Acoustic Water Leak Detection

Using Machine Learning Methods

1 PROBLEM & MOTIVATION

Societies around the world are aiming to become more environmentally friendly. Effective water usage is necessary to achieve this; however, water leakage via cracked pipes is an obstacle.

WHY IT MATTERS

- Pipe leaks waste water and energy used by water pumps, and many are found only after visible damage has occurred.
- Traditional inspection is slow and relies on intrusive methods, while also requiring skilled technicians.
- A leak makes a characteristic sound, so it can be detected automatically from audio.

GOAL

Detect water leaks automatically from audio recordings of pipes, using signal processing and machine learning.

2 DATA

Recordings	Total length	Background time	Leak time
54	371 min	226 min	145 min

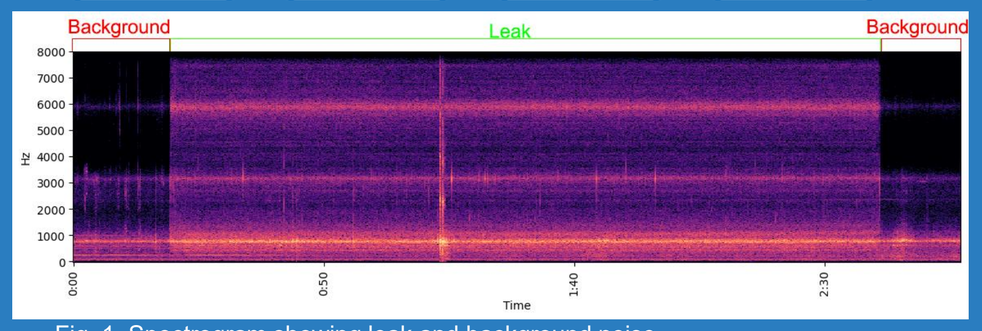


Fig. 1. Spectrogram showing leak and background noise

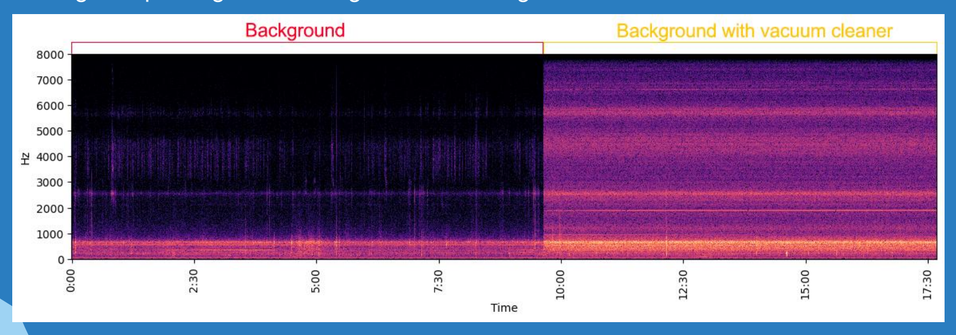


Fig. 2. Spectrogram showing regular background and vacuum cleaner noise

3 THEORY & METHODS

Pressurised water escaping a crack turns turbulent and makes a steady hiss that travels along the pipe and the water. It shows up as wideband energy (Fig. 1).

A spectrogram turns each clip into a frequency-over-time image. A CNN learns the specifics of leak noise from it and tells leaks apart from other wideband sounds, like a vacuum cleaner (Fig. 2).

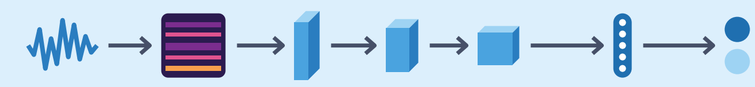
METHODOLOGY

Audio clip → Spectrogram → CNN Classifier → Leak / no leak

Spectrogram (x: audio, w: window, H: hop size, N: FFT size)

$$S(m,k) = \left|\sum_n x[n] \cdot w[n - mH] \cdot e^{-j2\pi kn/N}\right|^2$$

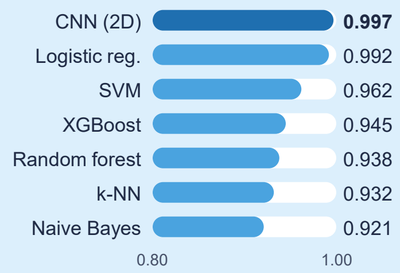
CNN: each block = 3×3 conv + batch norm + 2×2 max-pool



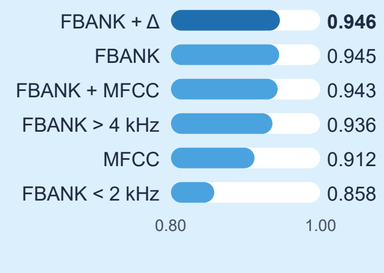
EXPERIMENTS

macro F1, 5-fold CV

Models (FBANK features)



Features (XGBoost)



Earlier setup with a smaller dataset of 12,004 windows and a different file split, so not directly comparable with section 4.

4 RESULTS

Models were evaluated using 5-fold cross-validation, with folds split by recording.

0.965	0.958	0.972
Macro F1	Leak F1	Background F1

CNN INPUT & WINDOW (macro F1)

Spectrogram 0.96 s window	FBANK 0.96 s window	Spectrogram 3 s window
0.969	0.961	0.969

	Pred. leak	Pred. background
Leak	10035	284
Background	593	15469

Fig. 3. Confusion matrix for 0.96 s windows

TAKEAWAYS

- The model handles easily identifiable cases well
- The model struggles when dealing with low-pressure water leaks or machinery noises that closely resemble leaks

CONCLUSION

A CNN model using spectrograms as features can effectively identify most water leaks.

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