Risk Analysis and Support System for Children with ASD Using IoT

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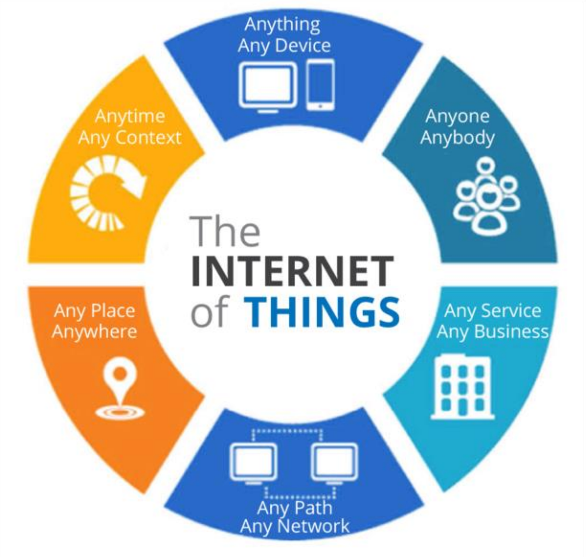
Contents

INTRODUCTION

Autism Spectrum Disorder (ASD) is a medical condition that occurs in children which affects communication and behavior of a kid.

Internet of Things (IoT) is simply a network of “things” that are connected to the internet so they can share data with each other.



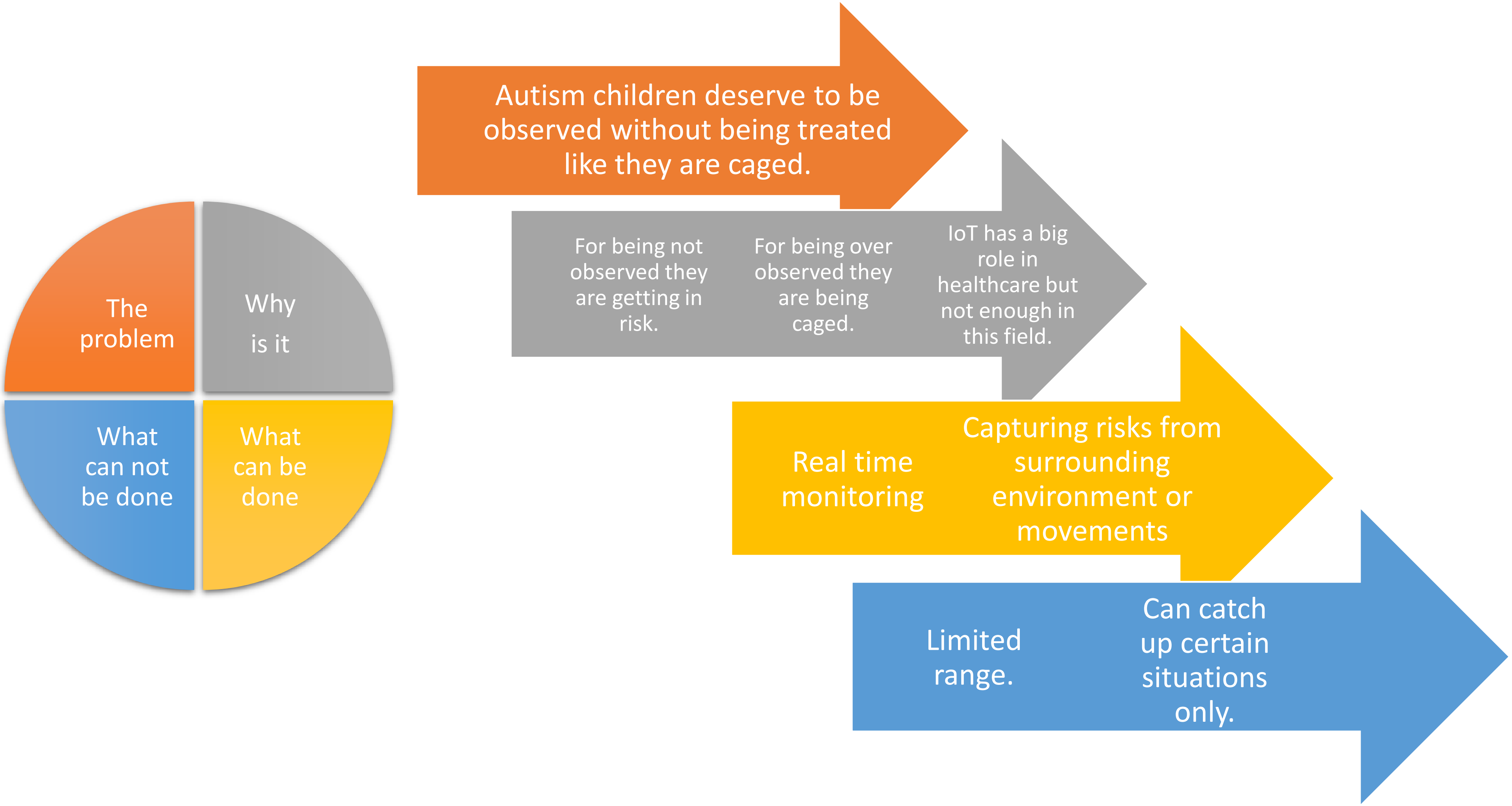
MOTIVATIONS

- Acquiring knowledge
- Assuring safety
- High availability of IoT
- Contribute for health sector
- IoT’s previous success

OBJECTIVES

- Aims for observing and analyzing risk
- To examine the extent, range, and efficiency of IoT
- To make risk detection algorithms reliable
- Propose a protection device model

PROBLEM DESCRIPTION



LITERATURE REVIEW

Here are some review on works that have been conducted on the similar field -

Title	Brief	Pros	Cons
Autism Support System using RFID Technology [1]	Identifies the location of ASD child and informs parents using RFID.	Common technology, low cost, available tools.	Backdated GSM, low range, RFID can only detect physical scenarios.
A support system for autistic children using Internet of Things technology [2]	Uses advanced computing device and multiple sensors to observe the children and acknowledge parents.	WIFI for communication, Several risk detection, calming section.	Complex implementation, large device, internet dependency.

LITERATURE REVIEW (cont.)

Title	Brief	Pros	Cons
Emotion Recognition of Autism Children Using IoT [3]	Use thermal infrared (IR) information as data to detect the facial expression of ASD child and analyze their status.	User friendly, effective in mental and social risk/problem detection, doesn’t use multiple sensors.	Some ASD child make abnormal facial expressions.
Role of IoT and ML for autistic people [4]	A comparative study about the various systems currently being used for monitoring the autistic patients’ and how can those be efficiently applied.	Polysomnography, pulse rate sensor, eye tracking glasses.	Some proposed applications are sensitive, stationary and inefficient

METHODOLOGY (SYSTEM FLOW AND ENGINEERING PROCESS)

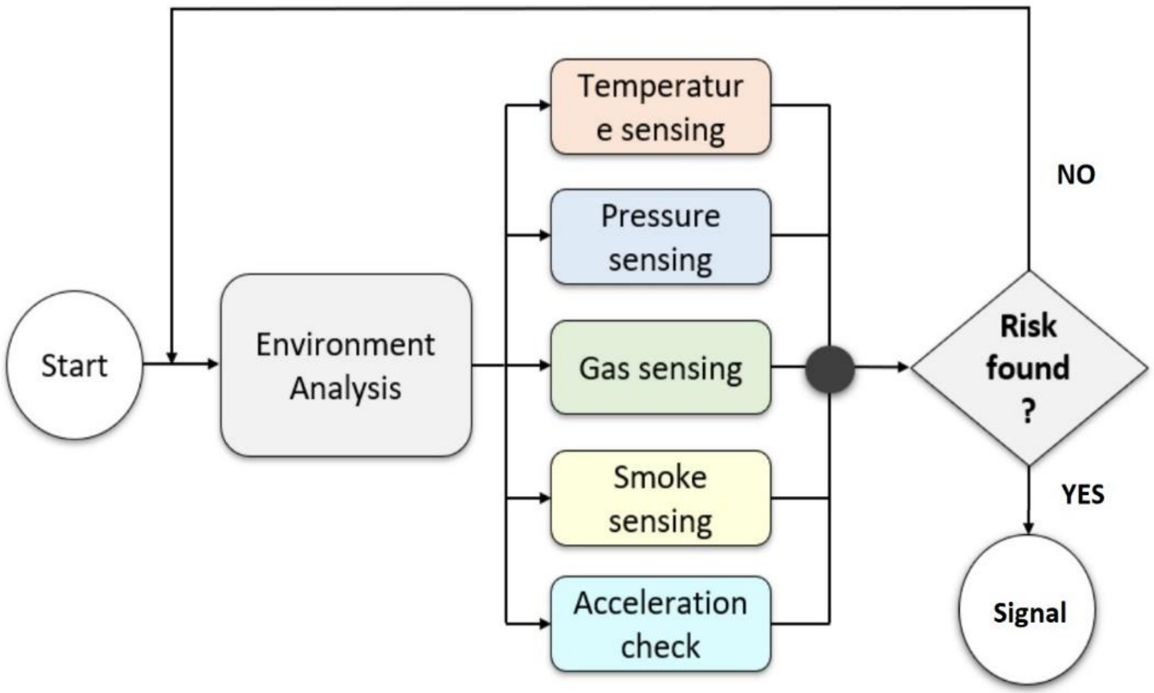


Fig: Flow of the risk detection system

METHODOLOGY (SPACE OPTIMIZATION)

Clock-Queue: Overcoming the Storage Problem

There are 3 different queues for each of the sensor data, a single cell of a higher level queue represents a whole lower level queue by storing the average of lower level queue. Which ensures data abstraction and space optimization.

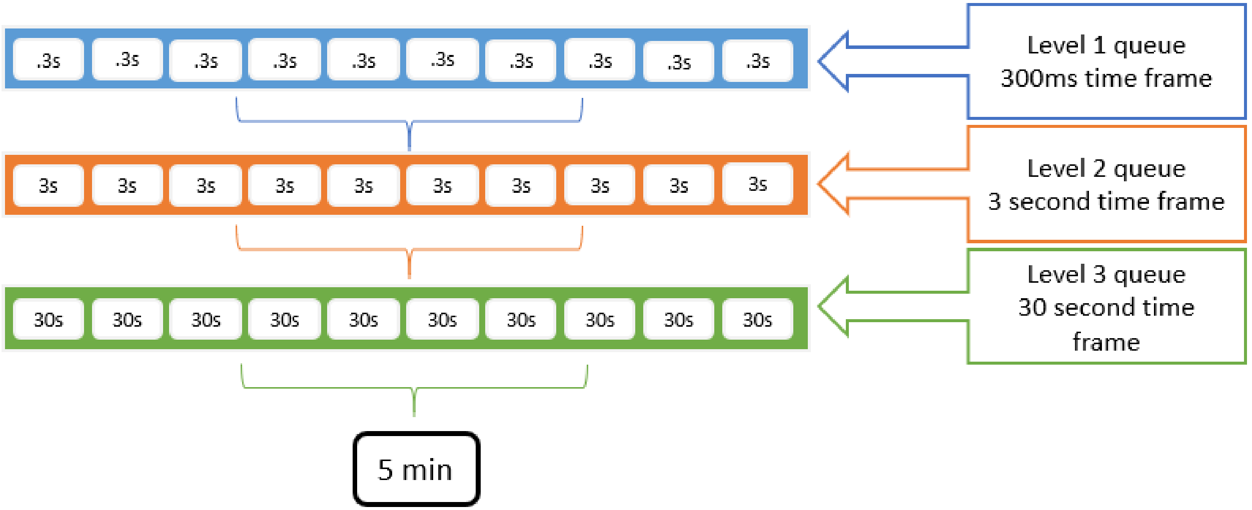
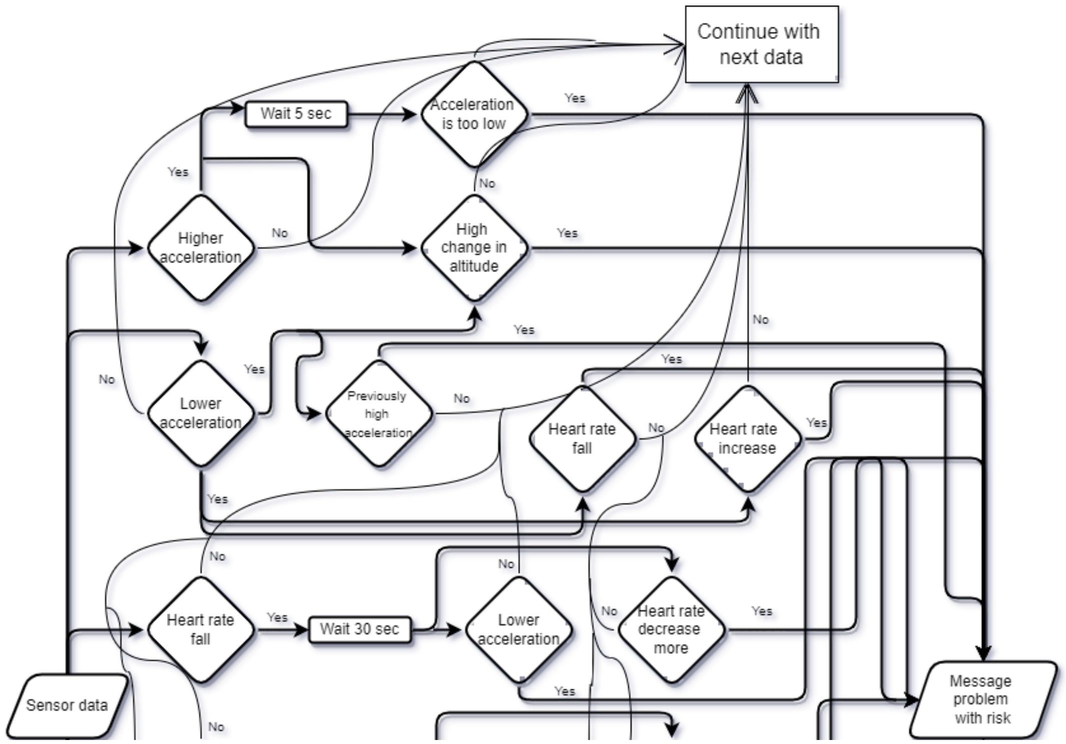


Fig: Clock queue data structure

METHODOLOGY (FLOWCHART)



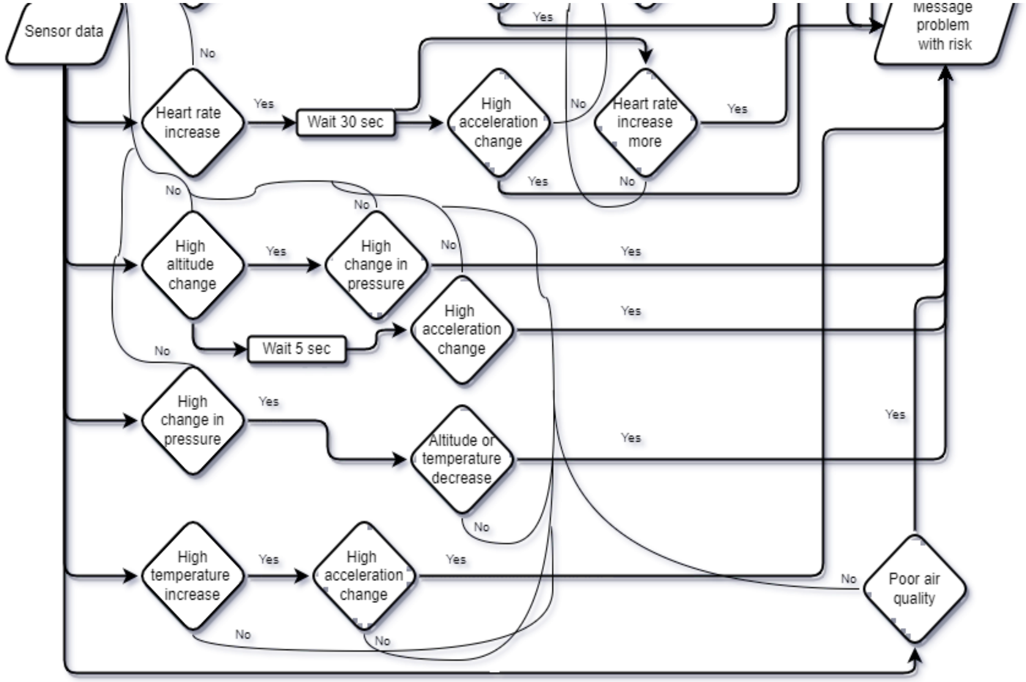


Fig: Flow chart of algorithms

METHODOLOGY (ALGORITHMS)

The system uses the data in real-life logical conditions to determine a state. There are 5 different algorithms that handles a dozen types of input data; each one is connected with others' yet independent. A cooperative flow shown here, is the backbone of the system.

Algorithm 2 Detection of Getting Stuck in Fire or Polluted Location

```
TGA ← toxicity_in_air
dT ← temperature_difference
dAc ← acceleration_difference
if TGA = HIGH then
    Got into harmful and polluted location.
else if dT = POSITIVELY HIGH then
    if dAc = POSITIVELY HIGH then
        Got into fire, trying to escape.
    else if dAc = NEGATIVELY HIGH then
        Got into fire, body not moving.
    end if
end if
```

Fig: Algorithm 2

METHODOLOGY (ALGORITHMS)

Algorithm 1 Detection of risks - got into high temperature, entering a fire and attempting to escape, body not moving after entering a fire, got into very harmful location, entering a harmful or polluted location

```
dT ← temperatureDifference
dA ← accelerationDifference
gasToxicity
dG ← gasToxicityDifference
if dT ≥ 3 then
    got into high temperature
    if dA ≥ .4 then
        entering a fire and attempting to escape
    else if dA ≤ −.4 then
        body not moving after entering a fire
    end if
end if
if gasToxicity > 400 then
    got into very harmful location
else if dG > 30 then
    entering a harmful or polluted location
end if
```

Fig: Algorithm 1

Algorithm 3 Detection of risks - fallen from a high location, cardio, body not moving after falling from a high location, accident

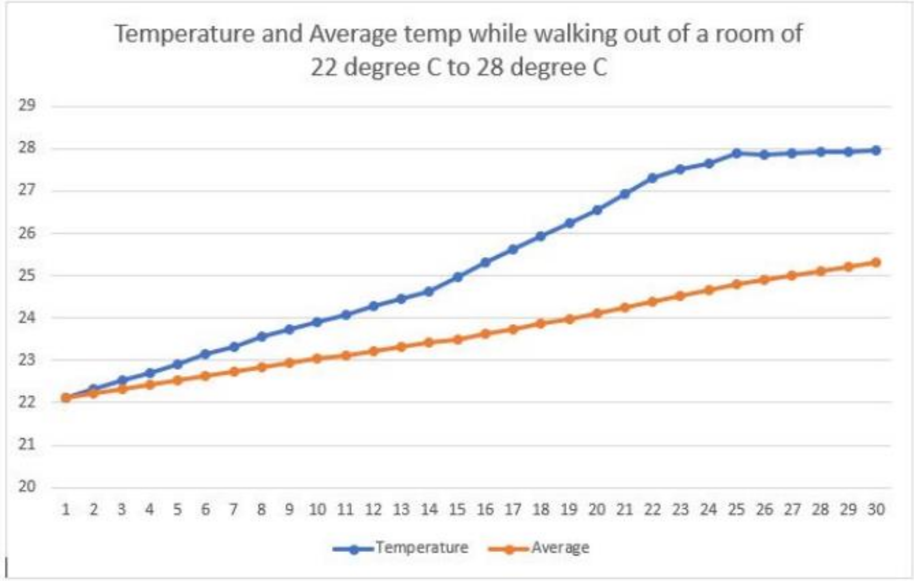
```
dH ← heartRateDifference
dAc ← accelerationDifference
dAl ← altitudeDifference
if dAl < −10 then
    Fallen from a high location
    if dAc < 0.25 then
        Body not moving after falling from a high location
    else if dAc < 0.25 then
        Accident
    end if
end if
if dH > 10 and dAc > 0.25 then
    Cardio(running, playing, quarrelling)
end if
```

Fig: Algorithm 3

METHODOLOGY (THRESHOLDS)

To figure out different threshold values, we conducted several experiments for each of the input data. The experiments are divided into two different types.

1. **Regular events:** Experimented on regular environments and surroundings to observe what the data looks in **no-risk** situation.
2. **Risky events:** Experimented on risky environments and surroundings to observe what the data looks in **risky** situation.



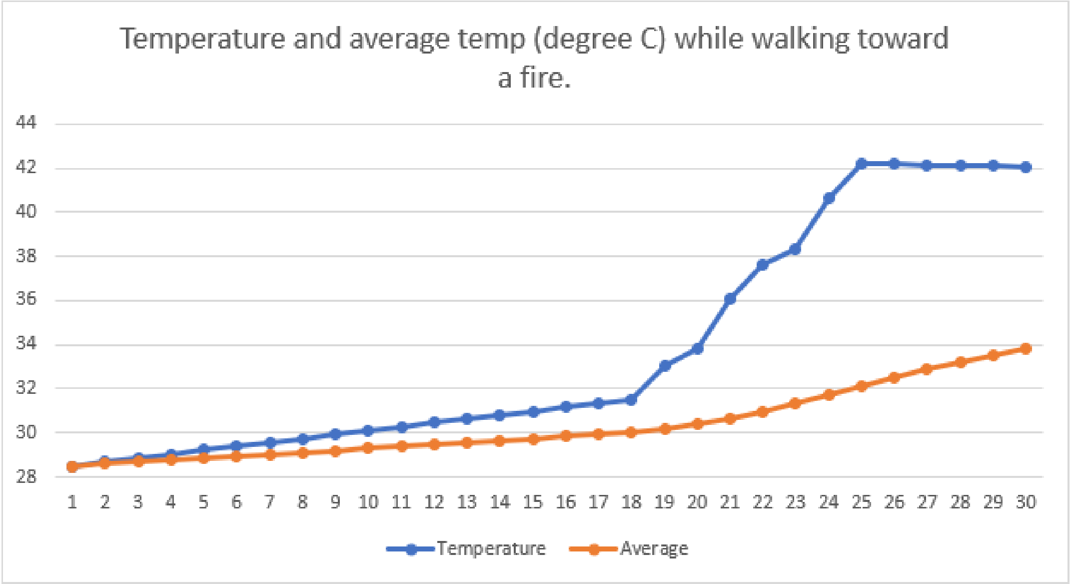
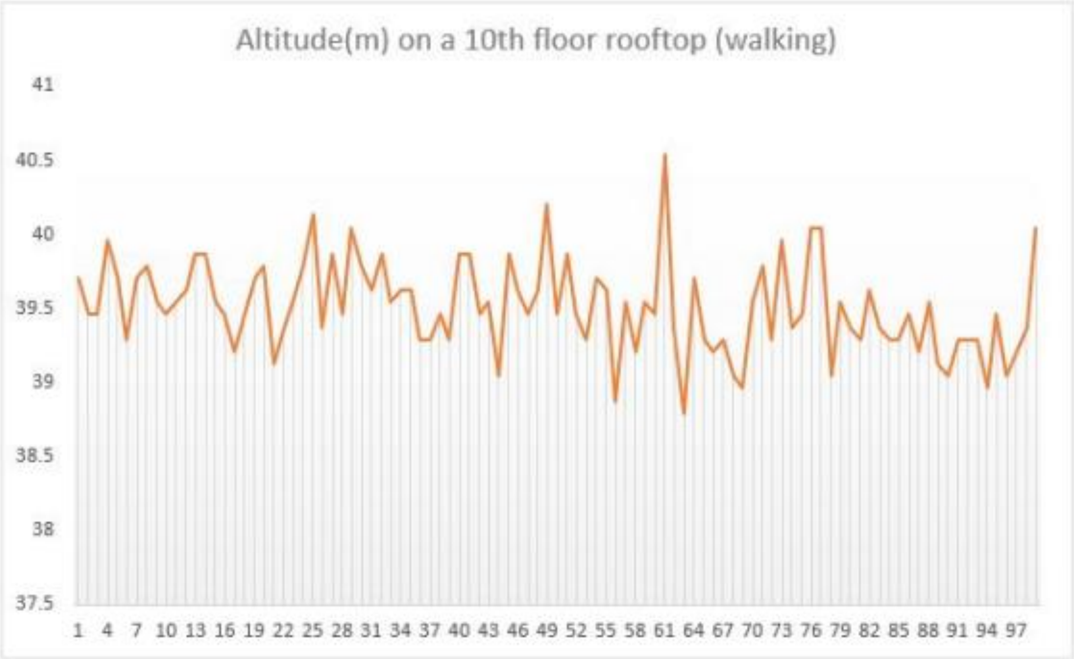


Fig: Experiment results on Temperature threshold

METHODOLOGY (THRESHOLDS)



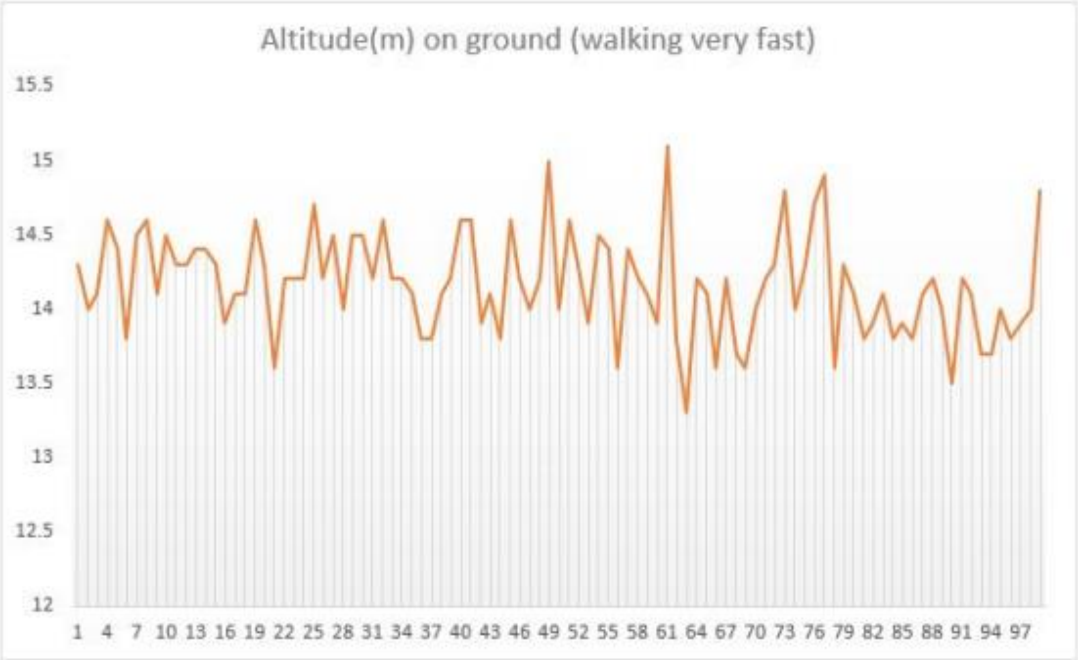


Fig: Experiment results on Altitude threshold

TOOLS AND TECHNOLOGIES

The proposed system consists of a processing device(Arduino Uno), a communication device (GSM module) alongside with 4 sensors, those are –

- Accelerometer (MPU6050)
- Gas (MQ135)
- Barometric pressure(BMP-180)
- Heart rate (MAX30102)

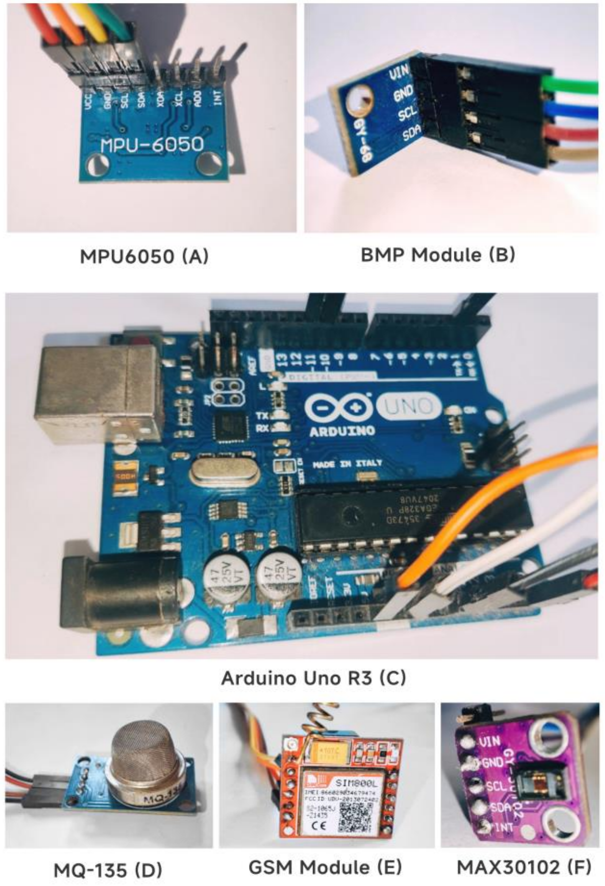


Fig: Hardware components

IMPLEMENTATION

The following figures shows the implementation of the work.

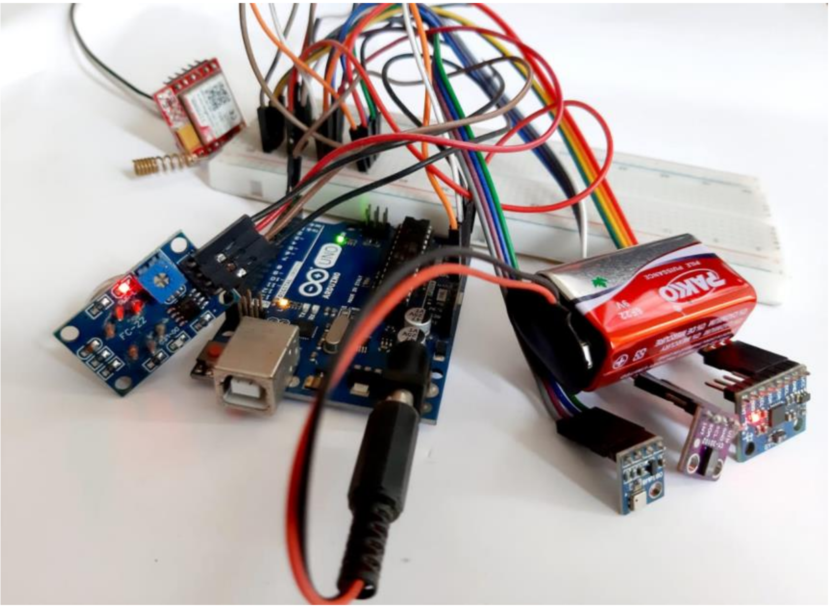


Fig: Hardware implementation

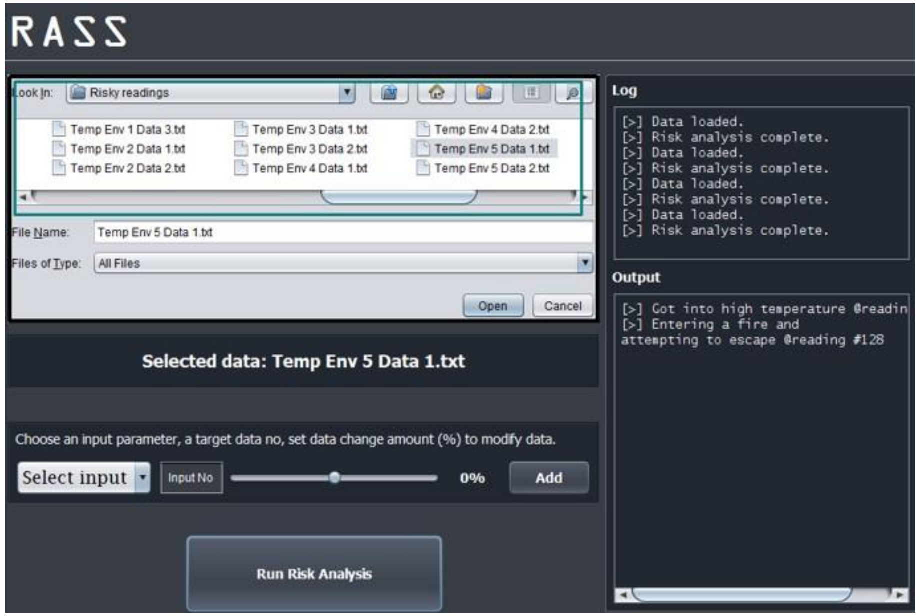
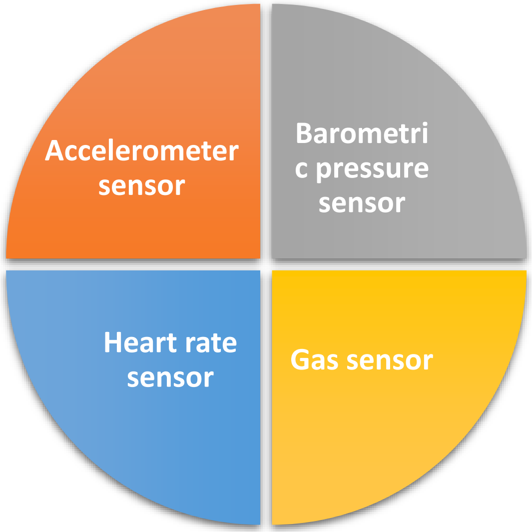


Fig: Software implementation

DATA COLLECTION

Designed prototype system relies on sensor based environmental information. Each sensor provides some certain types of real-time data.



Acceleration (3-axis), Angular rotation

Temperature (nature), Pressure, Altitude, Humidity

Ammonia (NH_3), Sulfur (S), Benzene (C_6H_6), CO_2

Heart rate, Pulse oximeter, Temperature (body)

DATA COLLECTION (cont.)

The 4 different sensors read 3 data per second (300ms interval), the following snap of the data are direct input for our algorithms. The data is collected from the real world in real time.

590	232	27.2	100843	40.13	100849	40.88	101023	91	28.18	1.36	2.05	389.34
591	231	27.1	100834	40.13	100844	40.71	101152	91	28.13	1.38	2.76	389.67
592	230	27.2	100846	39.79	100839	39.87	100994	91	28.22	1.37	1.01	389.72
593	226	27.1	100844	40.54	100843	40.13	100732	91	28.22	1.36	1.54	389.84
594	223	27.1	100851	40.13	100837	39.79	100969	91	28.18	1.38	1.32	389.84
595	223	27.1	100848	39.79	100844	40.04	101087	91	28.27	1.37	3.46	390.28
596	223	27.1	100843	40.04	100845	40.63	101215	92	28.08	1.38	0.57	390.17
597	225	27.1	100850	39.87	100847	39.96	100704	91	28.13	1.36	1.49	390.23
598	224	27.2	100849	39.79	100854	39.54	100964	91	28.13	1.36	2.12	390.45
599	225	27.1	100848	39.46	100847	40.04	101126	91	28.13	1.37	1.08	390.49
600	236	27.2	100844	40.54	100844	40.54	101322	92	28.18	1.36	1.9	390.67
601	233	27.1	100844	40.13	100844	40.54	100954	91	28.18	1.36	1.87	390.77

Fig: Input data

EVALUATION

The testing of the system and efficiency of algorithms are conducted in two different types. First one includes testing with no-risk data while the second one involves data that represents a risky event.

In both of the cases the algorithms could capture results pretty perfectly.

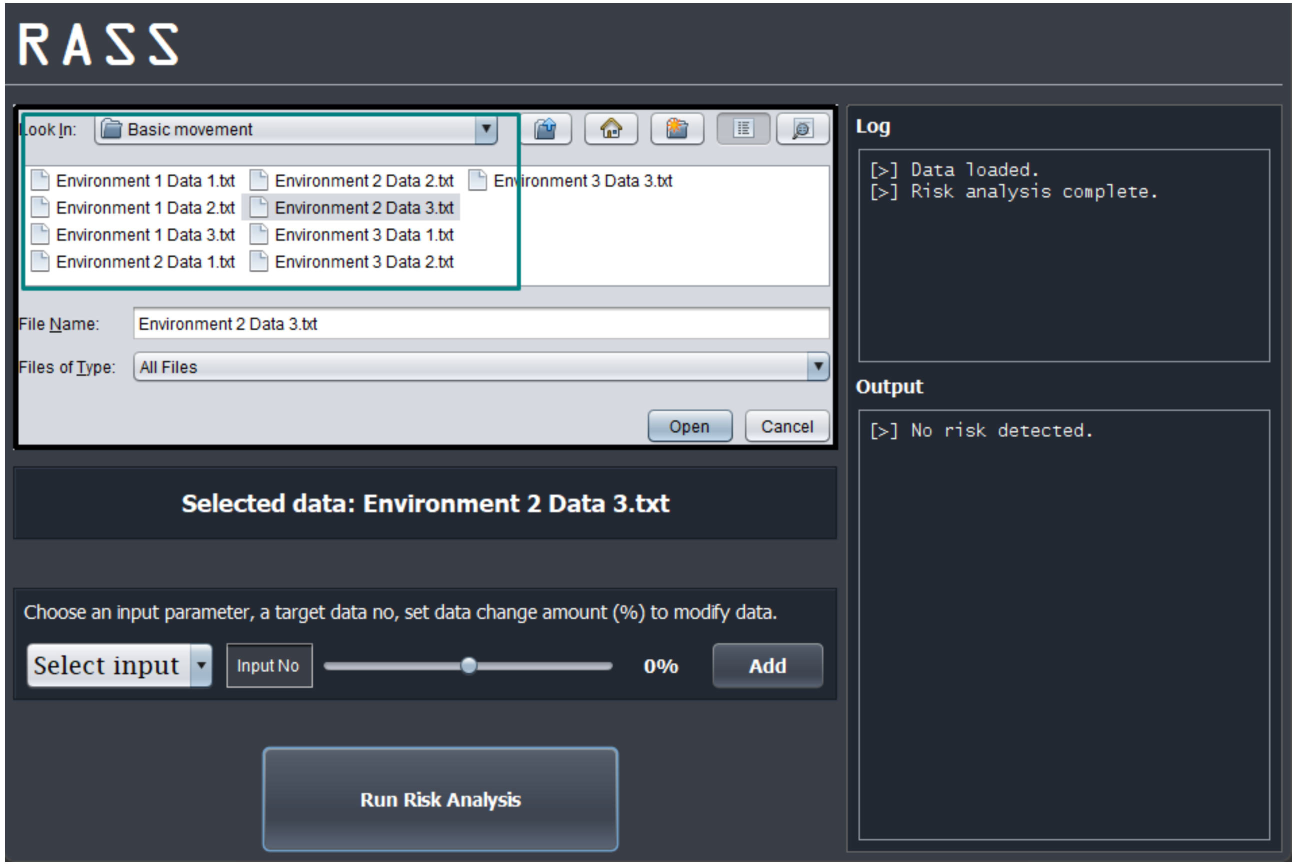


Fig: Normal event testing

EVALUATION (cont.)

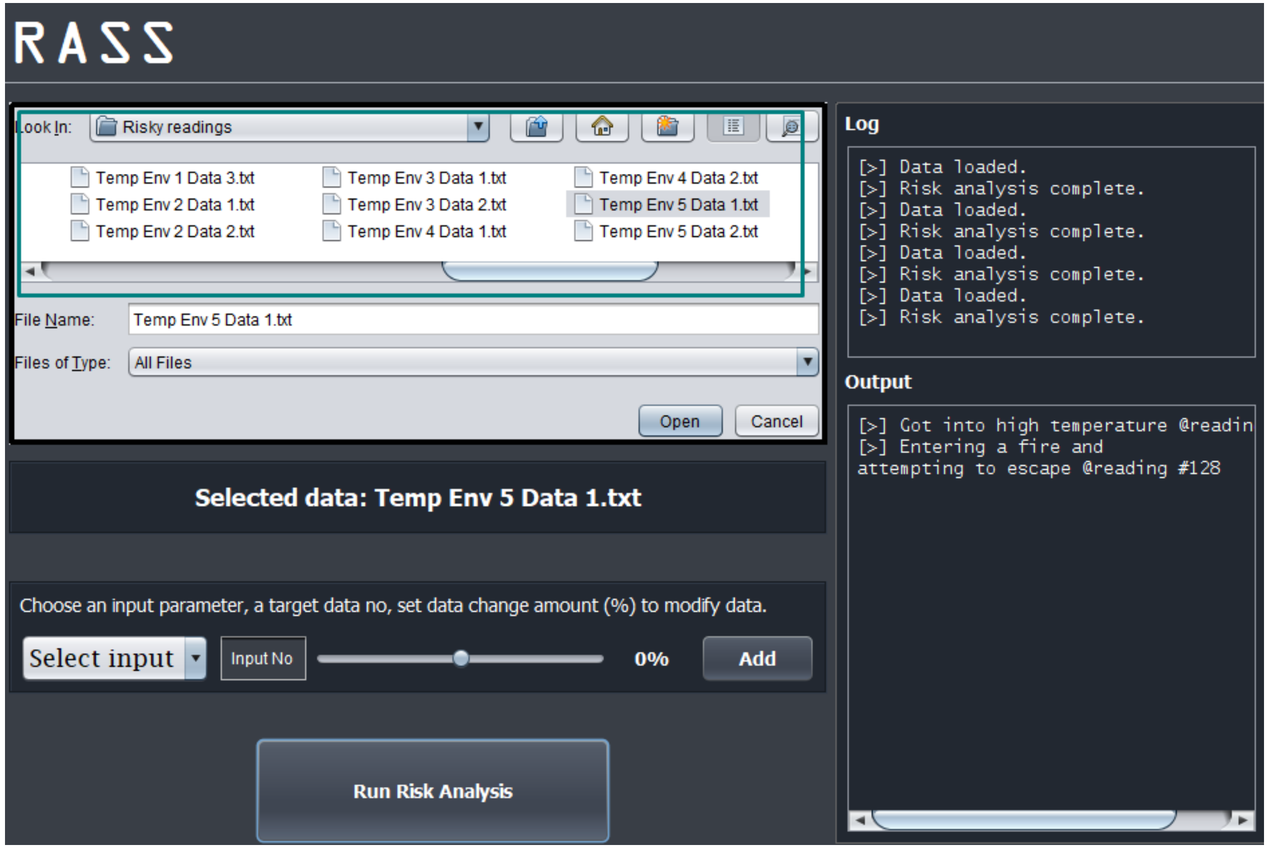


Fig: Risky event testing

COMPARATIVE RESULTS

Work	System Type	Physical risk detection	Mental risk detection	Differentiating regular vs risky event	Regular vs risky events differentiating performance	Embedded Risk Analysis	Dataset
[1]	Detection, Tracking	Yes; A Few	No	No	-	Arduino, RFID, GSM	Real-time Data
[2]	Detection, Analysis, Tracking	Yes; Several	Yes; Several	No	-	Yes; Particle photon, Arduino, Sensors, GSM	Real-time Data
[3]	Detection, Analysis	Yes; A Few	Yes; Several	Yes	Very Low	Yes; Arduino, IR, Camera	Real-time Data
[4]	Detection, Analysis	Yes; A Few	Yes; A few	Yes	Very Low	Yes; Arduino, IR, Camera	Real-time Data
Propos ed Work	Detection, Analysis, Tracking	Yes; Many	Yes; Several	Yes	Very High	Yes; Arduino, Sensors, GSM	Real-time Data

LIMITATIONS AND CHALLENGES

The system works as expected till now, but further evaluation may figure out more defects.
However some drawbacks found yet are –

- **Differentiating risky events vs regular events.**
- Limited risk detection.
- Testing is hard and risky.
- Failure propagation.
- Hart rate sensor is not capable enough.

FUTURE WORK

The work can be extended based on the previously mentioned limitations in future. New capability or extent that can be added to our existing research are -

- Adding more risk detectability
- Updating threshold with more experiments
- Advance in sensor devices

CONCLUSION

- Autistic children face many difficulties which includes life threatening risky events as well.
- Their parent or a supervisor can not always keep observing the child.
- Our proposed framework comes up with different risk detection for the sake of their safety and freedom.

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[1] A. S. Agnal, S. Janani, C. Maneesha and K. Ramya "Autism Support System using RFID Technology," Int. J. Engineering and Advanced Technology, vol. 9, no. 1, pp. 4706-4710, 2019.

[2] N. M. Abdullah and A. F. A. Allaf, "A support system for autistic children using Internet of Things technology," 2021 Int. Conf. Advanced Computer Applications (ACA), pp. 51-56, 2021.

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[4] S. Dedgaonkar, R. K. S. Bedi, K. Kothari, R. Loya and S. Godbole,"Role of IoT and ML for autistic people," Int. J. Future Generation Communication and Networking, vol. 13, no. 3, pp. 773–781, 2019.

Accepted Paper from this Thesis

[1] S. Debnath, T. Akter, S. Y. Feeham and M. S. Mia, “Risk Analysis and Support System for Children with ASD Using IoT” International Conference on Sustainable Technologies for Industry 4.0, 2022.

THANK YOU