CM3203 – One Semester Individual Project - 40 Credits

Initial Plan- Develop an IoT Edge device to Capture and Classify Species using Sounds to Support Wildlife Conservation Activities

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Project Description

History and Context

Automatic sound recognition has been a thing for a while, the first system that used such technology was called Audrey developed in 1952 by Bell Laboratories (Sonix, 2021), it was a speech recognition system that was used to identify spoken numbers. Today, there are many examples of systems and projects that use machine learning techniques to perform complex sound recognition, in particular for animal classification. For example, Microsoft developed a project that would classify an endangered bird species using sound with a limited amount of training data (Microsoft, 2020). Another example is a research paper on automatic species recognition using acoustic as identification, that takes all kinds of recording conditions and factors into an account (Stowell, 2019).

Problem

Wildlife has been in danger for quite some time due to many factors such as poaching activities and climate change. All of the factors are caused due to the human destructive nature, which impacts not only the wildlife but also human's lives. According to the Worldwide Fund for Nature, it has been estimated that global wildlife population has dropped by 68% since 1970 (WWF, 2020). As well, according to United Nations, it has been found that over a million of species are now at risk of extinction (United Nations, 2019). Cardiff University is one of many organisations that try to mitigate the effect and save wildlife through conservation projects and research activities, with one of their managed facilities called Danau Girang Field Centre in Sabah, Malaysia. One of the key conservation activities the facility undertakes is understanding and monitoring the whereabouts of different species in the wild, which then will be used to develop plans and tactics on how to protect them. For example, planning to perform reforestation to provide a healthy habitat for increasing number of animals in an area. In terms of what already out on the market, there are recording devices that only capture the sound and then use further proprietary software to classify sounds. However, they are very expensive and not easy to use, an example of such device is Song Meter SM4 acoustic recorder for $849.00 (Wildlife Acoustics, 2021).

Project Overview

For my project, I will develop an IoT Edge device that will capture and classify species using sounds. This will be a low-cost edge device, that will classify sounds right on the device and then will send the results as messages over the chosen long-range wireless network. This device will be able to show which animals have been recognised, at what times and locations. The device will be a budget alternative, hopefully with the same accuracy and precision as already existent devices that will be used to support wildlife conservation activities carried out in the previously mentioned University's research facility.

Overall Aims

The project will be divided into two development areas, one for the IoT architecture, this cycle will be responsible for creating a self-powered hardware solution with an ability to run the machine learning model. As well, this will include designing an IoT framework that will be responsible for reading data from audio sensors to pass to the model and then sending model's predictions over the network to any listening device. Also, during this phase to

make the project more practical, a 3D case will be created to ensure that the device could be installed on different surfaces and tested in the real world. The second development cycle would be responsible for creating a valid neural network model that will predict animals based on the audio inputs. This will include designing neural network model, training the model, and then testing and verifying it against other existent models.

Ethical Approval

As I will be purely working on animal data that is available publicly and will not involve human nor animal participants at any point of the project, I therefore will not require an ethical approval.

Project Aims and Objectives

Here is a list of aims and objectives, that I am expected to achieve on finishing the project successfully.

Designing IoT Architecture

My first objective I was set to achieve is to create hardware solutions on two different platforms Arduino microcontroller and Raspberry Pi single-board computer. These solutions will be required to transmit messages wirelessly, be energy efficient, take audio inputs, ability to run machine learning models and should be battery-powered. As well, systematic evaluation and measurement will be carried out to evaluate both architectures, this will include measuring machine learning model performance on the device, energy consumption, resource utilisation and more. Both hardware solutions' capabilities will be measured to understand each other trade-offs and which architecture is the most suitable for the developed model.

Create IoT Framework

One of the main objectives is to allow Machine Learning model to be deployed to IoT solutions. For this, an IoT framework would be created that would manage sensor input and forward it to the installed model, store results locally and then transmit specific results over the wireless network to any listening devices.

Creating 3D Case Solution for Devices

Another aim of the project is to make the device solutions deployable in real environments, making sure that they are weather resistant by protecting the whole device. For this, a 3D case would need to be designed for both Raspberry Pi and Arduino solutions, that would be printed and tested to make sure it fits all devices and sensors. These cases are required to capture all of the equipment, but at the same time are required to provide holes/openings for the microphone. As well, the case is required to support different kinds of installations (e.g. zip ties, screws) on various surface areas.

Designing and Create Machine Learning Model

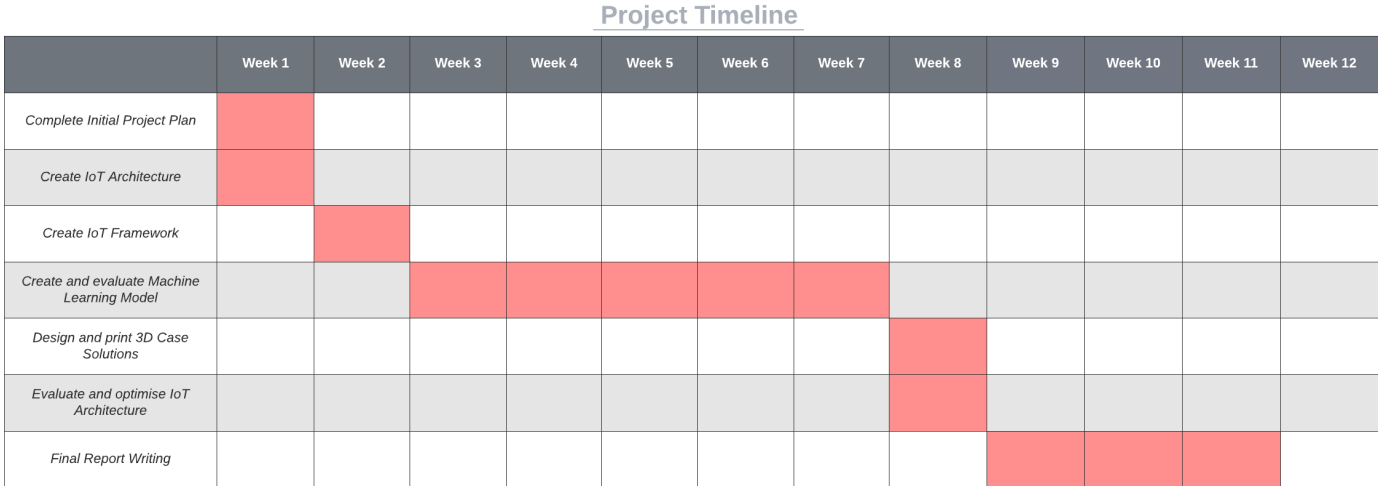
Another main objective is to create a Machine Learning model that would classify sounds of animals. It has not been specified which animal type would be within the model's context, which I will be required to choose. I am also expected to evaluate the performance of the model by comparing it to an already existent model to see if it has the same accuracy. I will

measure all kinds of metrics such as recall, F1 score and confusion matrix to analyse the performance which would be then used to improve the model. The main aim for the model is to have a similar accuracy level as other existent models, being able to confidently classify animals within real world environment.

Work Plan

During the development process, I am planning to constantly take notes that can later be used to write up the report. Additionally, I am planning to have short 30-minute meetings every week with my supervisor, to discuss the progress I have made on the project and ask for any guidance if needed.

Gantt Chart



Milestones, Goals and Tasks

Week	Milestones	Goals	Tasks
1	• IoT Architecture Completed. • Initial Project Plan Submitted.	• Complete Initial Project Plan. • Order all required equipment and sensors for the project.	• Write Initial Project Plan and discuss it with the supervisor. • Research and create a list of devices, sensors and equipment that will be used in the project, for both Raspberry Pi and Arduino solutions (battery solutions, sensors, equipment for development, transmission devices). • Forward the hardware list to university for them to purchase.

2	IoT Framework Completed.	• Get familiar with Edge Impulse (Edge Impulse, 2019) that will be used to train the model. • Create a basic IoT framework that will take inputs, send them to the model and transmit the results wirelessly for both Raspberry Pi and Arduino platforms.	• Write modules for both solutions to take audio input from sensors and feed it to the model. Store the result locally. • Create a simple ML model that classifies “yes” and “no” key words. And then deploy the model to the created architecture. • Develop a process that would wirelessly transmit model’s results over a chosen network. Write a documentation on how to listen to the results using a laptop/computer.
3		• Understand Machine Learning Concepts. • Collect and augment learning data that will be used to train the model.	• Do some background reading for Machine Learning. Read research papers on audio processing. • Choose an animal type the model will be classifying. Do some research on the real data implications. • Research what Machine Learning models are out there that classify the same type of animal. • Collect learning data and perform data augmentation on it, that will make the model prone to possible background noises.
4		• Create a basic model that will classify animal sounds.	• Design a feasible machine learning model.

			• Choose a set of features for analysing patterns in data. • Train the model with training data. • Try deploying the model to both hardware solutions, to make sure hardware can run the model.
5 6	Machine Learning Model Created.	• Adjusting the model to improve the performance. • First major review meeting with supervisor to discuss progression in more detail.	• An iterative process of tinkering with the model and evaluating its performance to find the best combination of parameters. • Evaluate the model against an already existent model that was previously found. • Record and visualise all evaluations. • Perform a major review meeting with supervisor.
7	• Machine Learning Model Evaluated. • IoT Architecture Evaluated.	• Optimise IoT architecture if needed. • Testing out the model in real world. • Evaluate both architectures.	• Deploy and evaluate the model running on both hardware solutions. Carry out real life tests. • Carry out systematic evaluation for both architectures. • If there are any issues with models running on the current architecture, research about different optimisation strategies and implement them.
8	3D Case Solutions Completed.	• Design a 3D case solution for both Raspberry Pi and Arduino solutions.	• Design and print case solutions for both devices. • Carry out practical tests: install them on

			various surfaces, fit devices inside the case. • Most likely will not fit the first time. Make revisions if needed.
9		• Start producing report	• Begin writing the report using all of the notes collected throughout the development. • Collect necessary figures, references, resources and more.
E1		Used for the Easter break. In case running behind on the project, the time here will be used to catch up.	
E2			
E3			
10		• Progress on the report towards presentable state. • Second major review meeting with supervisor.	• Continue writing the report. • Carry out another major meeting with supervisor to showcase project progression. Ask them to undertake a report review.
11	Final Report Submitted.	• Finalise report	• Finish writing the report. • Implement review changes that were discussed in the meeting. • Reread the report and submit.
12		• Extra week in case running behind with writing the report.	

References

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