

FEASIBILITY ON DETECTING DOOR SLAMMING TOWARDS MONITORING EARLY SIGNS OF DOMESTIC VIOLENCE

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Can we use microcontrollers (such as Arduino) and machine learning to detect potential early warning signs of domestic violence?

Research Questions:

- How can we quantify whether a door is being closed aggressively or not?
- Can sensors be used to detect aggressive behaviours?
- Can we mitigate risks to the privacy of users?

What hardware and tools do we have at our disposal?

- Arduino Nano BLE 33 Sense
- A standard internal MDF door
- TensorFlow

Results:

- Model can successfully differentiate between a door being closed normally versus being slammed with an accuracy of 88.89% (with no background noise).
- Accuracy declines to 87.5% when background noise is mixed in at a relative volume of 0.5 that of the sample.

Methodology

- We attached an Arduino Nano BLE 33 Sense to doors and captured 2-second audio samples of the door closing and being slammed.
- Spectrograms for slams and closes generated using Mel-Filterbank Energies (MFE).

Machine Learning

- Using TensorFlow we experimented with different neural network architectures to determine which gave us the most accurate results for audio classification.
- We determined that using convolutional layers provided generally far more accurate results than using entirely dense layers. We show this in the diagram below:

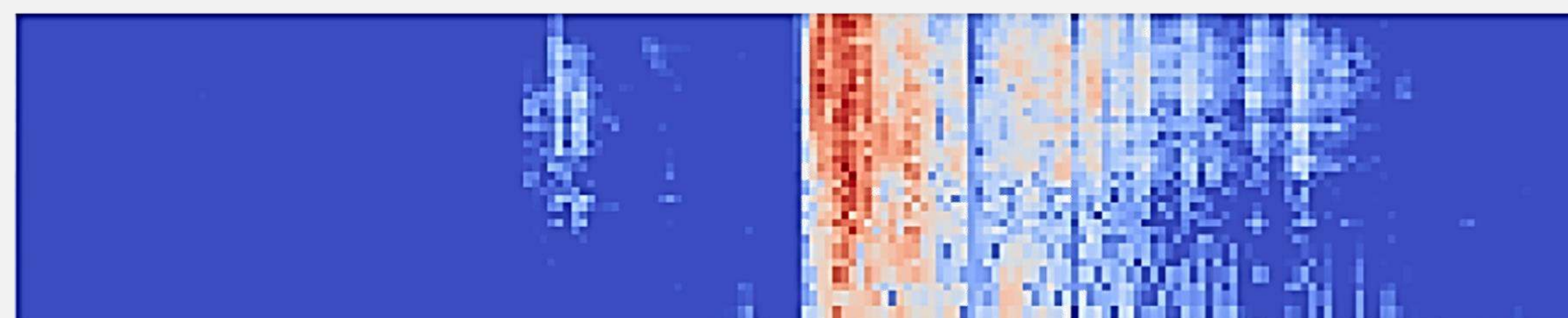
Machine Learning Model



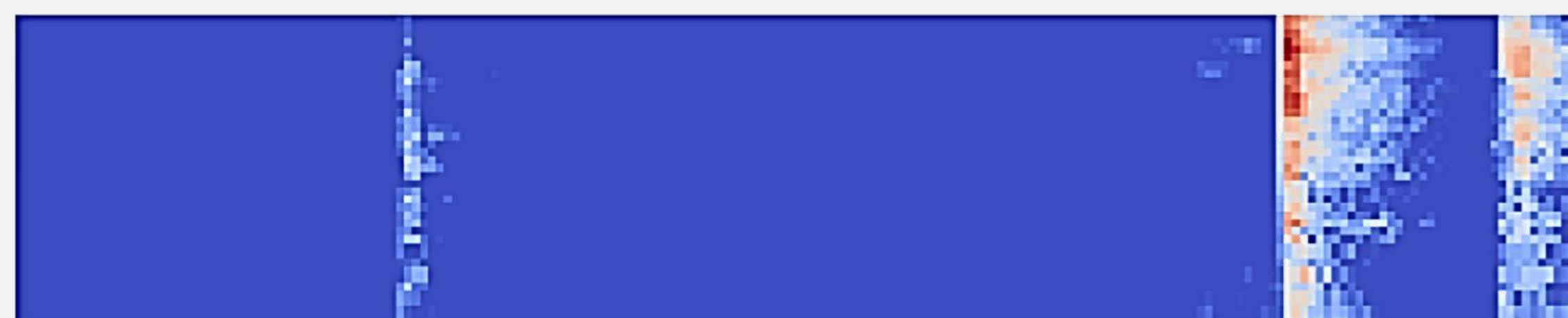
What about the other sensors?

- The Arduino Nano BLE 33 Sense comes equipped with an Inertial Measurement Unit (IMU) and Pulse-Density Modulation (PDM) Microphone.
- IMU used to detect if the door is moving or not.
- If the IMU detects acceleration above a given threshold, then audio sampling commences.

The spectrogram shows a slamming door.



The spectrogram shows a door closing normally.



Proposed Deployment

- Arduino embedded in door, rendering it tamper-proof.
- Wirelessly chargeable battery included alongside microcontroller to provide power over long term deployments.
- Nearby Bluetooth capable node to collect and store the results transmitted by the microcontrollers.
- Wi-fi is also possible for data transmission as many boards come equipped with pre-installed Wi-Fi modules.
- Note however that BLE consumes far less power than Wi-Fi, and is therefore recommended for longer-term installations.

