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IoTumble

IoT and Fall Detection – cloud alerting, data logging and visualisation

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Introduction

The industry of healthcare can greatly benefit from the **Internet of Things (IoT)** and the **cloud**, specifically within **wearable** technologies and the application of **fall detection**. Detecting when a patient **falls**, and **alerting** the necessary personnel in a timely manner, could be a matter of life or death for a patient.

IoTumble provides a **wearable** device which can detect and publish possible **fall incidents** to **Amazon Web Services (AWS)**. Worn on the waist, the ***IoTumble*** device is built using the ultra-compact **Raspberry Pi Zero 2 W**, which interfaces with an accelerometer to track **3-axis acceleration**, and detect **fall incidents**.

The incidents can then be **visualised** in readable form, via the ***IoTumble*** program. Developed in **Python**, it provides an **easy-to-use GUI**, that can view the incidents published to **AWS**. The program can **plot** these incidents as **graphs**, or export them in **CSV** format.

Aims

The main aims of ***IoTumble*** were as follows:

- Develop a **comfortable** and **wearable** device that can **wirelessly** detect possible **fall incidents** from a user.
- Interface the device with **AWS** to store the accelerometer data of **fall incidents**.
- Build the necessary **AWS** architecture to hold the data, and **alert** the necessary personal in a timely manner.
- Develop an **easy-to-use GUI** program to **visualise** the data in a readable form.

Method

The method for the projects development can be separated into the following categories:

- **Hardware:** The ***IoTumble*** device was built using the **Raspberry Pi Zero 2 W**. Running on a **Linux-based OS**, the board provides **wireless** connectivity and a 40-pin header to allow for more components. The **ADXL345** accelerometer measures its **3-axis acceleration** and communicates it through **I2C**. The **LiPo SHIM** is a small PCB with a JST connector for a power supply. To reduce the devices cost and **environmental impact**, an old smartphone battery was **repurposed** by soldering a female JST wire to its pins.

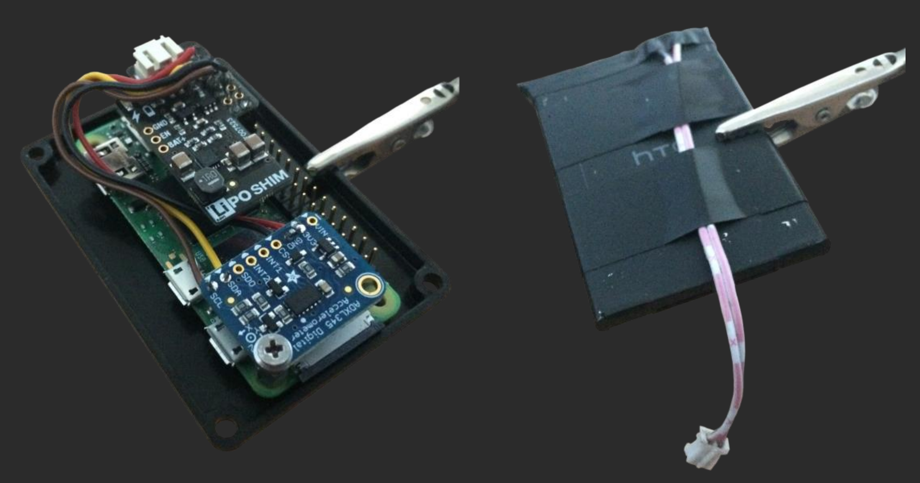


Figure 1: *IoTumble* Device and repurposed battery

- **AWS Architecture:** The diagram below shows which **AWS** services are being used and how they interact with each other.

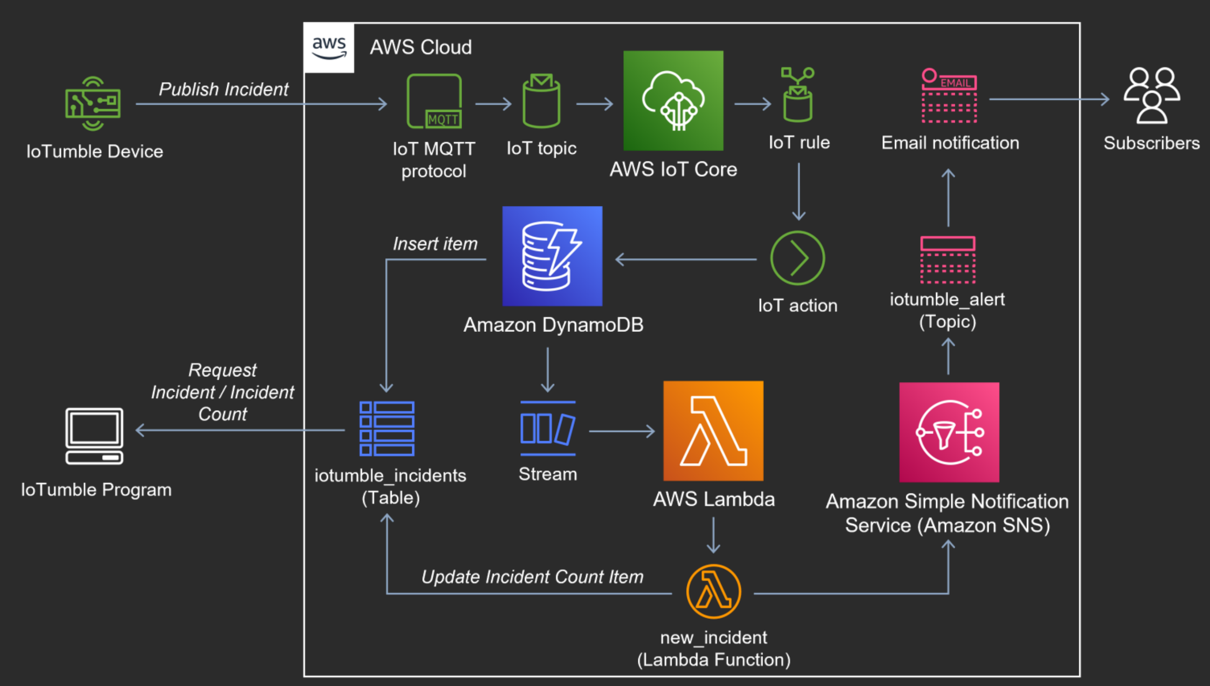


Figure 2: AWS Architecture Diagram

- **Software:** The ***IoTumble*** program was developed in **Python**. It uses **Tkinter** for its **GUI**, **Matplotlib** to plot its graphs, and the SDK **Boto3**, to allow for integration with **AWS** and the database service **DynamoDB**. The ***IoTumble*** device uses the **AWS IoT Device SDK** to access **AWS IoT** and send **MQTT** messages to a **DynamoDB** table.

Figure 3: *IoTumble* Program displaying an incident

- **Fall Detection:** The **acceleration** data is monitored and used to calculate the **Signal Vector Magnitude (SVM)**. If these go over certain thresholds, the data is combined to check if the user has become **inactive**, and if they have, it detects a possible **fall incident.**

$$\text{SVM} = \sqrt{(A_x)^2 + (A_y)^2 + (A_z)^2}$$

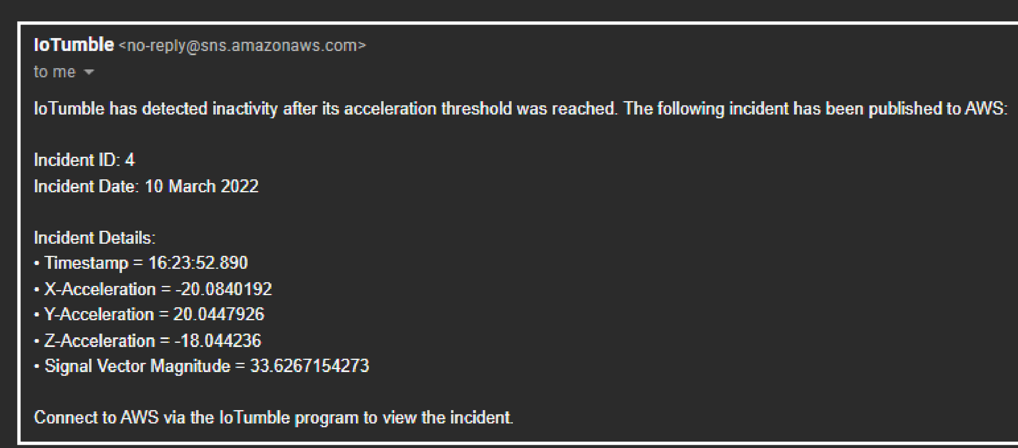
Equation 1: Signal Vector Magnitude (SVM)

Results

The first result of the project is that a **comfortable** and **wearable** device has been built to detect and publish possible **fall incidents** to **AWS**. The device sits in an old camera holder, and is attached to the users belt.

Figure 4: *IoTumble* Device attached to a belt

The second result, is that when **incidents** are inserted into a **DynamoDB** table, a **Lambda** function is called to send an **Amazon SNS** email to **alert** all subscribers of a **SNS** topic.



IoTumble <no-reply@sns.amazonaws.com>
to me

IoTumble has detected inactivity after its acceleration threshold was reached. The following incident has been published to AWS:

Incident ID: 4
Incident Date: 10 March 2022

Incident Details:
- Timestamp = 16:23:52.890
- X-Acceleration = -20.0840192
- Y-Acceleration = 20.0447926
- Z-Acceleration = -18.044236
- Signal Vector Magnitude = 33.6267154273

Connect to AWS via the IoTumble program to view the incident.

Figure 5: Amazon *SNS Email for a detected incident*

Lastly, an **accessible GUI** program has been developed to view **incidents** published to **AWS**. The **incidents** can then be exported in **CSV** format or **plotted** as a selected **graph**.

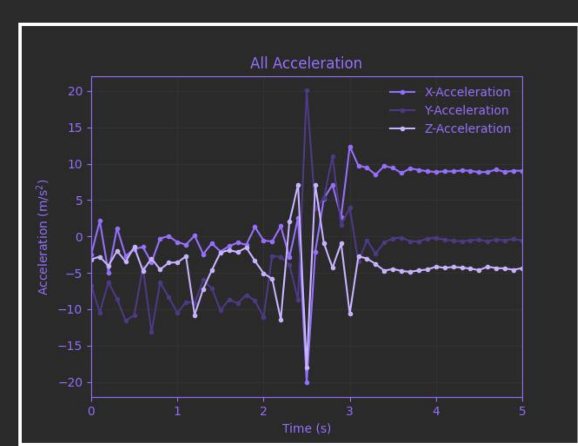


Figure 6: Graph showing thresholds being reached, followed by inactivity

Conclusion and Reflection

In conclusion, the development of ***IoTumble*** has been a success. I have become more **knowledgeable** in the field of **IoT** and **cloud** applications. I have improved my **creative** skills, by developing a stylised **GUI**. I have further developed my **technical skills**, particularly in **AWS**, **embedded systems**, and **Python**. If I was to change an aspect of the project, I would incorporate a **gyroscope** sensor to calculate the angular motion of the device, and produce more accurate **fall detections**.

Acknowledgements

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