

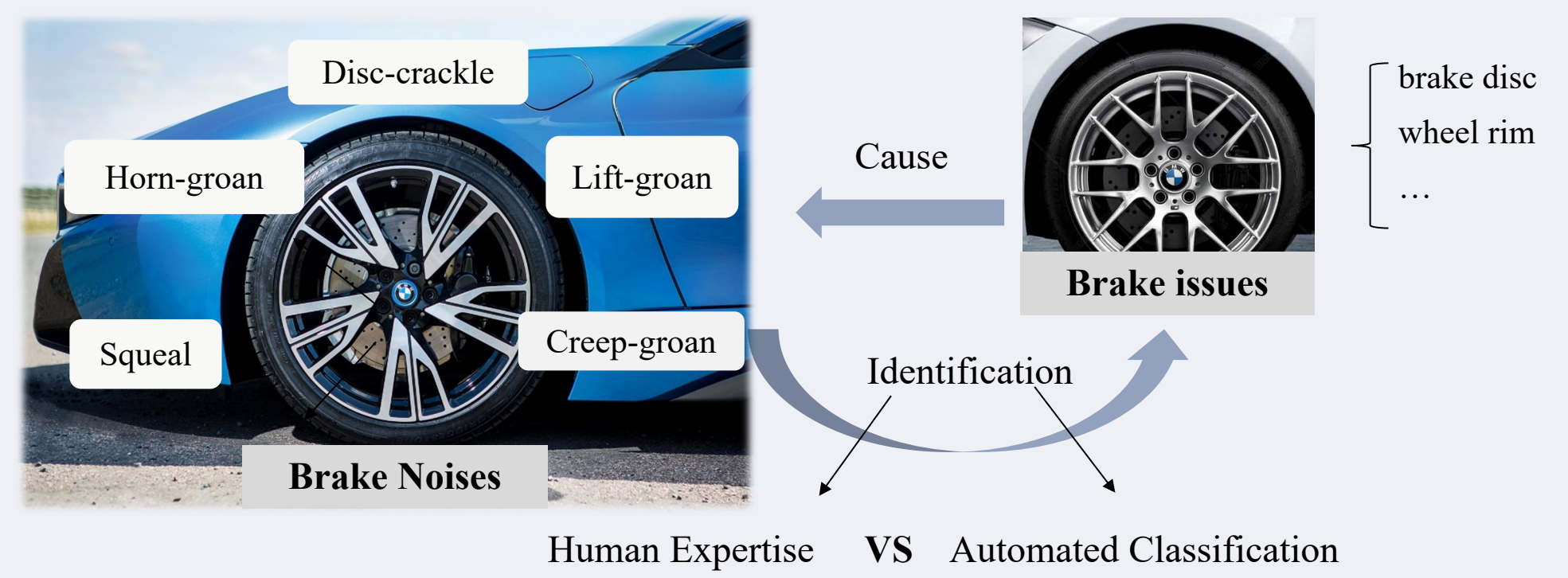


## Project Overview

Detecting and identifying brake noises from a vehicle is crucial at all stages of its lifetime, from the earliest stages of development to years after a customer purchased it. Disturbing noises are responsible for **360k warranty cases** for BMW Group (2018), and concerns **14% of the manpower** with a high level of **expertise**.

Developing methods for automatic identification that enable **faster** and **more accurate** diagnostic would lead to **high savings in manpower**, increased **customer satisfaction** and less **warranty cases**.

**Key methods used:** Convolutional Neural Network, Recurrent Neural Network, Object detection, Sound Similarity



### Challenges in the Dataset

**Lack of Samples**  
1080 Audio Samples

**Imbalanced Data**  
(6 classes)

**Background Noises**

**Class Specific Data Augmentation**  
1080 → 3000+

No brake noise:	29%	↓	22%
Lift-groan:	7%	↑	13%
Creep-groan:	12%	↑	18%
Squeal:	25%	↓	18%
Disc-crackle:	23%	↓	17%
Horn-groan:	4%	↑	12%

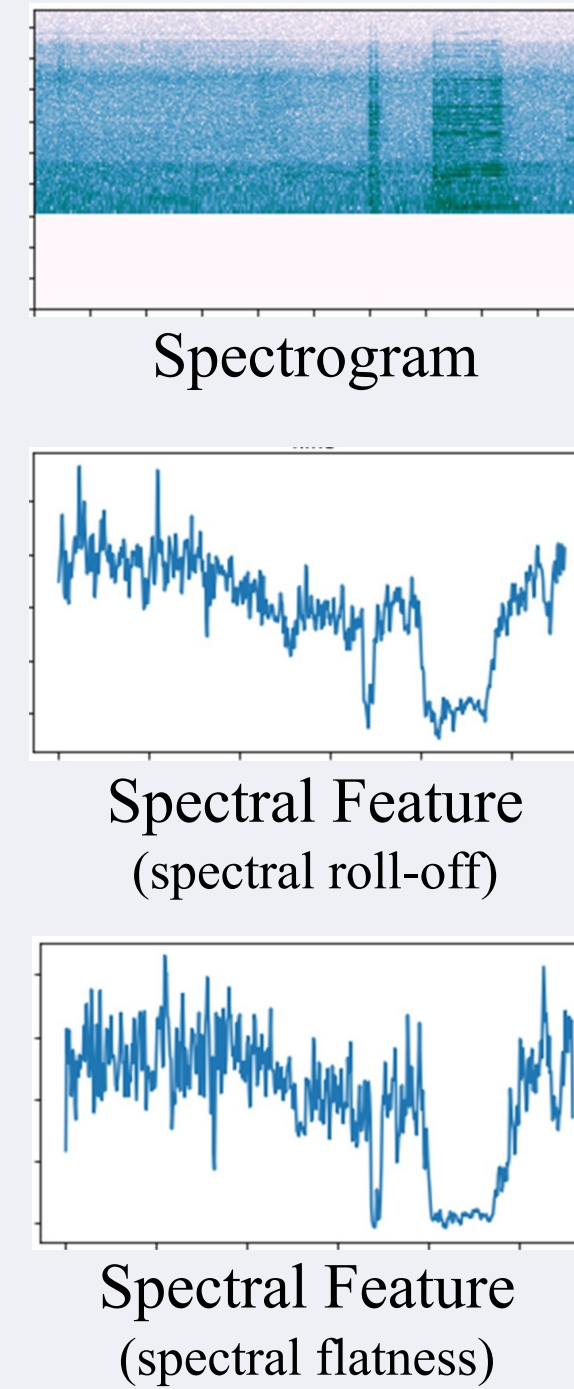
**Noise Filtering – 3 Methods**

- Amplify brake noise
- Remove various background noises (eg. engine, microphone)

- 1 Nearest Neighbor Filter
- 2 Spectral Gate Filter
- 3 Microphone Noise Filter

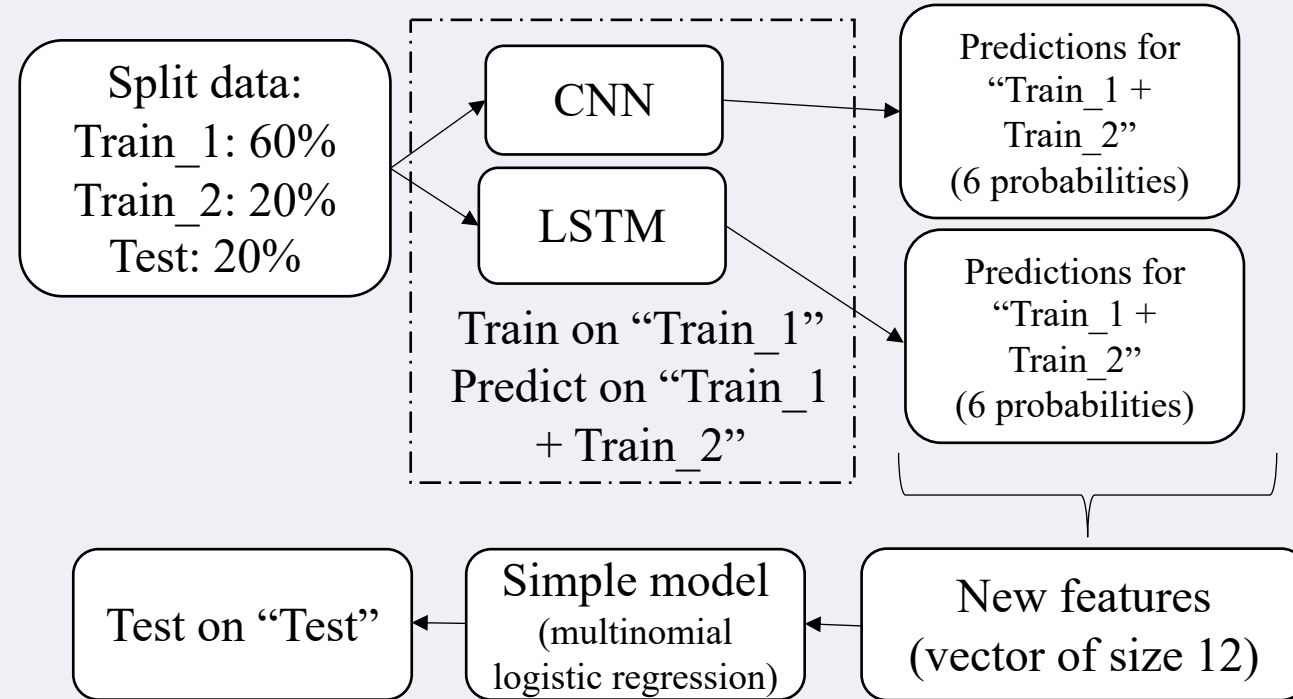
Original audio vs. Additional augmented audio (time stretch performed)

### Feature Extraction



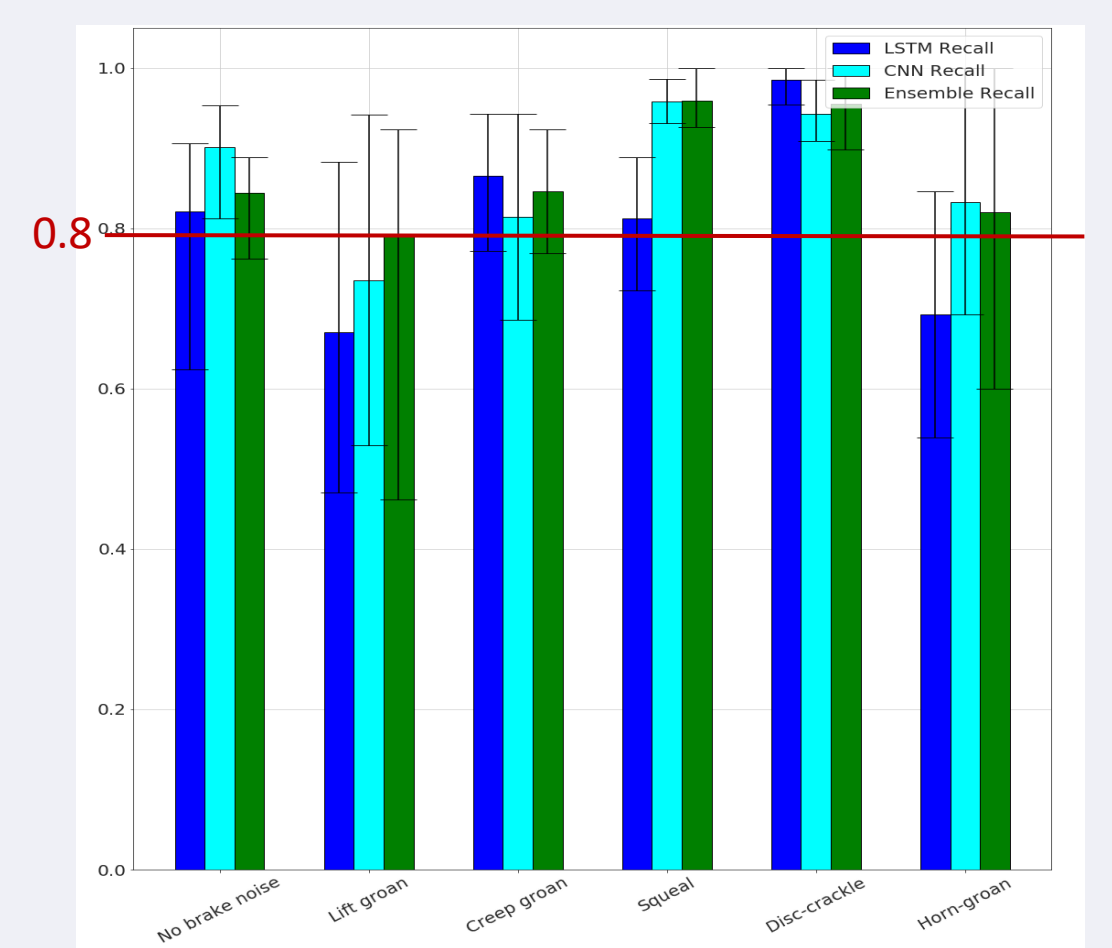
### Deep Learning Models

- Convolutional Neural Network
- Long Short-Term Memory
- Ensemble Model: CNN + LSTM



### Improved Accuracy and Recall

Accuracy improved: 80.4% → 90%



**1. Data Processing**

**2. Noise Classification**

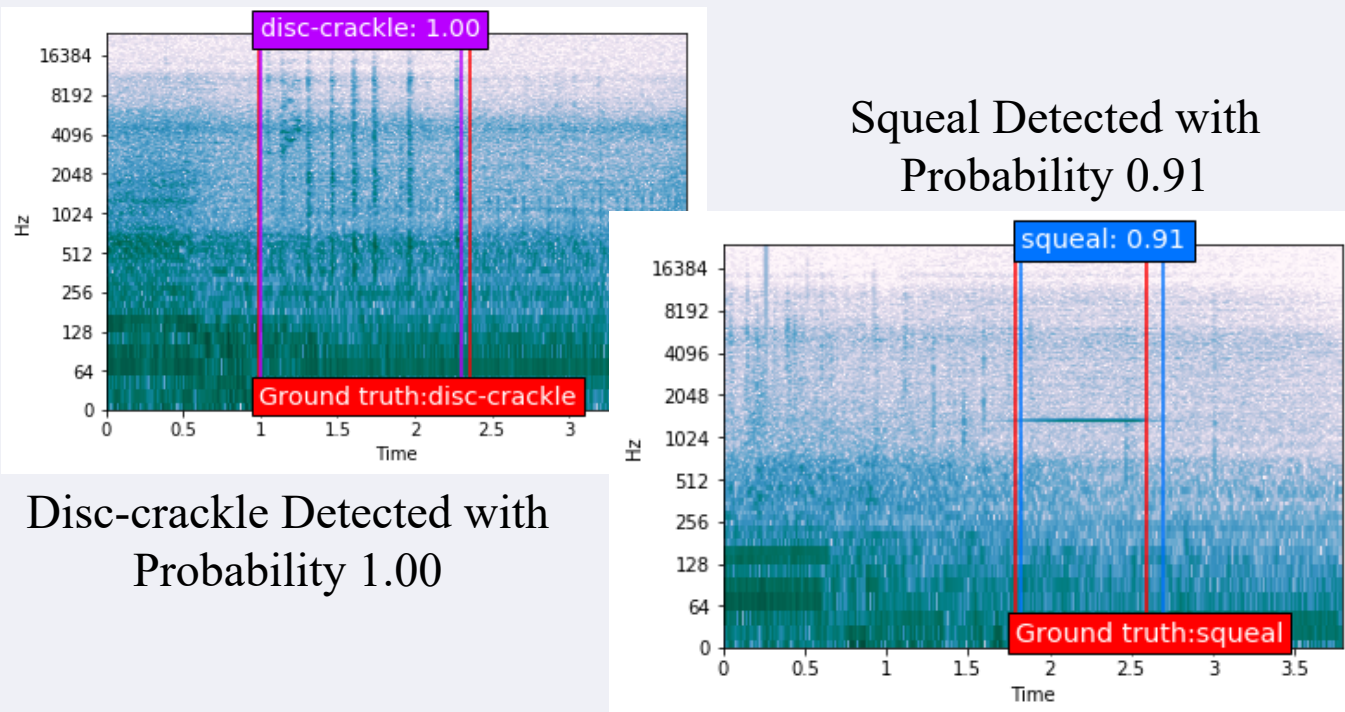
**1080 Audio Samples**  
(recorded on test cars)

**3. Noise Detection and More**

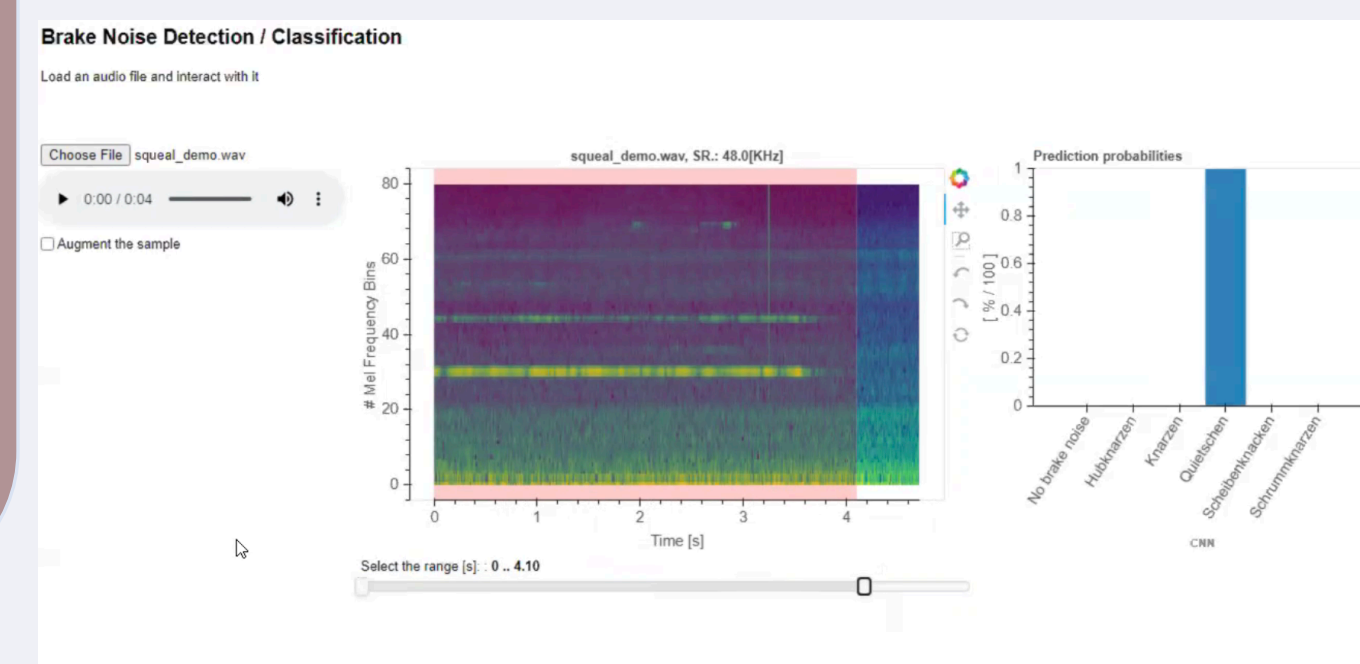
**4. Business Impact**

### Moving from Classification to Detection

- Adapted Single Shot Multibox Detector (SSD) for noise detection
- Enables automatic noise cutout



### Prediction App Deployed in AWS



### Sound Similarity Analysis Conducted for Unlabeled Data

- BMW Group is building a noise database (potentially unlabeled) containing different car noises and the associated repair
- Successful identification of noises similar to each other would enable engineers to quickly refer to repairs conducted before

- 1 Cutting out the noise
- 2 Calculate Distance between Noises
- 3 Identify Closest Neighbor

brake noise vs. Dynamic Time Warping

Class	Accuracy
Lift-groan	100%
Creep-groan	100%
Squeal	81.5%
Disc-crackle	91.7%
Horn-groan	60%
<b>Overall</b>	<b>88%</b>

### Test Vehicles



- Identify **issues during development**
- Decrease **warranty cases** on long term
- Collect more data and **reduce the number of tests / number of vehicles** needed during development

### Car Sharing Vehicles



- Optimize the vehicle **service intervals** with predictive maintenance
- Raise customer **driving experience**

### Customer Vehicles



- Provide the **right solution rapidly**
- Increase **customer satisfaction** and **reduce warranty costs**