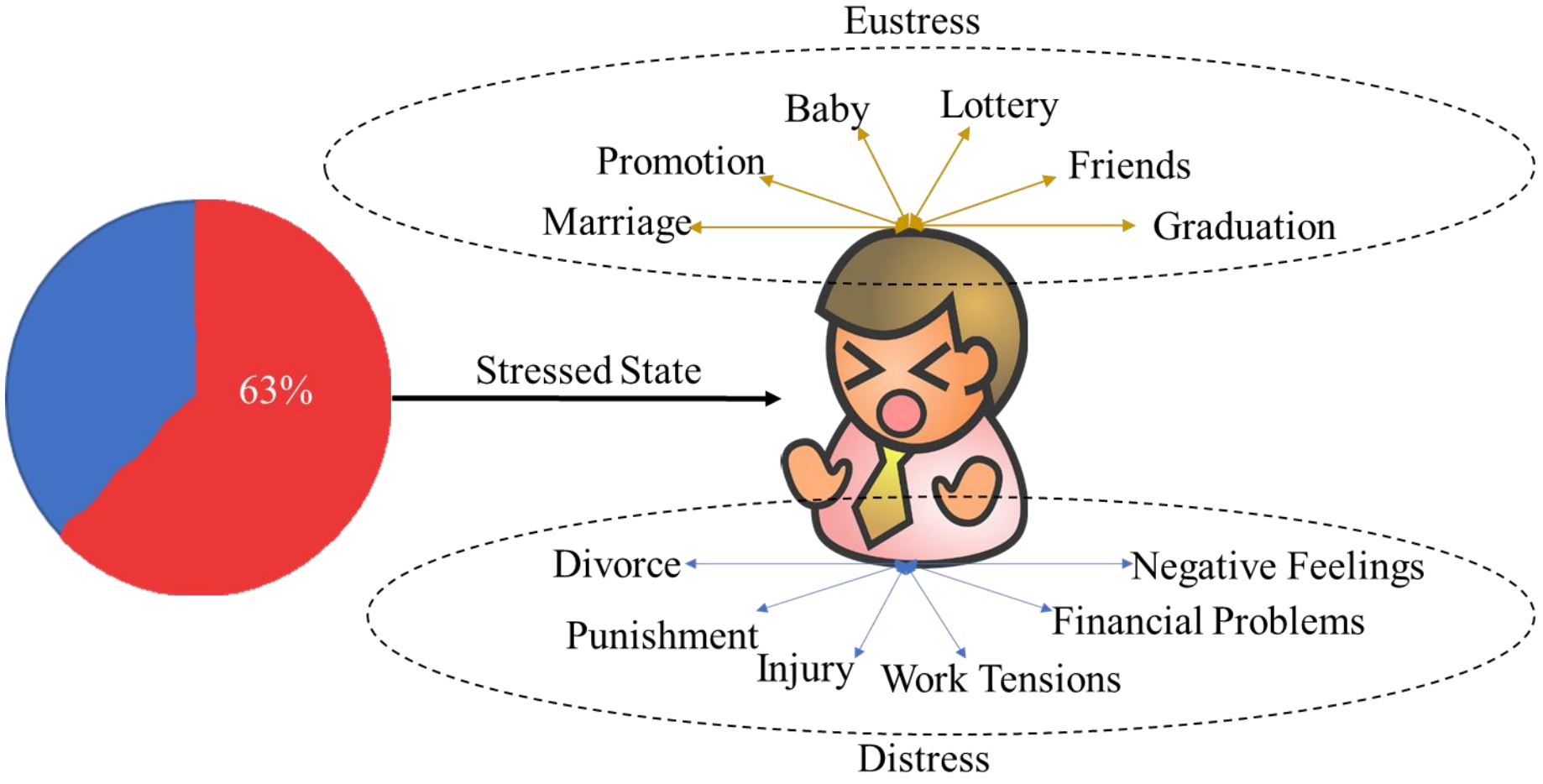
Distress

- ❖ Lack of Energy
- ❖ Type 2 Diabetes
- ❖ Osteoporosis
- ❖ Mental cloudiness (brain fog) and memory problems
- ❖ A weakened immune system, leading to more vulnerable to infections

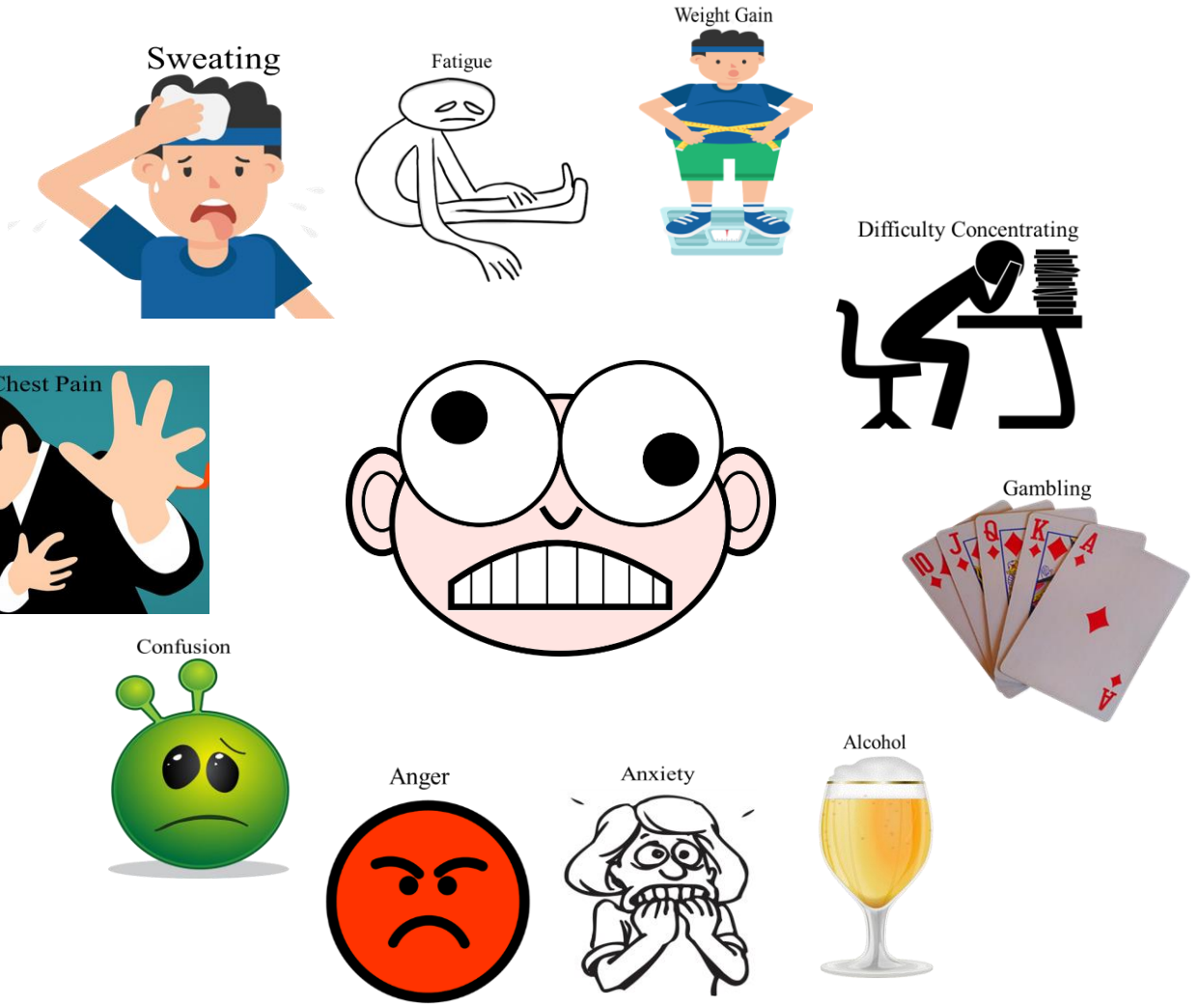
Eustress

Stress is the body's reaction to any change that requires an adjustment or response.

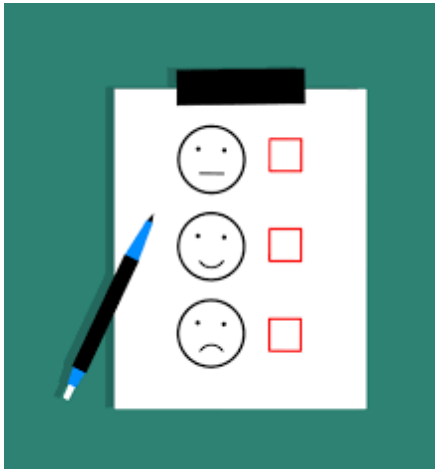
Stressors of Stress



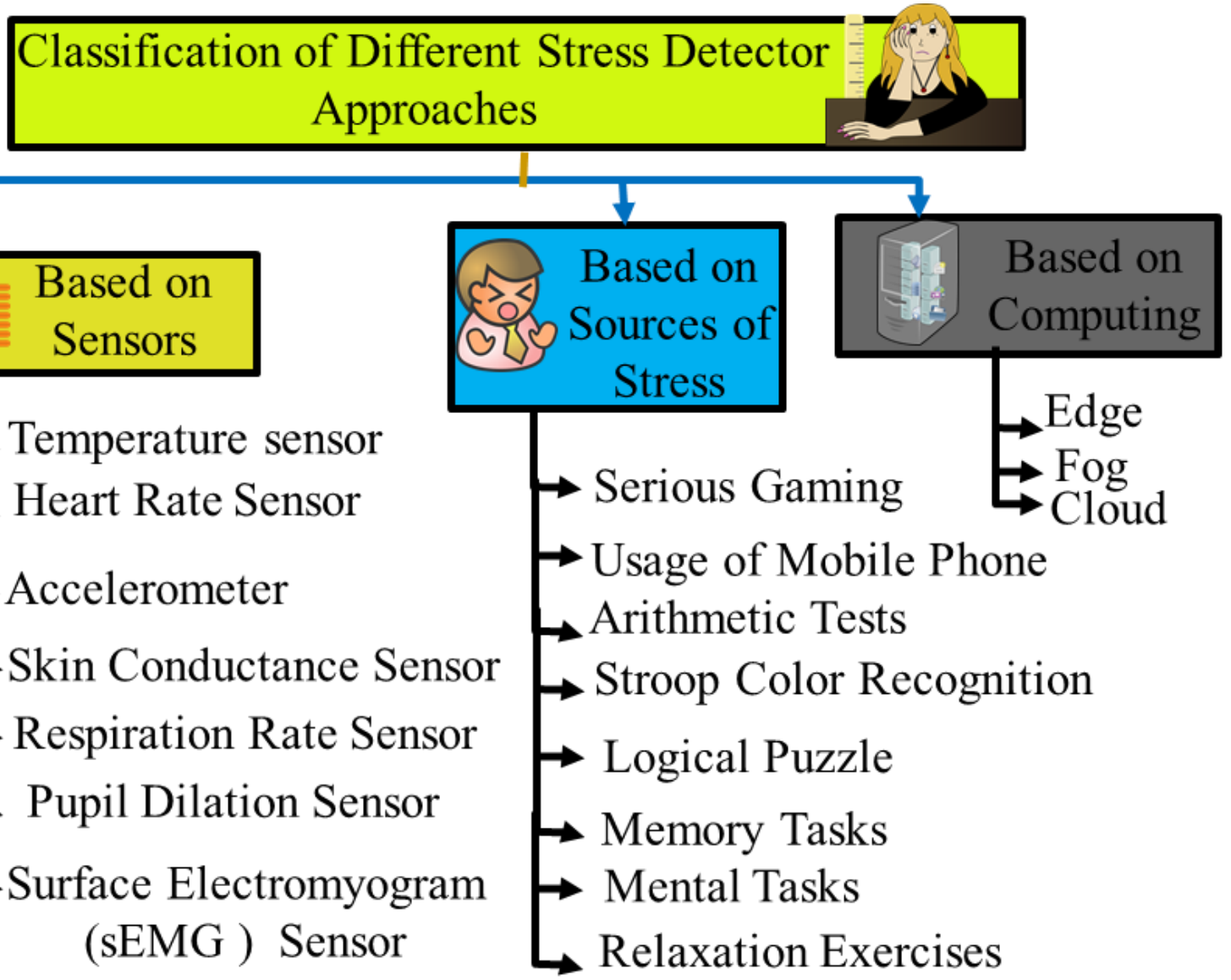
Symptoms of Stress



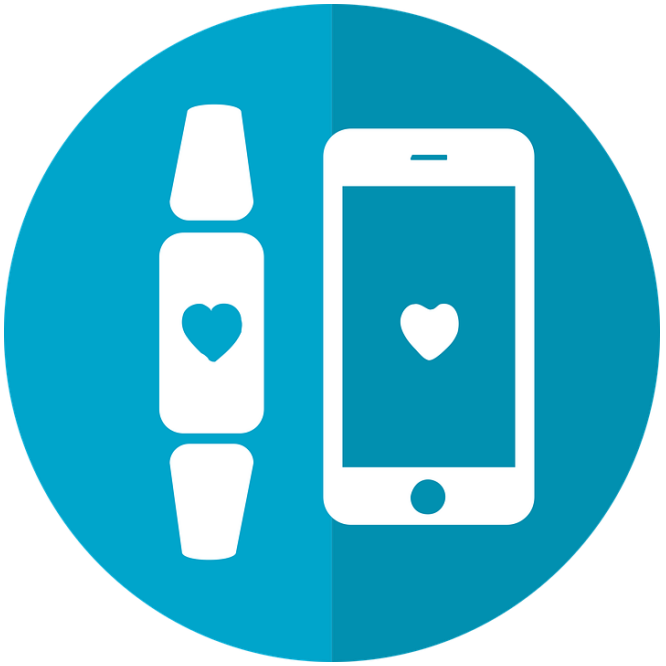
How to Monitor Stress?



How to Monitor Stress?



Existing Products



myfitnesspal

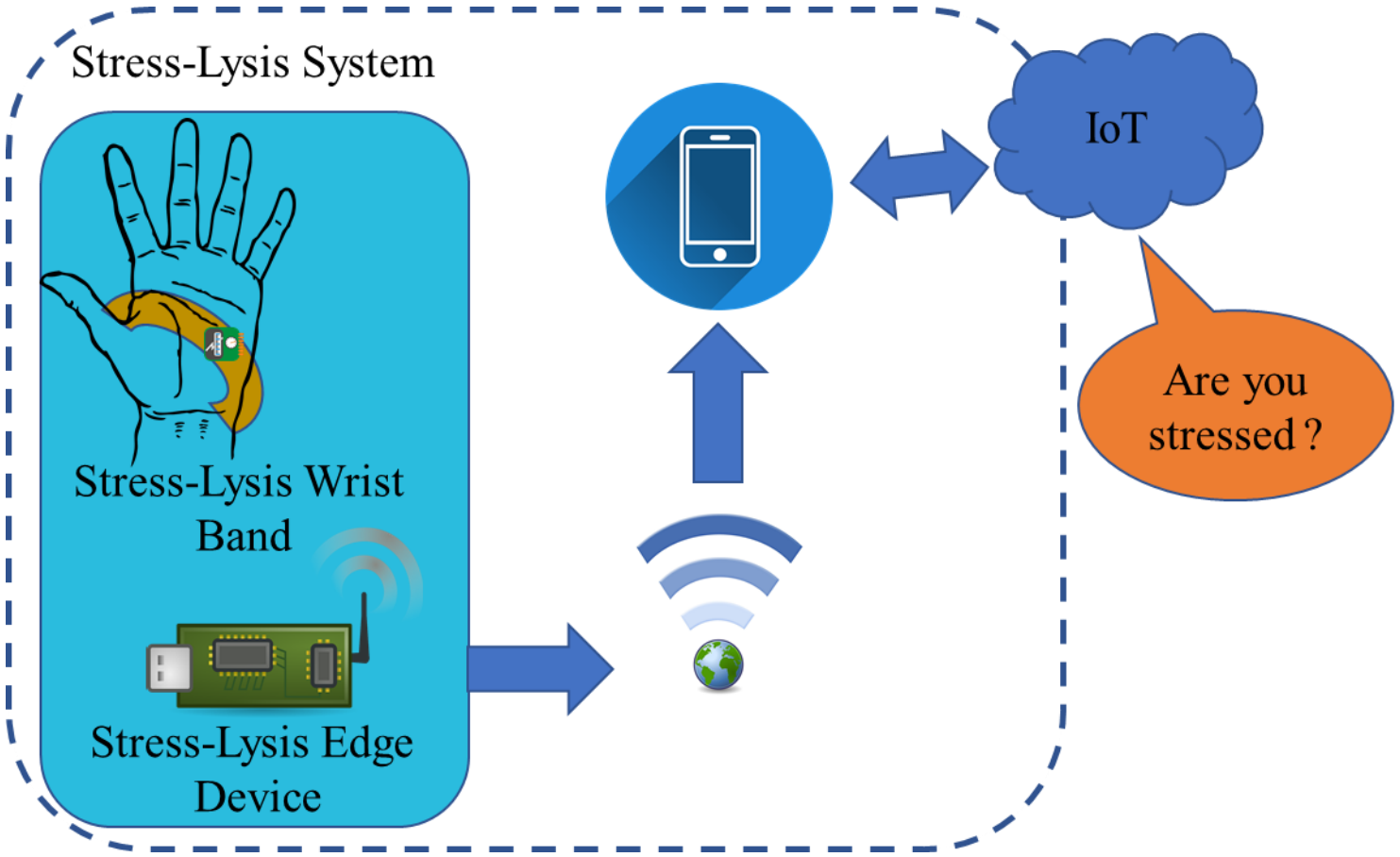
Muse-EEG

Issues of Existing Solutions

- Lack of Detection Accuracy of Stress Level.
- Lack of having multiple stressors for effective stress level analysis.
- No Unified detection of the problem.
- Fully automated features.
- Storage availability of the detected parameters for future usage.

Proposed Solution: Stress-Lysis

✓**Conceptual Overview of the iStress System.**

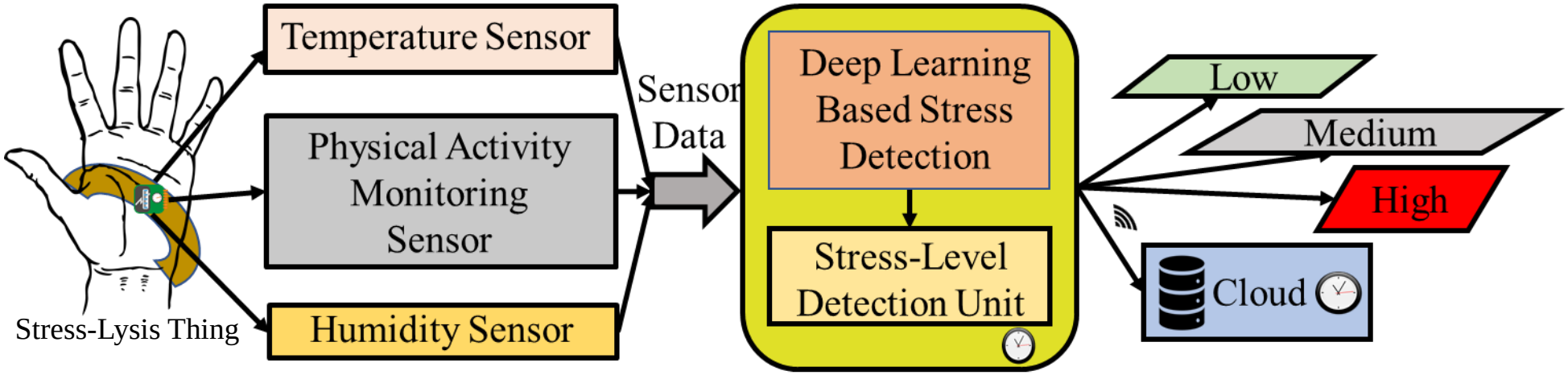


Novel Contributions

- A novel, accurate, and rapid stress level detection system that acquires and models sensor data and detects stress level at the user end (at the edge) and stores the data in the cloud.
- A novel real-time deep learning system for accurate stress detection from physiological activity.
- A novel consumer electronic proof of concept with Deep Neural Networks (DNN) deployed on edge devices, thus contributing to the advancement of the state-of-the art.
- A novel approach that combines human body temperature, rate of motion, and body sweat to accurately detect stress rapidly, in contrast to existing approaches which use only a single parameter.
- A novel smart sensor device that uniquely quantifies the body temperature, rate of motion, and body sweat for fast and accurate stress level detection.

The Proposed Novel System

✓ Proposed Novel IoMT Based Architecture



The Proposed Novel System

✓ Design of Stress-Lysis Sensing Wrist Band

- ❖ Sensor for measuring Body Temperature Variability- we modeled a contact temperature sensor that can monitor the rate of variation in body temperature.
- ❖ Sensor for Sweat Analysis- a humidity sensor is used to detect sweat secretion on the palms.
- ❖ Sensor for Activity Monitoring- an accelerometer sensor is used to measure the step count of a person.

THE PROPOSED ML NOVEL APPROACH

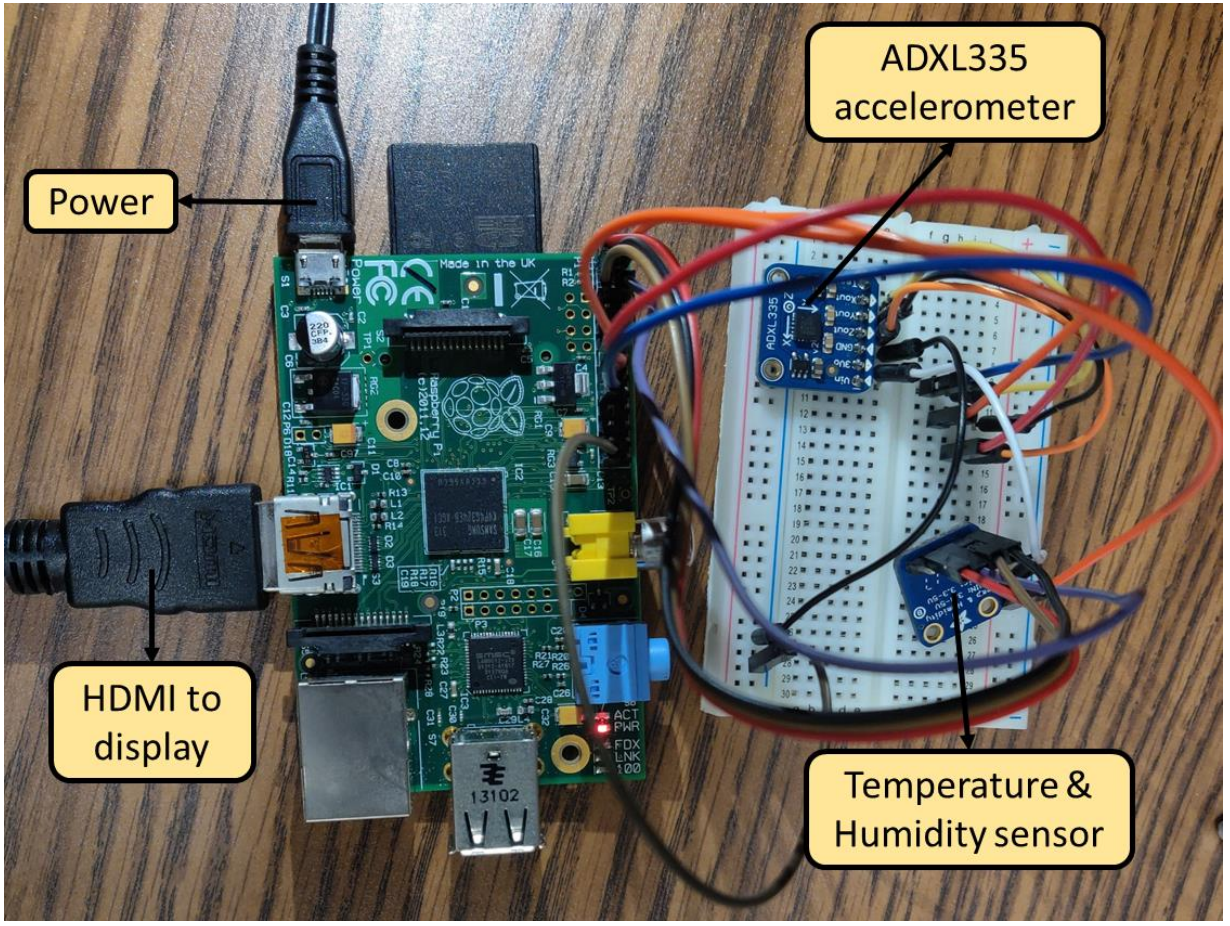
✓ Proposed Methodology for training the Stress-Lysis DNN model

- The training and testing of the network are done using a dataset of 26,000 samples based on sensor ranges.

Sensor	Low Stress	Normal Stress	High Stress
Accelerometer (steps/min)	0-75	75-100	101-200
Humidity (RH%)	27-65	66-91	91-120
Temperature ℉	98-100	90-97	80-90

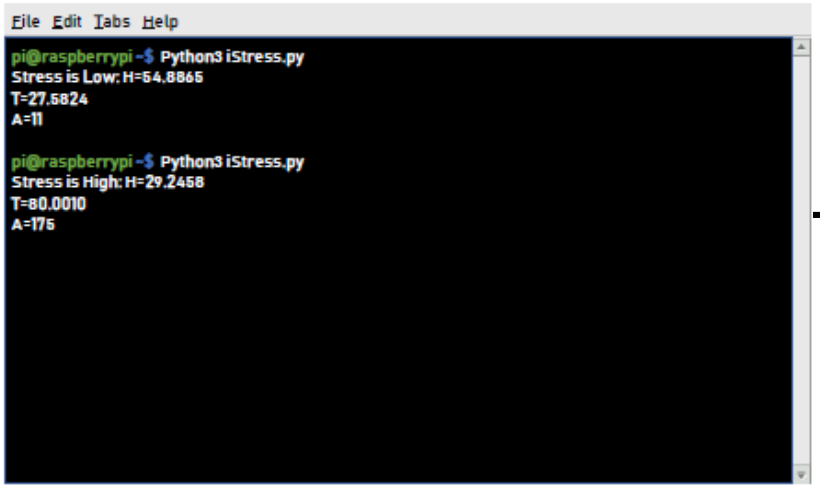
CONSUMER ELECTRONIC PROOF-OF-CONCEPT

✓ Consumer Electronic Validation of Stress-Lysis

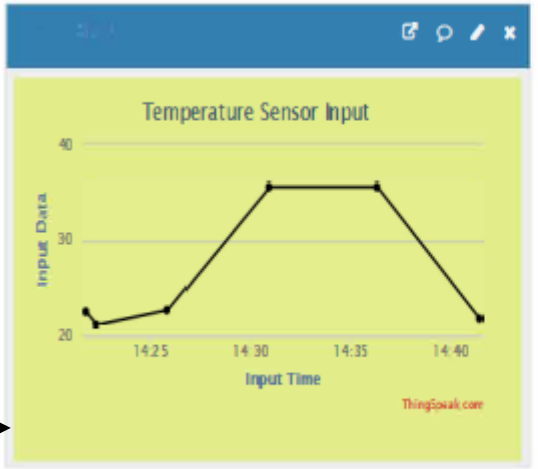


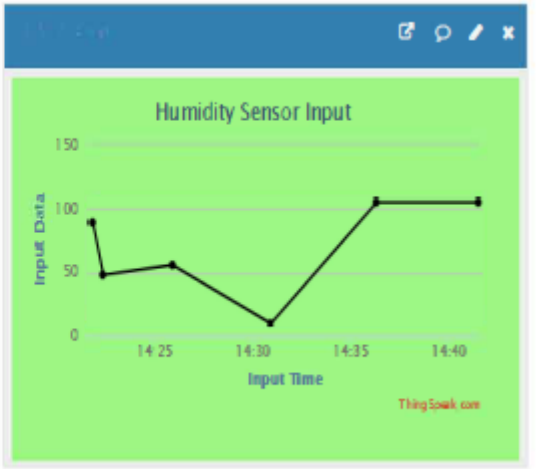
CONSUMER ELECTRONIC PROOF-OF-CONCEPT

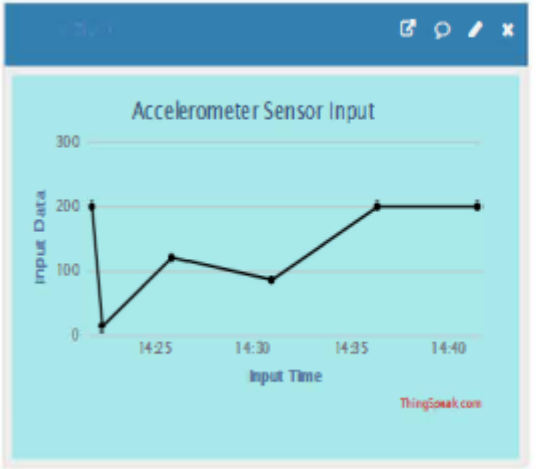
ThingSpeak IoT cloud

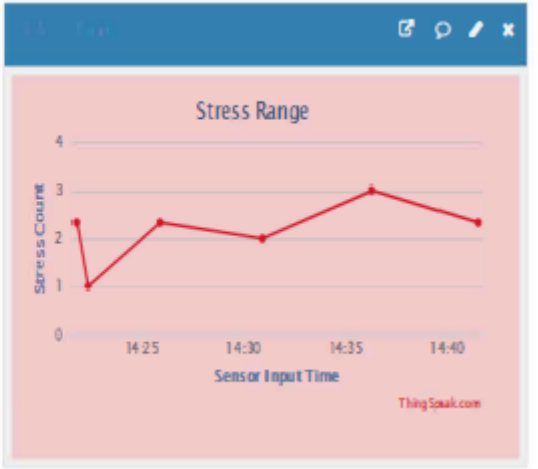


Raspberry Pi Output









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CONSUMER ELECTRONIC PROOF-OF-CONCEPT

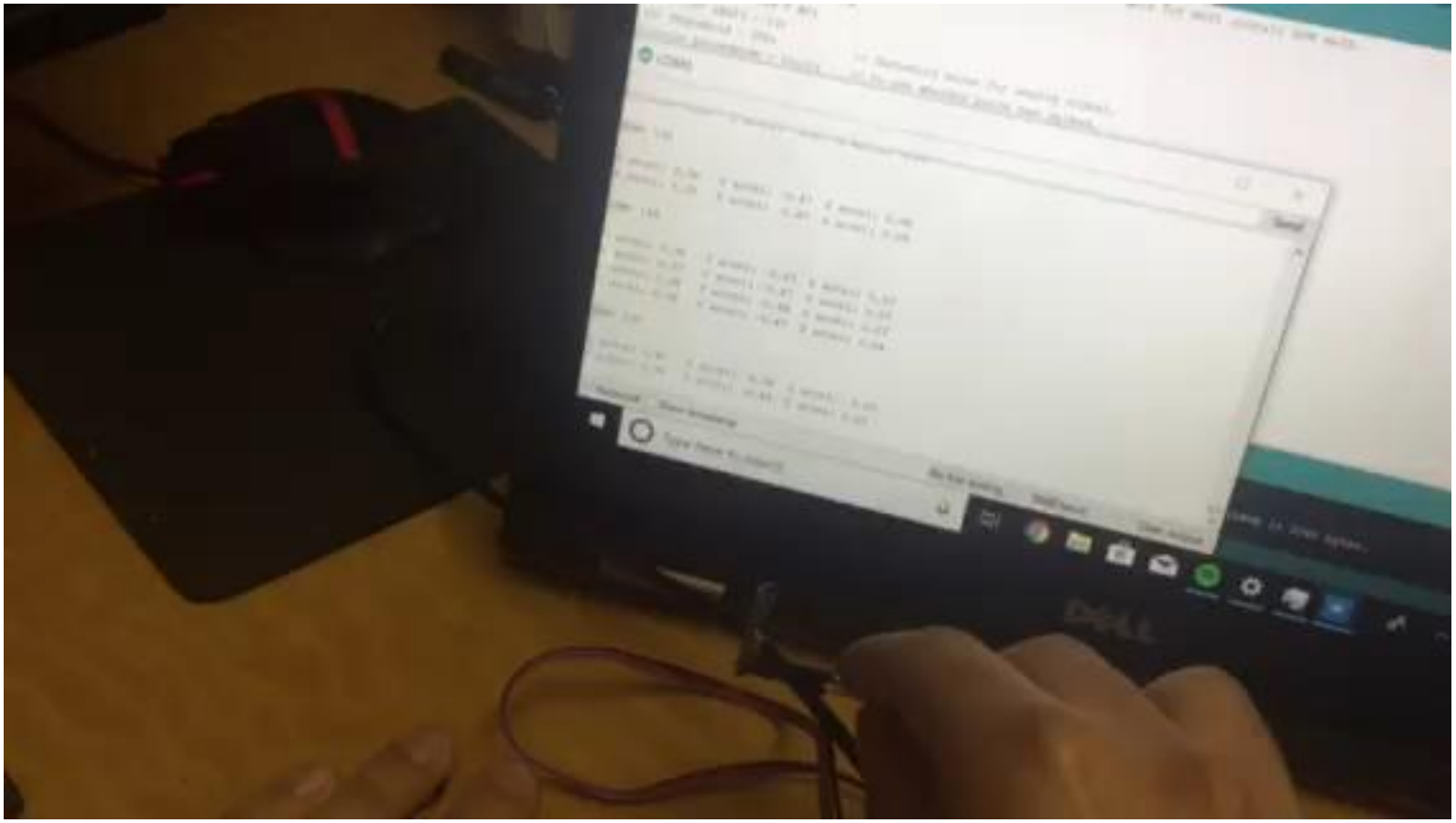
✓ Consumer Electronic Validation of Stress-Lysis

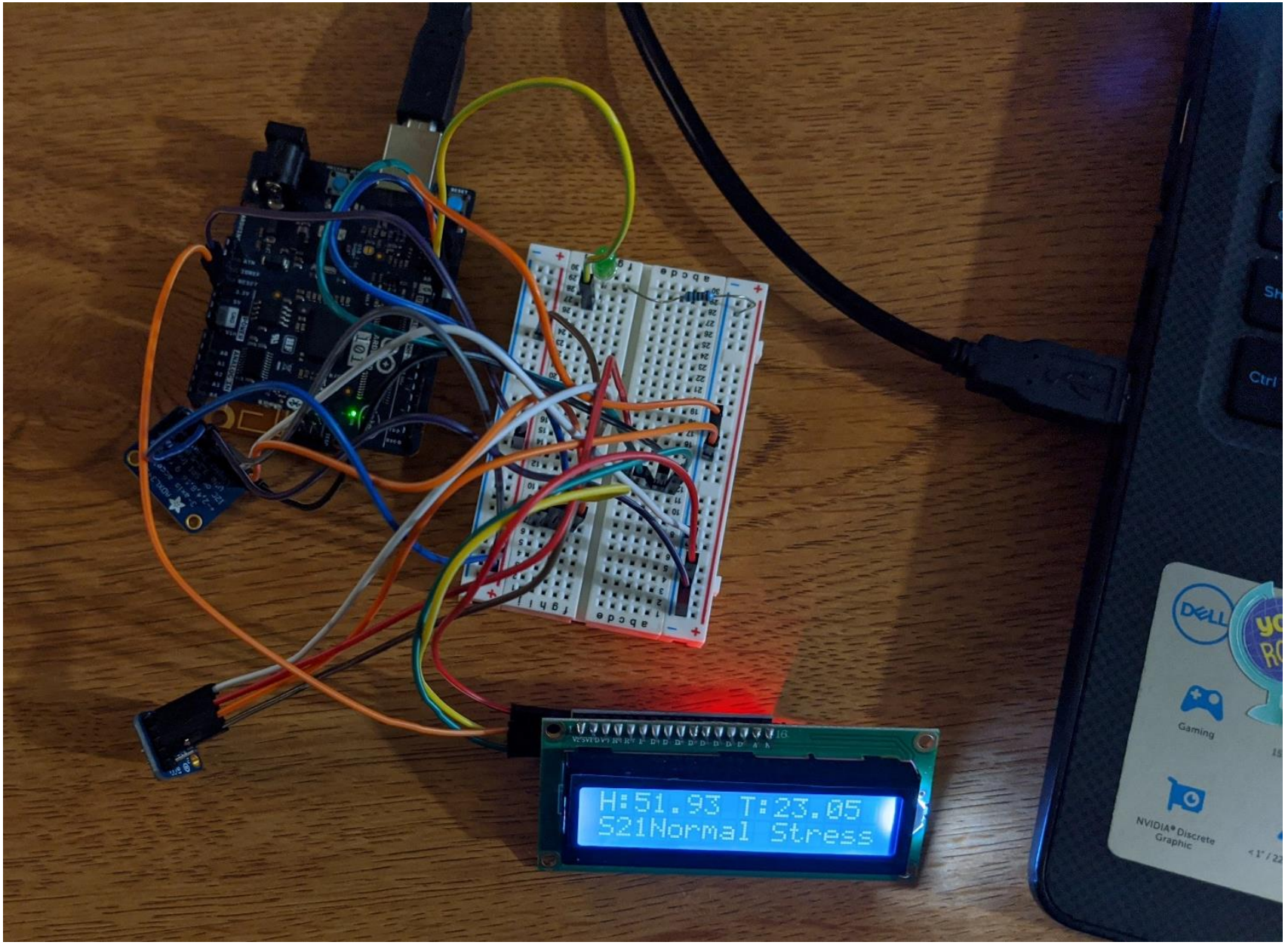
- The average time for evaluating stress level in the proposed framework is 2-4 minutes.
- The quality of resources that are used to validate the efficiency of the system depends on the computational complexity of the model.
- The most important characteristics that are considered to evaluate the efficiency of the model are time complexity and space complexity.
- With an approximate accuracy of 99% and SCI of 0.007, the time required to complete the operation in the model is approximately 3 minutes.
- In terms of computational time complexity, the neural network used is O(n4), where n is the total number of neurons in the model and the space complexity is O(n).

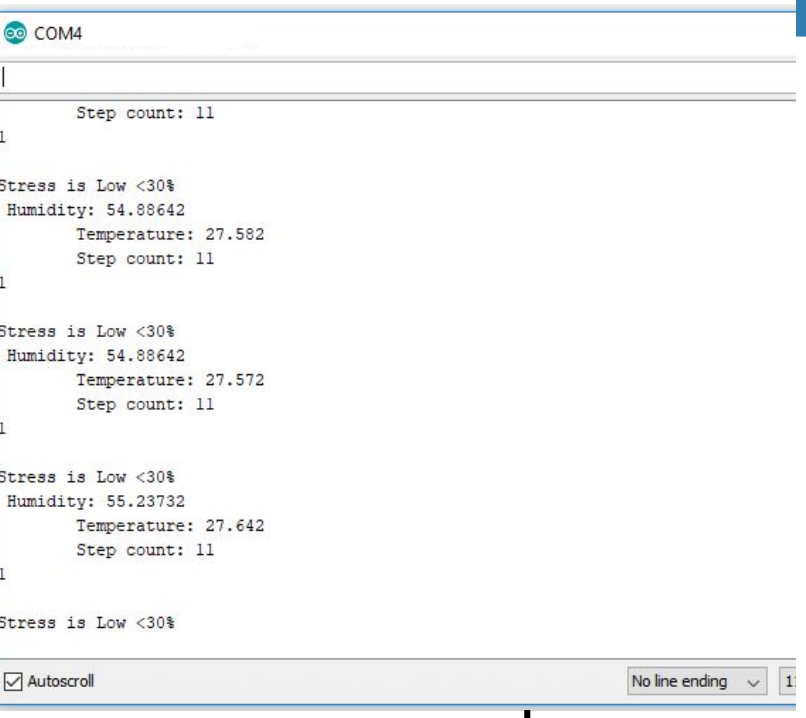
Hardware Demo

- Hardware Used:
  1. Arduino Uno
  2. ADXL 335 Accelerometer Sensor
  3. Si7021 Temperature and Humidity Sensor

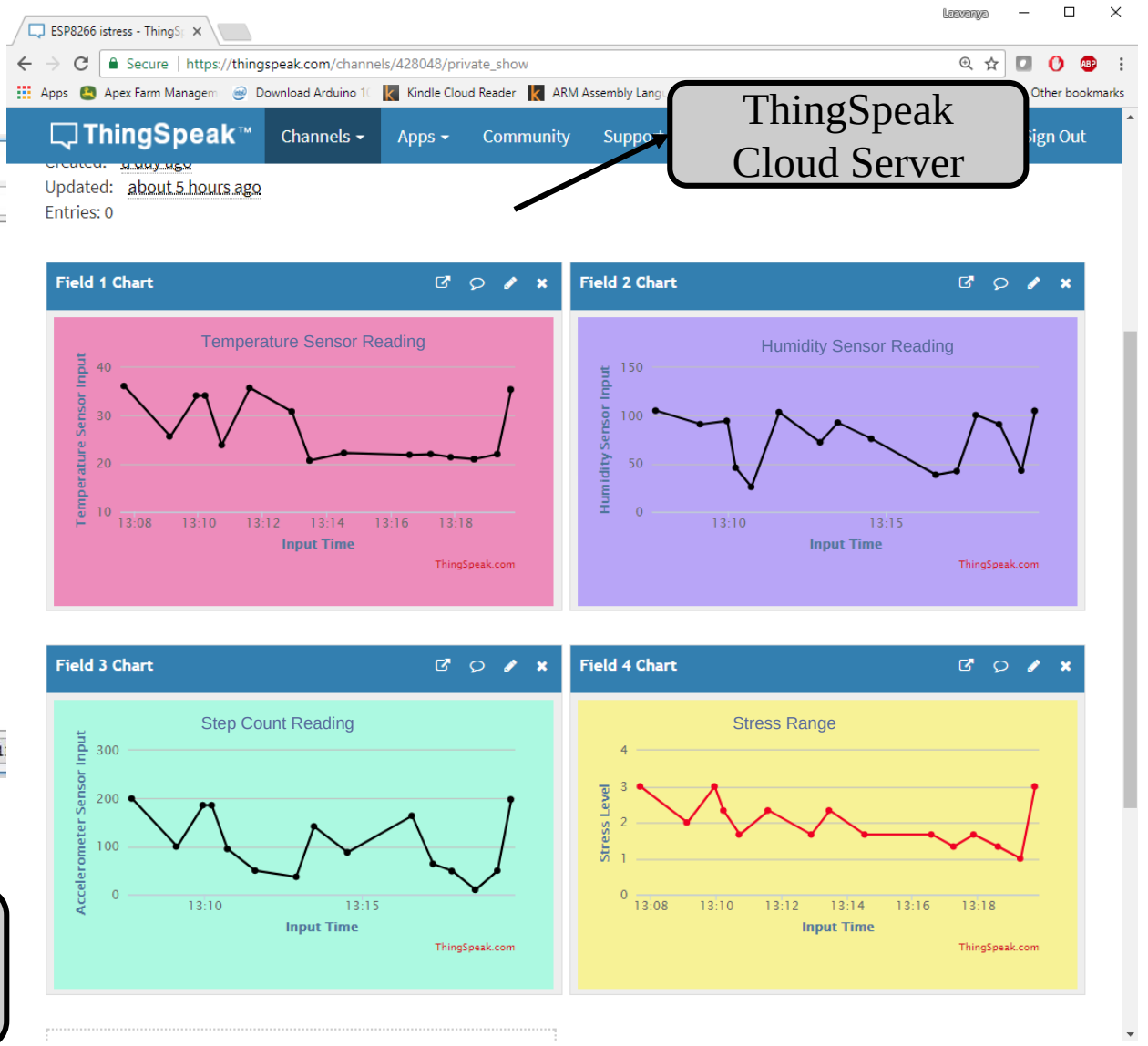
Working Demo




H:51.93 T:23.05
S21Normal Stress
Gaming
NVIDIA® Discrete Graphic



Serial Monitor Window output in Arduino IDE.



CONCLUSIONS AND FUTURE RESEARCH

✓ Conclusion

- A novel system for stress detection has been presented.
- In addition to helping the user in achieving emotional balance, the proposed Stress-Lysis system helps in monitoring chronic stress from early stages.
- A deep learning system is developed and tested with three different datasets with sample sizes of 2000, 4000 and 20,000.
- The training of the system is done with 67% of the sample size while the testing is done with 33% of the sample size.
- Validation and testing of the proposed framework is done in real-time with the help of available frameworks. The results when the system is tested with the training set were accurate in a range of 98.3% to 99.7% with a loss of 1% or less.
- The accuracy and loss plots confirm that as the sample size increases accuracy.
- A GUI implementation of the concept is used to represent the ease of use the system which can later be developed as a mobile application.

CONCLUSIONS AND FUTURE RESEARCH

✓ Future Research

- Our future directions in this area of research include deploying the developed prototype as wearables for veterans and women to analyze the stress values during post-traumatic stress disorder (PTSD).
- To develop smart healthcare models which incorporate various activities such as type, amount and time of food consumed, the number of hours slept along with the sleep behaviors and the changes in physiological parameters during sleep to not just predict stress, falls but also to analyze human behaviors.
- To Integrate security and privacy features to our smart healthcare systems using blockchain technology for more credibility.

Thank You !!!