MAKERERE UNIVERSITY

An Urban Noise Classification Model for Edge devices

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Outline

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- Objectives
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- Methodology
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- Work Plan

Introduction

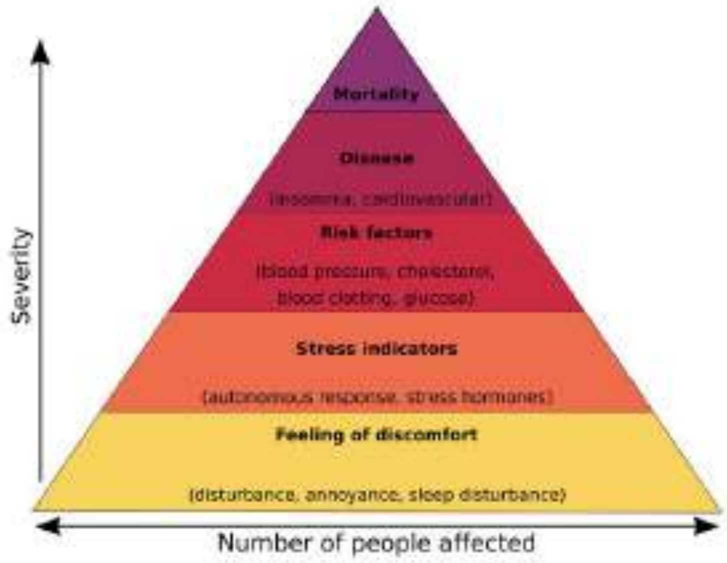
Sound - What we Hear?

World Health Organization - Noise is unwanted sound. Depends on listener and context. SI Unit - ***Decibel***

Exposure to environmental noise - increased risk of negative physiological and psychological health outcomes.

Limited knowledge on noise sources and population exposure - developing world cities higher risk.

Over 5% of the world's population require rehabilitation for ***disabling hearing loss*** (As of 2019, 432 million adults and 34 million children). By 2050, 700 million.



Introduction

Measured using a sound level meter by City Authorities. For the case of Uganda, National Environmental Management Authority, Kampala Capital City Authority.

Adaptation of Environmental Sensing: Sounds of New York City - 55 smart acoustic sensors.

Involves use of microcontroller based edge devices to capture and process data relating to noise exposure (both intensity and source).

This research therefore seeks to build, deploy and assess performance of an optimal noise classification model on an edge device to provide noise pollution statistics for evidence based policy making.

Problem Statement

It is resource intensive to continuously send field agents with handheld monitors to measure noise.

Instantaneous noise measurement gives false representation of the noise landscape.

Visual on-site tracking of noise sources is quite challenging, tedious.

High battery consumption on edge devices to transmit raw audio files to a remote server.

High computing requirements to deploy online model for classifying audio data.

Conversion of a noise classifier model from Google Colab - Retain Performance.

Optimal memory management on the edge device to ensure proper functionality.

Objectives

Main Objective

To implement, deploy, and assess performance of an optimal machine learning model for noise classification on urban IoT-enabled edge devices.

Specific Objectives

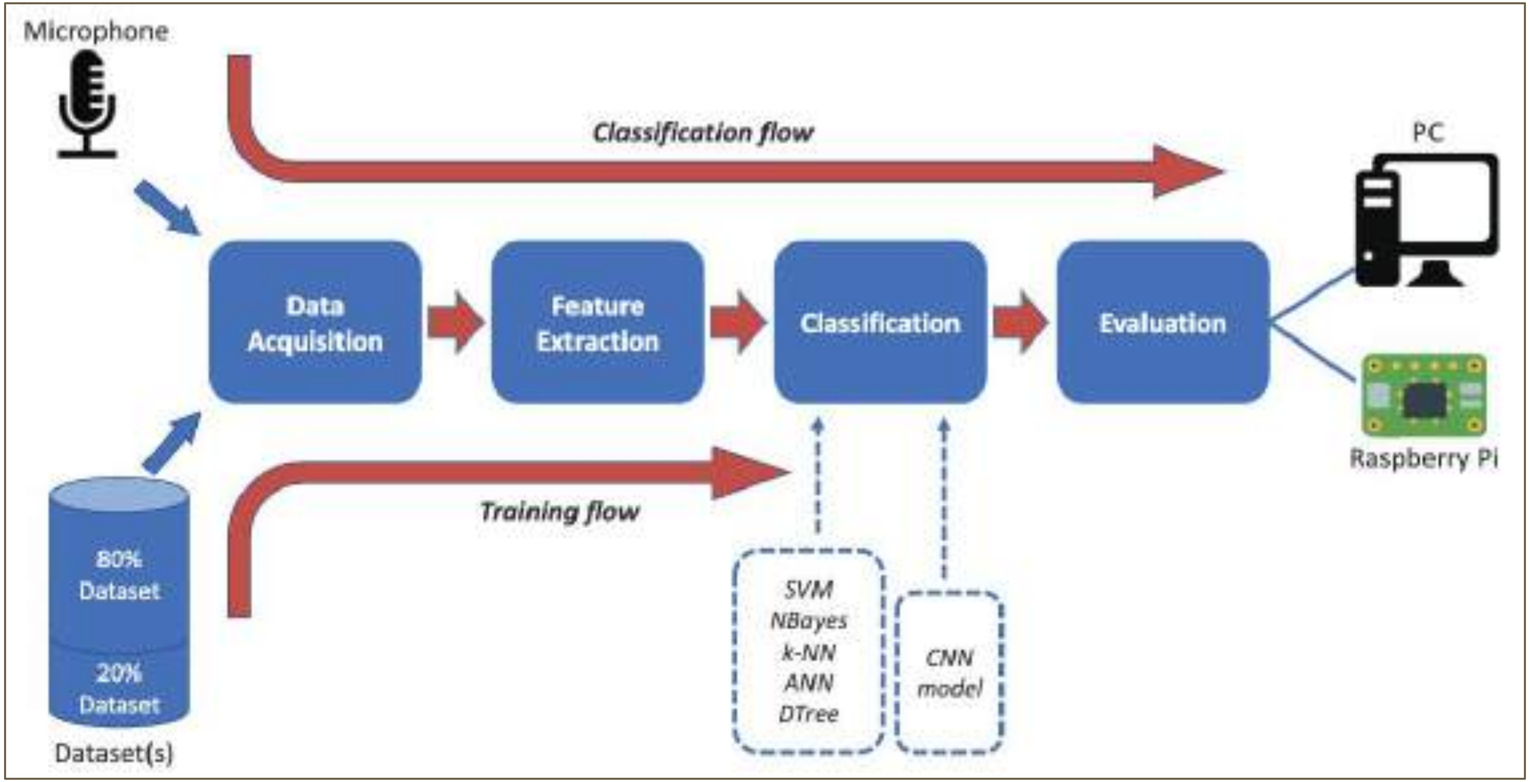
1. To test, evaluate and select the best performing model from existing noise classifier models in order to benchmark and guide on model implementation for the edge device.
2. To build an optimal classification model for the edge device.
3. To test and evaluate the performance of the noise classification model on the edge sensor unit, in relation to the power and memory consumption, in a practical field setting.

Significance of the Study

This research would greatly improve the health of citizens living in urban environments both locally and also at a global scale with reduced exposure to noise.

This will be achieved through the utilization of the product of this research as an evidence based policy making tool, by the relevant regulatory authorities to implement regulations and guidelines to mitigate noise pollution.

Methodology - Architecture



Methodology - Dataset Exploration

Dataset	Comprised
Urban Sound 8K	curated into 8732 clips of labelled audio, 10 target classes
YorNoise	dataset of vehicle noise with 1572 samples of audio categorised in 2 main classes.
ESC-50, ESC-10	2000 samples of environmental sounds with 50 main target classes.
BDliib	12 classes representing real-life situations
AudioSet	632 audio event classes and a collection of 2,084,320 human-labeled 10-second sound clips drawn from YouTube videos
Sunbird AI Noise	Urban Noise samples collected from Entebbe and Kampala City on Sunbird sensor network

Methodology - Model Selection, Evaluation and Conversion

The Convolutional Neural Network models PicZak CNN, SB-CNN, D-CNN, EnvNet and YamNet will be evaluated utilizing the listed datasets to identify the most optimal model to serve as benchmark/baseline for implementing the custom noise classifier model.

Metrics to assess performance include the accuracy, precision, recall, f1-score in addition to the confusion matrix.

To convert the model to an edge deployable version; Tensorflowlite, micromlgen, everywhereml - Google Colab.

C, C++ header file with input functions to return an inference - Arduino IDE.

Methodology - Deployment and Evaluation on the Edge

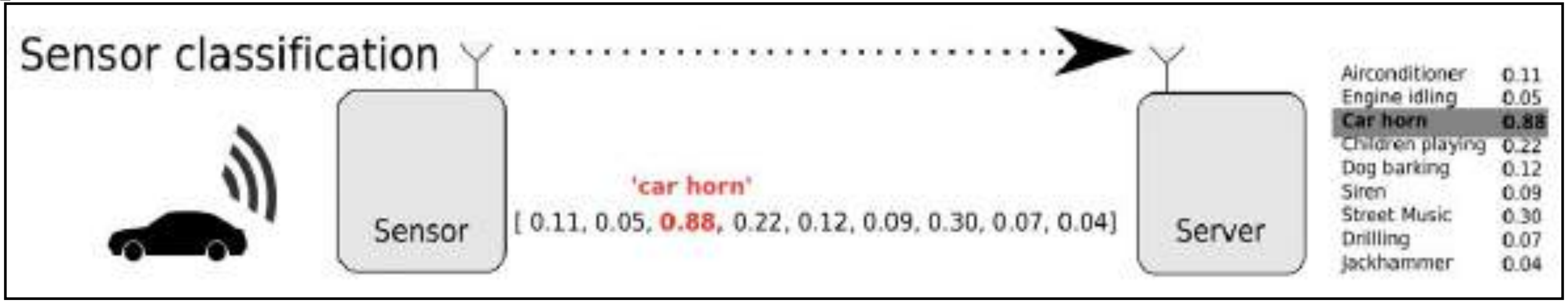
Microcontrollers; Nano 33 ble sense, Pi Zero, ESP32.

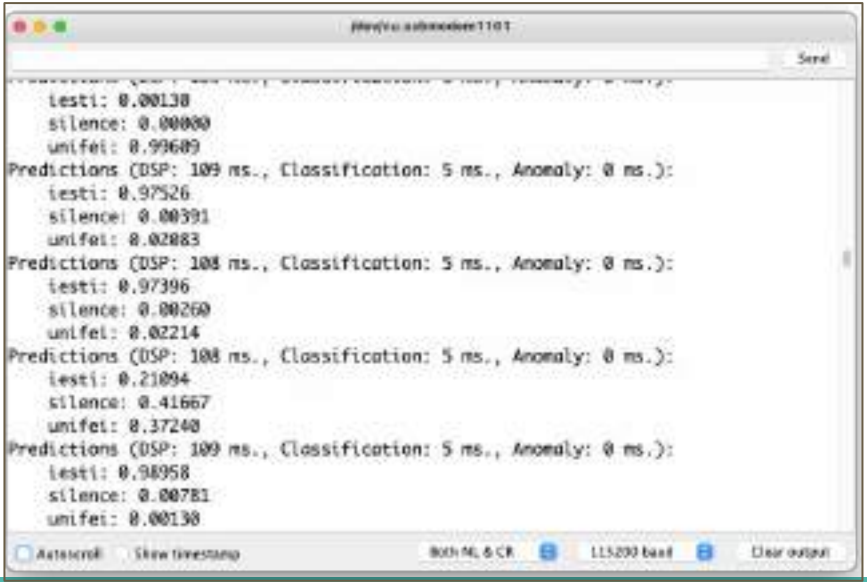
Perform inferences on urban audio data collected from noise.sunbird.ai dataset.

Observe inference performance on new audio samples collected from field environment as well as inference time.

Measure power consumption of assembled edge unit setups during various operation cycles; sleep, active, transmission, assemble corresponding battery sizing.

Expected Results





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    iesti: 0.00130
    silence: 0.00000
    unifei: 0.99609
Predictions (DSP: 109 ms., Classification: 5 ms., Anomaly: 0 ms.):
    iesti: 0.97526
    silence: 0.00391
    unifei: 0.02083
Predictions (DSP: 108 ms., Classification: 5 ms., Anomaly: 0 ms.):
    iesti: 0.97396
    silence: 0.00260
    unifei: 0.02214
Predictions (DSP: 108 ms., Classification: 5 ms., Anomaly: 0 ms.):
    iesti: 0.21094
    silence: 0.41667
    unifei: 0.37240
Predictions (DSP: 109 ms., Classification: 5 ms., Anomaly: 0 ms.):
    iesti: 0.98958
    silence: 0.00781
    unifei: 0.00130
```


Work Plan

Activity	Timeline - 2023
Dataset Exploration	March
Model Selection, Evaluation and Conversion	April
Model Deployment, Model Evaluation on the Edge	April-May
Thesis Writing, Research Defense, Thesis Corrections, Thesis Submission	May - June

Thank You

“Nisi Dominus”