Emergency Info Hub

Research Manual

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Abstract

Emergency Info Hub (EIH), Is a central website that helps the emergency services to prepare for, respond to & recover from disaster, by providing all needed data for the targeted building (E.g. Number of people, area size and emergency exits).

The main objective of this project is giving the number of trapped people under rubbles or inside a building, by tracking their number using a simple movement sensor fitted on the main gate and face detection technology and save this number to the cloud to be used when a disaster happens

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1. Introduction

During the 21st century, the statics shows that over 60.000 persons have gone missing since the Syrian war start in 2011[1]. And more than 522 significant earthquakes happened [2], causing more than 430,000 death cases worldwide [3]. Most deaths are caused by building collapsing and trapping people under rubbles. Any the majority of adult people can stay for about 72 h under the rubbles if they were in good body and health situation with a sufficient amount of oxygen to survive [4]. The amount of available oxygen makes a difference to the time limit that the trapped person could still alive, where it is possible to the body to survive for more than three weeks without food, but only one week without water, where at least 60% of the adult body is the living body cells, and the water is needed to keep it functioning [5]. Several cases were survived after being under the rubbles for more than 14 days [6]. There are different methods are used now for searching on people under rubbles, asking survival about if they know about any others were with or around them on of the traditional methods to use, besides the technical methods which are based on camera and sound detections to check if people are under the rubbles or not [7]. However, the primary objective of the rescue team is to assess two basic characteristics of the search area: enough place to survive, and the stability of the size of the rubble [8]. To reduce the risk of rescue operations and injury. Rescue teams are currently using - life-detection systems based mainly on microphones, photovoltaic/thermal cameras and Doppler radar [16]. Voice signal analysis is an effective way to detect people trapped in the rubble, and some systems are already commercially available, such as Acoustic Life Detector, which relies on the processing of audio signals to identify low-frequency sounds for victims. Furthermore, many refined sound processing algorithms have been developed to detect human existence [9, 10]. Darren Buchanan | Assistant Chief Fire Officer, in Carlow has mentioned different tools in use for all different emergency cases to plan and prepare such as **Major Emergency Management** (**MEM**): *"to set out common arrangements and structures for front-line public-sector emergency management in Ireland"[11].* **Building Control Management System (BCMS)** *"A commencement notice is required to give notice to Building Control Authorities of the erection of such buildings, or classes of buildings, or the carrying out of such works, or classes of works, as may be specified in the regulations." [12].* The current methods of the **Syrian Civil Defense (SCD)** for the 9 years of dealing with a lot of different emergency cases during the Syrian war is mainly based on asking questions to the survivors about the number of the people they were with when the building collapsed and using the Hasty Search Kit to detect if there any movement can be detected [13,14].

The objective of this study is to evaluate the performance of a system based on:

- Raspberry Pi 4 board
- Raspberry Pi Camera Module
- PIR motion sensor module

to keep tracking of human number entering and exiting a building by detecting their faces and movement to store this number on the cloud for emergency cases. Which make easy to help the emergency services to prepare for, respond to & recover from the disaster.

2. Technologies, Operating System and Algorithms researched

2.1. How it works:

2.1.1 Front End:

At this point, for the front end, the pre imagination of the workflow will be with a simple website ask for the Eircode and the user click search. Then the APIs will be working with the Databases to fill the rows and columns of the table to display the needed information to the user **Figure 1.**

Figure 1 ***How it works - Front End***

2.1.2 Back-End

At this point, the back end will mainly depend on Raspberry Pi board with its sensors and Camera to be the main input for the system and feed the database with the relative and needed pieces of information in **figure 2.**

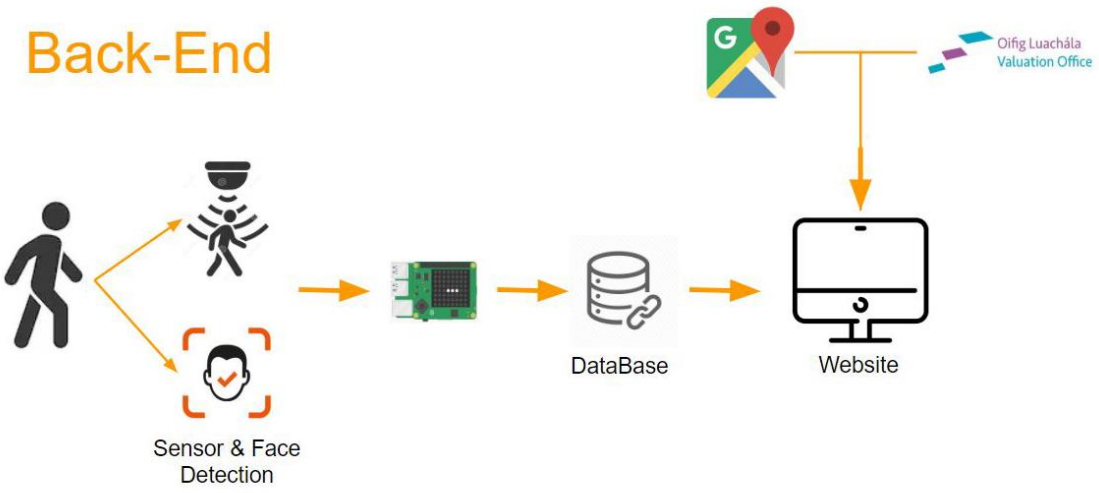

Figure 2 ***How it works - Back End***

2.2. Governmental helpful APIs:

Some Irish department provides some useful details by their APIs might be helpful for the project where it could be used as an external resource to feed the project with useful data about the Irish public buildings like:

1- **landdirect.ie**

"landdirect.ie is an online service from the Property Registration Authority (PRA). This site allows our customers access to many Land Registry services including searching the Registry map and viewing documents." Land direct website.

2- **valoff.ie**

"independent Government Office, under the aegis of Department of Housing, Planning and Local Government, staffed by civil servants." Evaluation office.

This API can provide a lot of information for all the Irish registered buildings such as the Building number, address, level numbers, car park size, the use, and the area.

These APIs could be used as an authorized source alongside with the main database and show out all the information to the users depending on any address request.

2.3. Operating Systems to use

During the research time, **Linux** is one of the tops uses the system in the computing world besides **Windows** and **IOS, figure 3,** and it became more popular in the programming world as it: Open Source, Secure and it can be used on poor hardware.

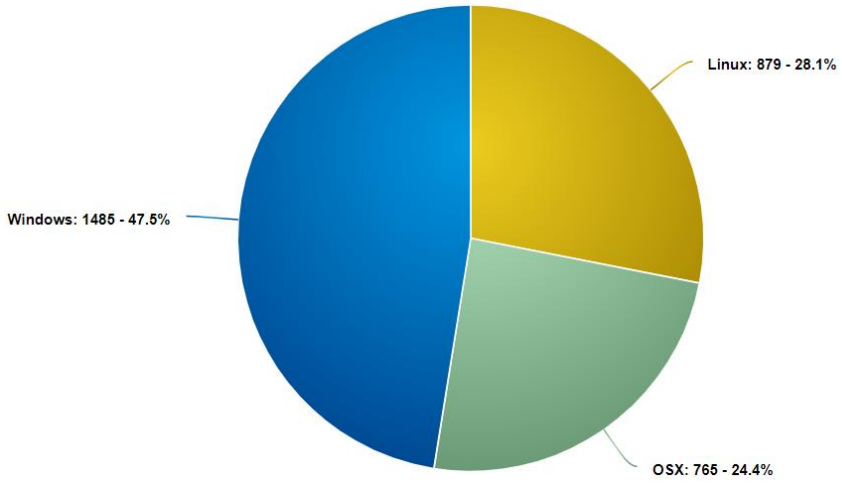

Figure 3 ***Operating System users Source: Medium. (2019). PC vs Mac vs Linux Users 2019***

Most of the developer show that they are using Linux as their main operating system for their Internet Of Things (IoT) devices, wherewith Linux environment the developers feels more powerful and the ability to connect and control all different components i.e. Sensors, Cameras, and I/O devices.[15] where is more than *"71.8 percent of respondents ticked "Linux" to the choose-all-that-apply question, "What operating system(s) do you use for your IoT devices?" Windows came in second with 22.9 percent, followed by FreeRTOS with 20.4 percent. The answer "No OS/Bare-metal" took fourth place with a 19.9 percent tally. No other operating system received higher than a 10 percent vote"*. **figure 4**

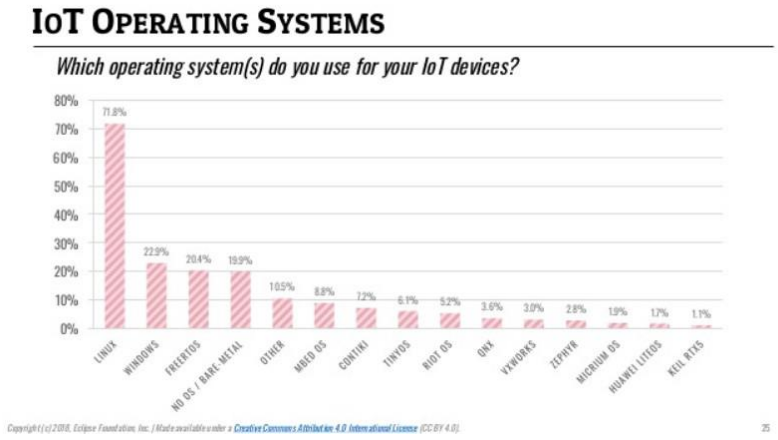

Figure 4 ***which operating system used more in IoT devices. Source: Hall, C. (2019). Survey Shows Linux the Top Operating System for Internet of Things Devices. [online]***

2.4. Python

From the research related to the project structure, we found that Python is one of the most suitable languages to be the main language of this project use. As the study shows that python is ranked 2 as the most usable language worldwide with more than 2.8 million users during 2019 **Figure 5**.

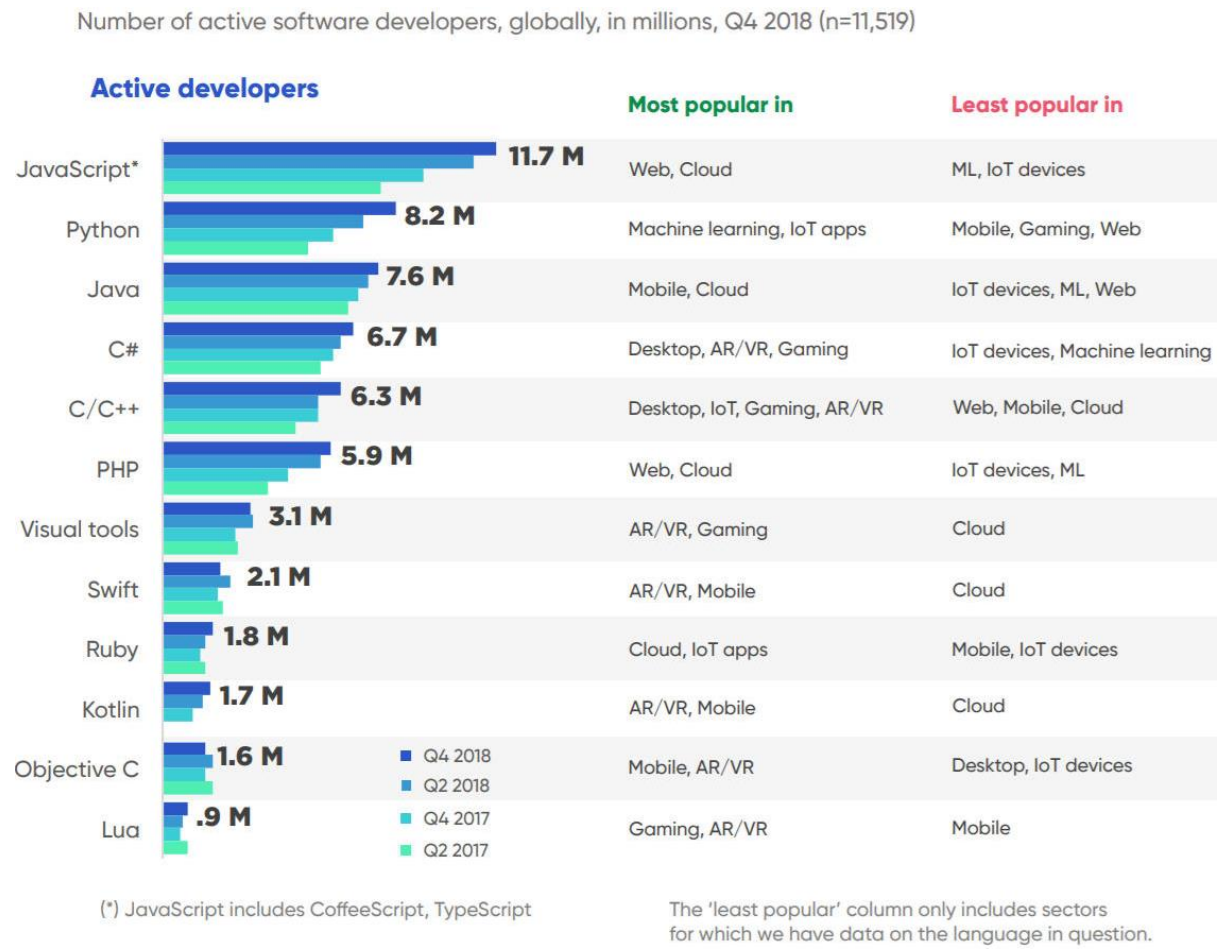

*Figure 5. **number of active software developers globally. Source: zdnet.com***

2.5. Face/body detection.

It is easy for a human to detect all different types of faces but the computer needs instruction to identify the faces. Face detection is distinct from other computer vision technologies that include human faces, such as face recognition, analysis, and tracking.

2.5.1. Face Recognition: it's usually used for biometrics purposes, like smartphone unlocking. Where every face is unique which it makes it easy to differentiate that face X is not facing Y

2.5.2. Face Analysis**:** it's usually used to determine the face reaction from the people such as their age or the emotions.

2.5.3. Face Tracking**:** is usually used for videos and photo purposes, where the camera focus keeps tracking the faces. Camera filters are the most popular application for face trackings like Instagram and Snapchat.

all these methods are different technologies used for different purposes where in this project face detection is the technology that will help detect and count the number of faces [16].

2.5.4. How Do Computers "see" images?

The way that computers see the images is different from humans, computers understand numbers only, were digital images must be stored in numbers to be understood by computers. Images made of the number of rows and columns of pixels which is the smallest elements of an image, the computer uses color models to translate this image into numbers, each pixel in black and white images is a single number representing the amount of light in this pixel, while colored images are represented in RGB color model, RGB stands for Red, Green, Blue which is represented by three numbers **figure 6**. Combining the pixels rows and columns create an image [16].

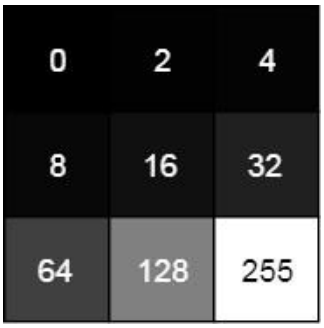

Figure 6 ***Example 3x3 image with pixel values and colors source: realpython.com***

OpenCV (Open Source Computer Vision Library) is an open-source computer vision and machine learning software library takes images as an input. OpenCV already contains many pre-trained algorithms to detect faces, eyes, smile,etc.. by providing python API to take an image as an input and able all the different function to detect if faces founded or not using Haar-like feature to detect eyes **figure 7** and nose **figure 8** [17].

Figure 7 ***Haar-like feature applied on the eye region****. (Image: Wikipedia)*

Figure 8 ***Haar-like feature applied on the bridge of the nose****. (Image: Wikipedia)*

3. Material and Hardware to use

3.1 Comparing Raspberry Pi 4 and Arduino

Several different hardware was taking a part of the research as the project requires the use of some device that monitors the movement and capture the photo of the public whose a moving toward the doors to count them by increment the counter as they moving inside and decrement the counter as they are moving outside of the buildings.

There main two controller boards were in the research Arduino and Raspberry Pi 4. On the surface, these boards loo about the same. They are a couple of circuit boards with some ships and me/O connectors, and the differences between these boards are **Table 1**

	Arduino Uno 3	**Raspberry Pi 4**
Price	30$	36$
Size	7.6 * 1.9 * 6.4 cm	8.5 * 5.6 * 1.7 cm
Memory	0.0002 MB	4 GB
GPIO	14	40
Clock Speed	16 MHz	1.5 GHz
On-Board Network	None	Gigabit Ethernet
Multitasking	No	Yes
Input Voltage	7 to 12 V	5 V
Flash Memory	32 KB	Micro-SD card slot for loading operating system and data storage
USB	One input only	2x USB 3.0 ports; 2x USB 2.0 ports
Operating System	None	Linux

Table 1 ***Arduino Vs Raspberry Pi 4 model B specifications. Source:*** *ReadWrite, The Pi Hut* ***[18, 19]***

Overall Raspberry Pi has more common with the normal computer than it does in Arduino. For example, instead of writing code to control the hardware directly, you are writing programs that run within an operating system. And for Raspberry Pi the operating system is Linux

Arduino is a microcontroller and the Raspberry Pi is a microprocessor. They both have a CPU to execute the instruction, timer and memory, and I/O pins. Microcontroller tends to have a strong I/O capability so that they can drive extra hardware directly, while Microprocessor then to have and I/O which need transistors to drive most hardware. The microprocessor is good at processing, so they are a little bit brainier than a microcontroller. For comparing the Arduino to Raspberry Pi we see that the Arduino is based on 32-bit architecture. The Arduino ram is measured in the kilobytes while the Raspberry Pi is measured in the hundreds of megabytes. The Arduino has no operating system while the raspberry Pi has a typical Linux operating system [20].

And for my project needs where are the camera and the sensor is taking a big part of the project the Raspberry Pi will be a better option.

3.2. PIR motion sensors

3.2.1 what is PIR Sensors

This project will be using a Passive Infrared (PIR) motion sensor. they are often used in burglar alarm systems. It has a long-range, wide-angle and low consumption. It has 3 pins GND, OUT and VCC with 2 adjustable switches one for Sensitivity adjustment up to 7m and the second one delay time 0.3 second – 3 minutes **figure 9.**

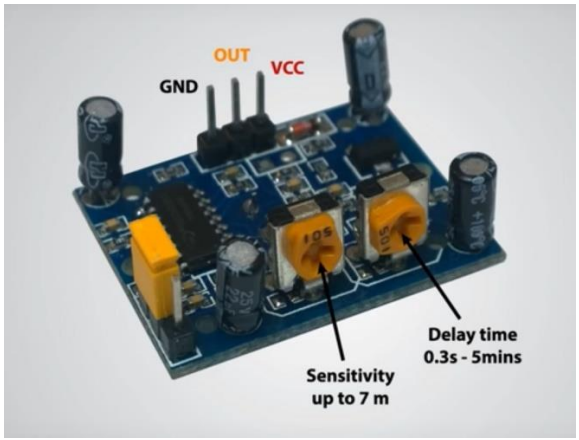

Figure 9 ***How PIR Sensor Works, Source:*** *YouTube. (2019).* ***[21].***

3.2.2 How it works

The PIR sensor is made up of two slots both are sensitive to Infrared (**IR**), both slots are detecting the same amount of IR in the idle status which is not visible to the human. Interacting with the two half of the seniors' beams generate a positive difference when a warm object intercepts it when this object leaves the detected area that will make a negative change. These positive and negative changes are detecting to send a signal to the main connected board [8]. If the temperature of an object or organism is above absolute zero (that's −273.15°C!), it emits infrared radiation. Infrared wavelengths are not visible to the human eye, but they can be detected by the electronics inside a PIR sensor. **As shown in Figure 10** [22].

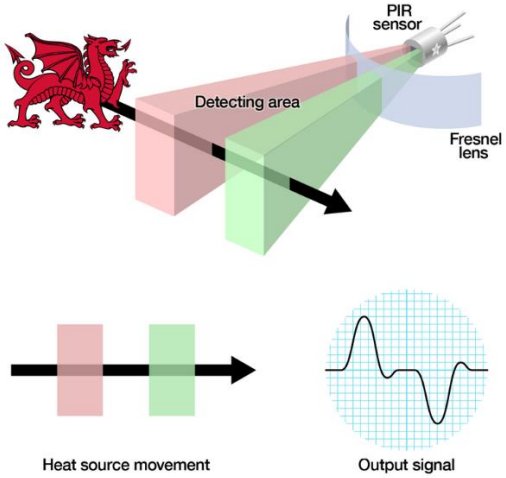

Figure 10 ***PIR Sensor Working. Source: learn.adafruit.com. (2019).***

3.3. IR Break Beam Sensors.

IR Break Beam sensors **figure 11** is the simplest way to detect motion, they work by having an emitter side and receiver side. The emitter sends out beams are not visible to the human, the receiver which is aligned across the way from the sender is sensitive to the same light. If an object beak the beam between the two sensors and it is not transparent to the IR beam, the sensors will change their status from High to low.

Comparing to the PIR sensors, they are faster and less expensive, the IR sensors can be targeting and specific are. However, you do need both emitter and receiver on opposite sides of the area you want to monitor[26].

Figure 9 Adafruit IR Break Beam Sensor

Technical details:

* Sensing Distance: can be in a different range.

* Power Voltage: 3.3 - 5.5VDC

* Response Time: <2 ms

These sensors can have a different implementing use in my project with different use cases.

3.3. Raspberry Pi Camera

Raspberry Pi Camera V2 Module will be used as a Raspberry Pi component to take a photo of the people approaching the doors and moving either inside or outside. The V2 model of these cameras is a camera board released by the Raspberry Pi foundation. Where it is a high quality of 8 megapixels made by **Sony** this camera is more like the phone cameras with 3280 * 2464 pixels for images and 1080 p30 for the videos. Easy to plug in and plug out with ribbon cable with the Raspberry Pi camera port. It has the self-focus lens, board size of 25mm * 23mm * 9 mm, 3 grams of weight [23]. The night vision Raspberry Pi NoIR camera was taking part in the research where it has the same specification of the normal camera with a night vision support of night time. And both of these cameras can needed face detection within this project. **Figure 11** Raspberry PI V2 camera and the Night vision camera

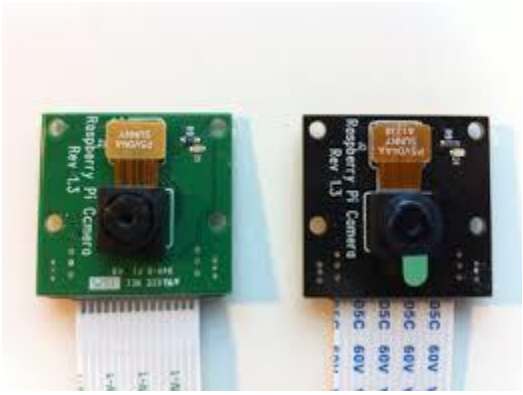

Figure 11 ***Raspberry PI V2 camera and the Night vison camera Source: frederickvandenbosch.be (2019)***

4. Similar projects.

During the research for this project, there were no existing systems or applications exactly like this project, where most of the previous has been done with the help and save the trapped people were not fully implemented as they either expensive or not doable. Most of the other researches their action was to be taken after the building collapsing happened, where they were looking on how to detect and help trapped under rubbles by detecting their number using a different type of system, implementations and sensors, comparing to this project where is a simple, cheap and easy system and hardware used and the project is running 24 hours a day for the full week and keep tracking the number to be ready to use when needed. One of the close research to EIH was study has been proposed to the "**US National Library Of Medicine National Institute Of Health**" in 2018 Mar, **PMCID: PMC5877370** by **Di Zhang**, **Salvatore Sessa**, **Ritaro Kasai**, **Sarah Cosentino** , **Cimarelli Giacomo**, **Yasuaki Mochida**, **Hiroya Yamada**, **Michele Guarnieri**, and **Atsuo Takanishi** [24]. The main purpose of this study was to create a new system that will be used to help to find the trapped people under rubbles after a building collapsed. The system was composed of these three types of sensors:

- Gas sensors (O_2 and CO_2) for the detection of human breath and quality of air.
- Microphones for the detection of voices, human-produced sounds, or environmental noise.
- Thermal vision camera for a direct view of the environment, localized temperature patterns.

Where it could be used by the emergency services to help the trapped people to be found. This project was tested in a site at the Singapore Civil Defence Force (**SCDF**) which is one of the collapsed areas with approximately (192 m^2) organized as a grid of cells of 2m * 2m. the test start with pre-experience about the building structure, a person entered the area randomly under the rubbles to be tested with distributing the sensors on the surface between the rubbles, the system was tested and mentored for three trail days and the results were recorded three times per day (a morning, an afternoon, and an evening trail) which is equal to nine trails in total for the three days. T**able 2** shows the results and the time is taken for each try, eight out of nine trails were successful with about 1 hour on average. Where 80% of the survivors recovered alive if rescued within 48 hours [24].

Table 1

Global results of the tests.

TEST	Execution Time	Result
Day 1 morning	1 h 35 min	Success
Day 1 afternoon	56 min	Success
Day 1 evening	1 h 25 min	Success
Day 2 morning	33 min	Success
Day 2 afternoon	50 min	Success
Day 2 evening	1 h 12 min	Failed
Day 3 morning	2 h 13 min	Success
Day 3 afternoon	20 min	Success
Day 3 evening	31 min	Success

*Table 2 the **results and the time taken for each try Source:** ncbi.nlm.nih.gov (2019)*

Another project was developed in 2013, Radar-based technology named **Finding Individuals for Disaster and Emergency Response (FINDER)** has been developed by the Department of Homeland Security's Science and Technology Directorate (S&T) and the National Aeronautics Space Administration's Jet Propulsion Laboratory

(JPL) was looking to detect a human heartbeat for the alive people under 30 feet of crushed materials, hidden behind 20 feet of solid concrete, and from a distance of 100 feet in open spaces. **Figure 14** shows the demo of the device

Figure 12 FINDER ***Demo, Source: (Department of Homeland Security, 2019)***

Where this project was mainly based on detecting heartbeats after a disaster happened as the emergency team move the device near to the collapsed building and get used to detect if any heartbeat was founded or not. *"Testing proved successful in locating a VA-TF1 member buried in 30 feet of mixed concrete, rebar, and gravel rubble from a distance of over 30 feet," said John Price*. The developers of this project were looking to keep working on developing this project not just detect the presence of a victim, but also more details to specify where is the victim located [25].

5. Summary and Conclusions

In this project, a new system including Software and Hardware designed to detect the human faces and store the number of people entering and exiting a building and use this number to figure out how many people trapped under the rubbles during a disaster when it's happening. The number of people got loss every year following earthquakes or a disaster shows the need for this project as many lives can be saved if the emergency services were notified about them. Linux, Python and all the technologies that were represented in this report show the effectiveness and quality to be used. The Raspberry Pi, RIP Sensor, and the Camera were proposed and tested. The effectiveness of the hardware was evaluated and confirmed.

Following step work, the system design and the user interface will be designed to deliver the information stored by a simple website takes the Eircode or the Address as user input and output the building details in addition to the current number of people stored.

In future step work, implementing this project in the real-life example to check the quality and the accuracy of the entire system (back-end and front-end). Develop this project to be able to detect the number of people within the rooms and smaller areas.

6. Plagiarism Declaration

Declaration

* I declare that all material in this submission e.g. thesis/essay/project/assignment is entirely my/our own work except where duly acknowledged.
* I have cited the sources of all quotations, paraphrases, summaries of information, tables, diagrams or other material; including software and other electronic media in which intellectual property rights may reside.
* I have provided a complete bibliography of all works and sources used in the preparation of this submission.
* I understand that failure to comply with the Institute's regulations governing plagiarism constitutes a serious offence.

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Student Number(s): C00220135

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