DEEP LEARNING MODELS FOR ENVIRONMENTAL SOUND CLASSIFICATION:

A COMPARATIVE APPROACH

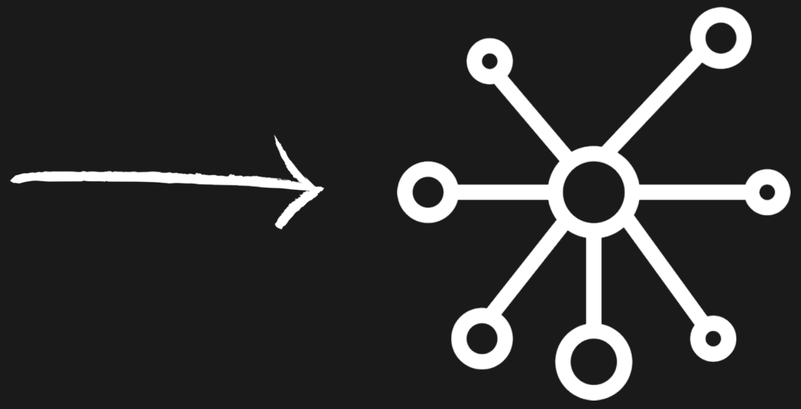
Project B2. Audio Classification Task.

CONTENT

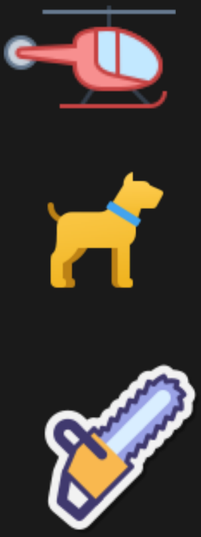
GOAL

AUDIO CLASSIFICATION TASK.

SPECTs or MFCC



CNN, RNN, CRNN



PREDICTIONS

ESC-10 DATASET:

What is it?

A subgroup of the well-known ESC-50 dataset.

What is it composed of?

Labeled data of environmental sounds, such as the sound of rain, rooster crowing, baby crying...

Main characteristics:

10 classes, 400 data, 40 per each class. 5 seconds per audio. Sounds clearly audible and classifiable by the human ear.

DATA AUGMENTATION

Harmonic Sound → Pitch Shifting

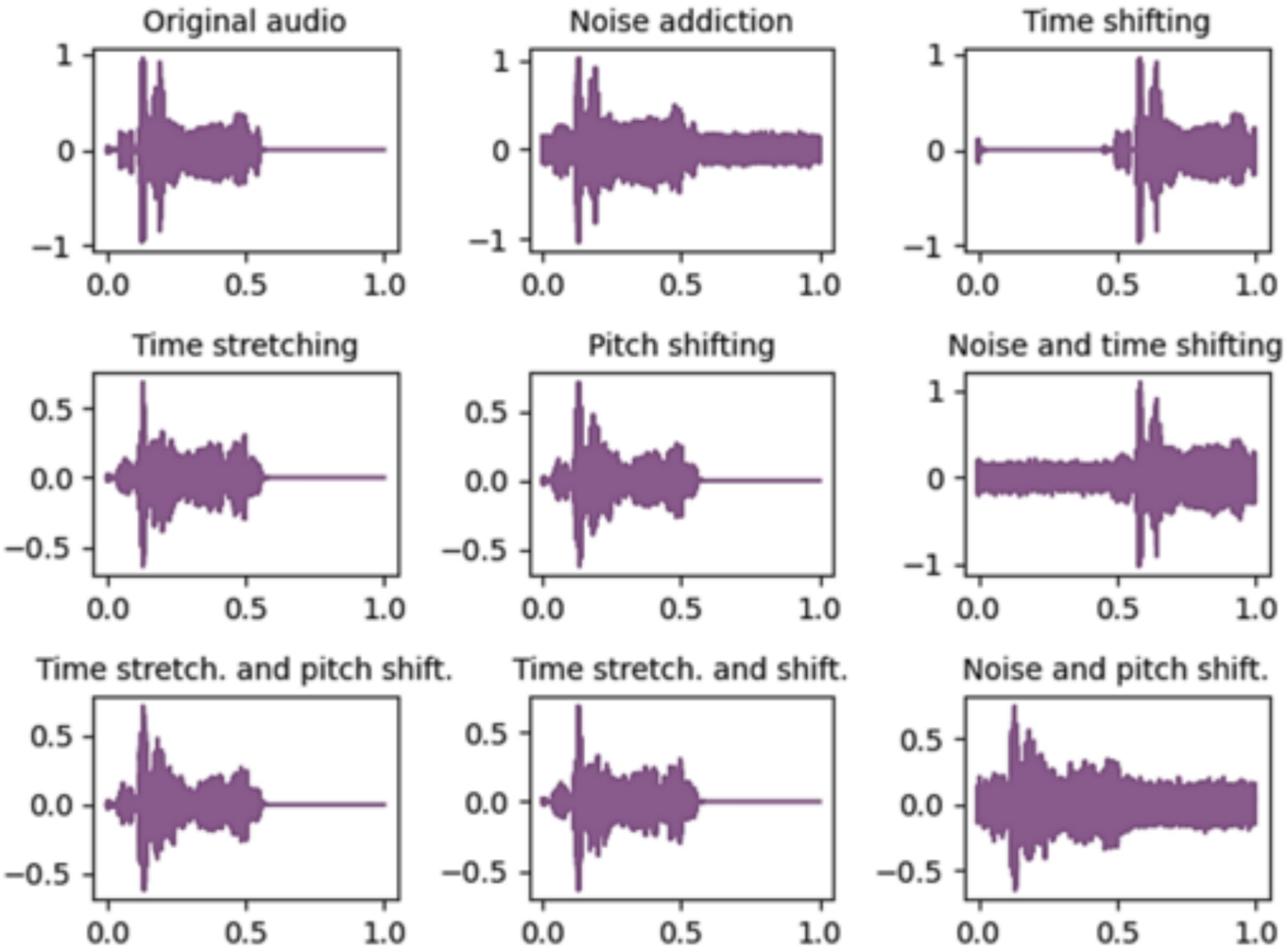
Soundscape → Adding Noise

Percussive Sound → Time Shifting

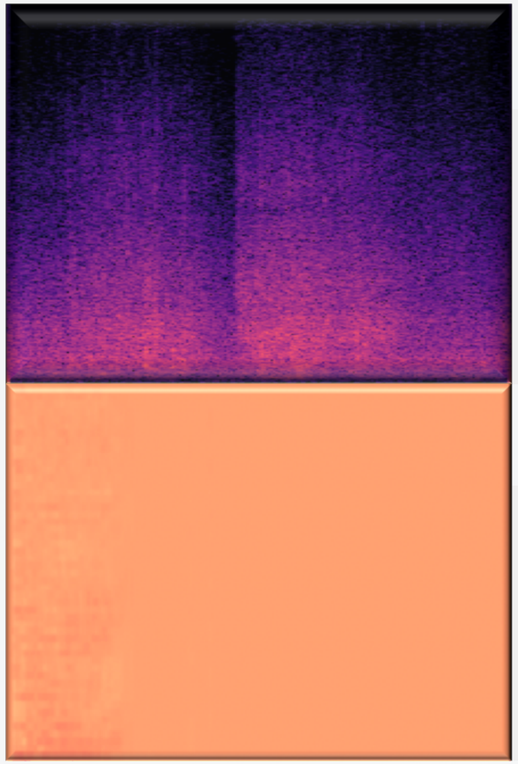
Percussive Sound → Time stretching

DATA AUGMENTATION

(of a )



AUDIO REPRESENTATION



SPECTROGRAM

Time VS frequency. Colors represent the magnitude or power of the frequencies at each point in time.

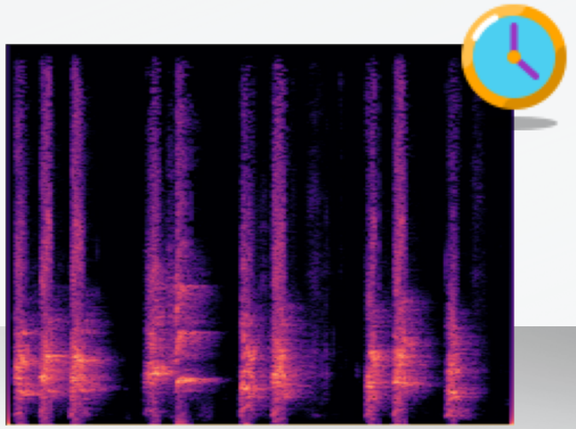
MFCC

Feature representation. It captures the spectral characteristics of a signal.

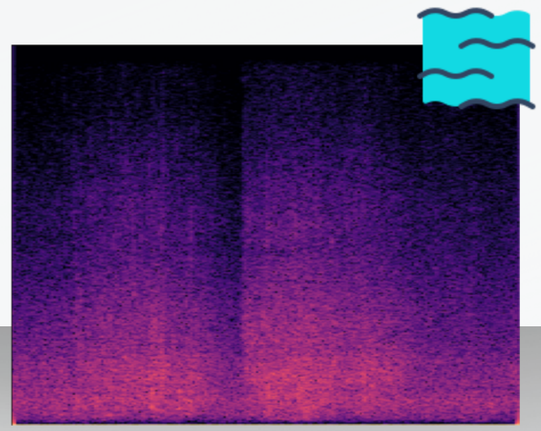
AUDIO REPRESENTATION:
SPECTROGRAM

Reasons why they might be a good choice:

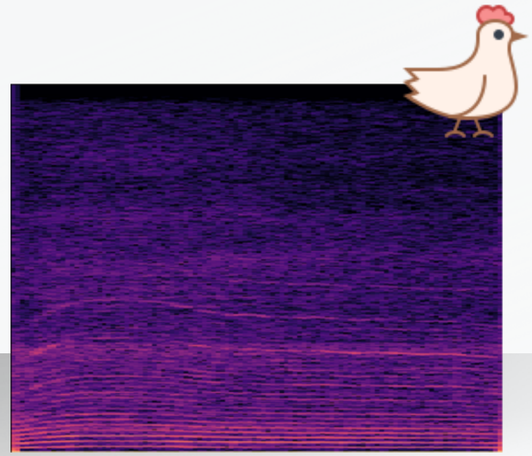
More sensitive to sound traits.



Percussive Sound

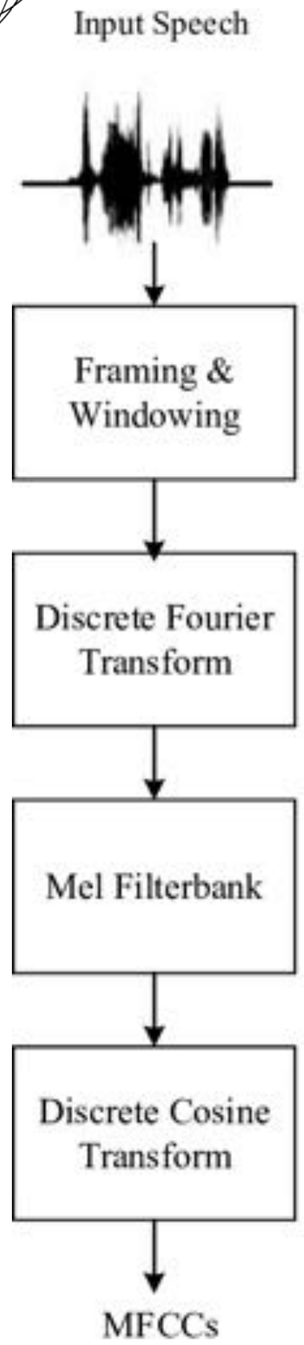


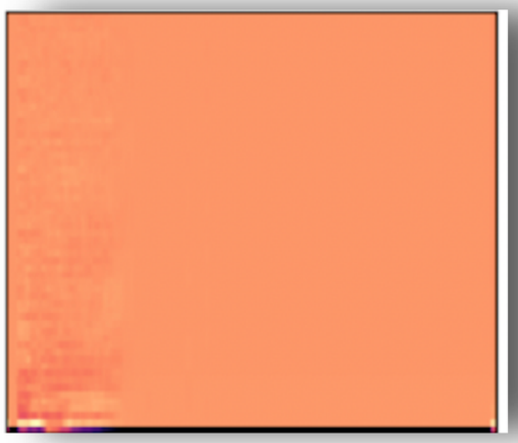
Soundscape



Harmonic Sound

AUDIO REPRESENTATION:
MFCC





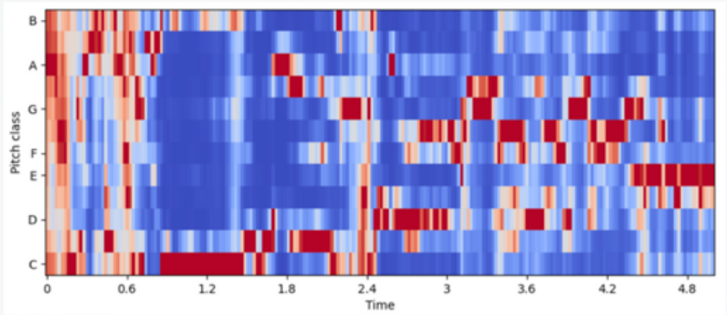
- Hop Length: 512
- Win Length: 1024
- Num. of MFCC: 60

AUDIO REPRESENTATION:
MFCC

Reasons why they might be a good choice:

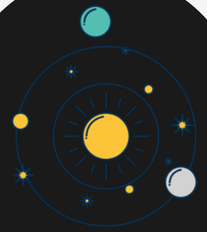
Highly appreciated in the scientific literature of this task

Integrate chromatogram in input, why?



Less sensitive to noise and temporal informatio

MODELS

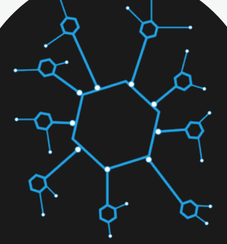


NN based on convolutional filters that enable the NN to automatically learn and recognize patterns, shapes, and structures within the data.

CNN

NN designed to handle long-term dependencies and capture sequential patterns in data.

RNN (LSTM)



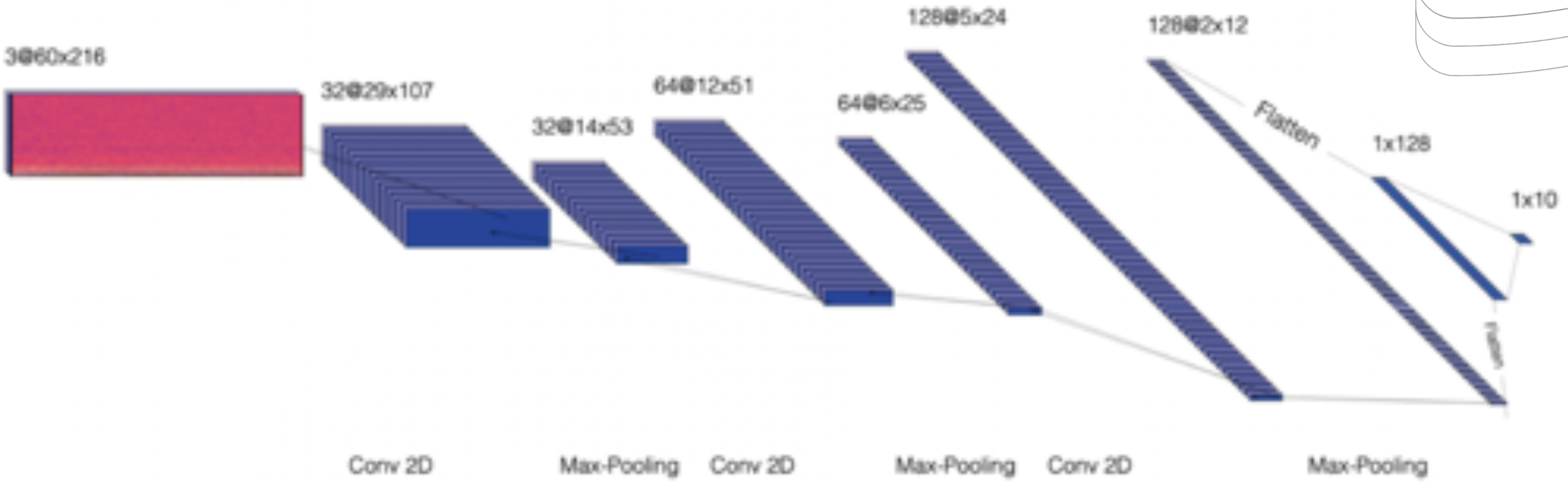
Hybrid NN architecture that combines convolutional layers for spatial feature extraction and recurrent layers for temporal modeling.

CRNN

CHARATERISTICS THAT ARE COMMON TO ALL MODELS IMPLEMENTED

ACTIVATION FUNCTION	LOSS FUNCTION	OPTIMIZER	EPOCHS CRITERIA
Softmax in the last layer. ReLU for the others.	Categorical Crossentropy	ADAM	Early stopping on validation loss with patience = 4 to choose the number of epochs.

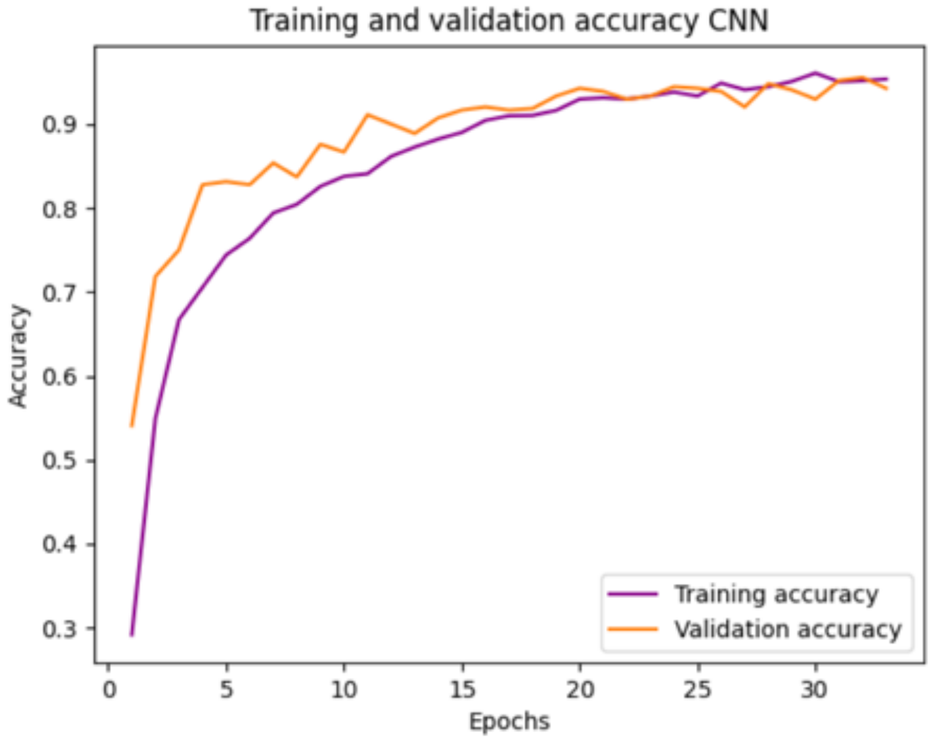
CNN ON MFCC

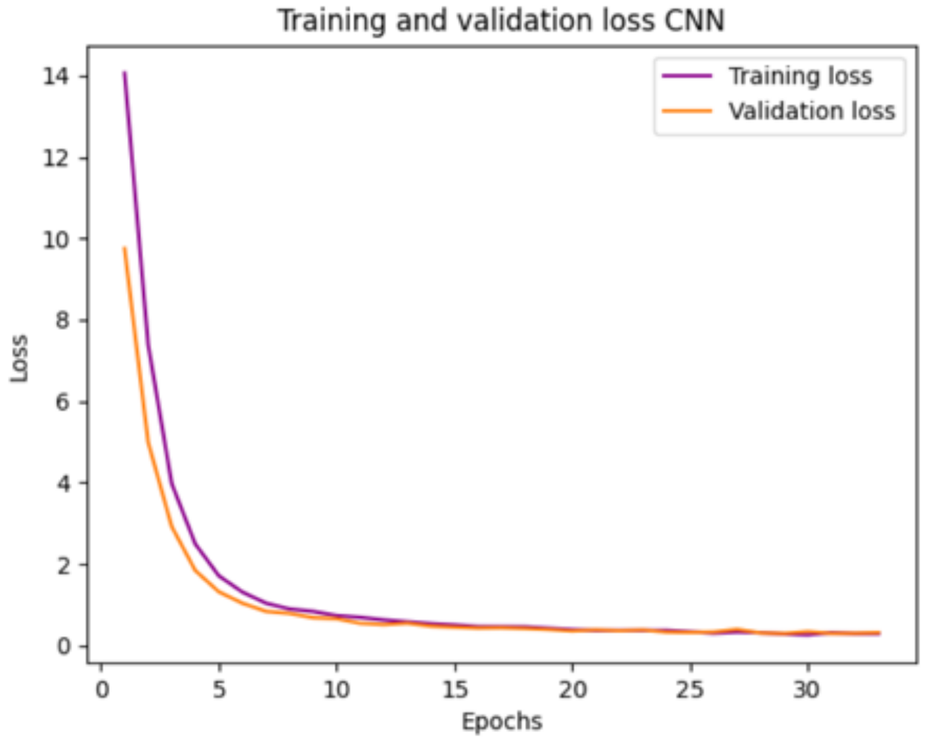


Moreover, the use of:

- **L1 regularizer (0.01)**
- **Dropout (0.2)**
- **33 epochs**

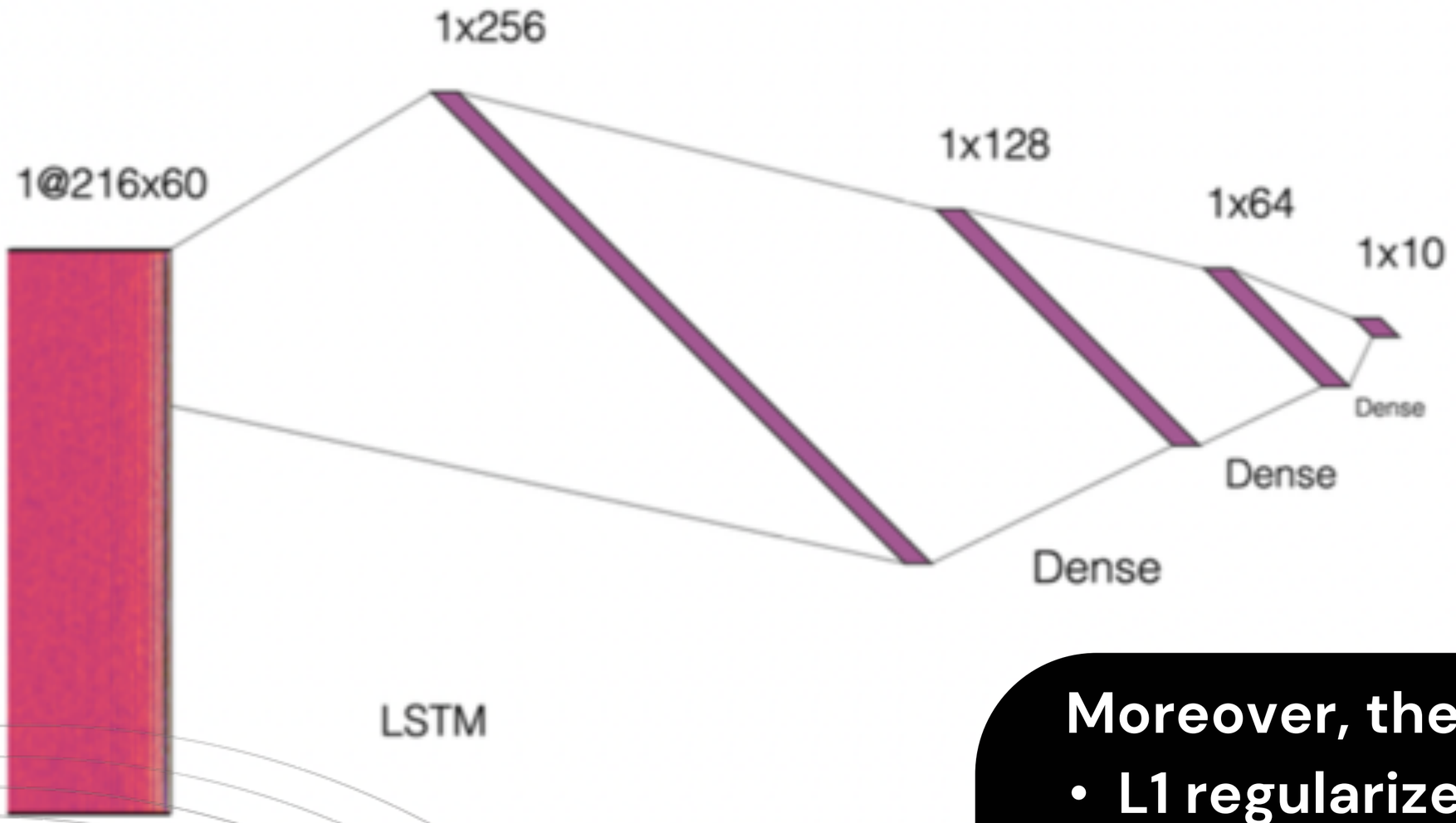
PERFORMANCE





Accuracy	Size of model (KB)	Inference time (s)
94.07	1622.69	0.28

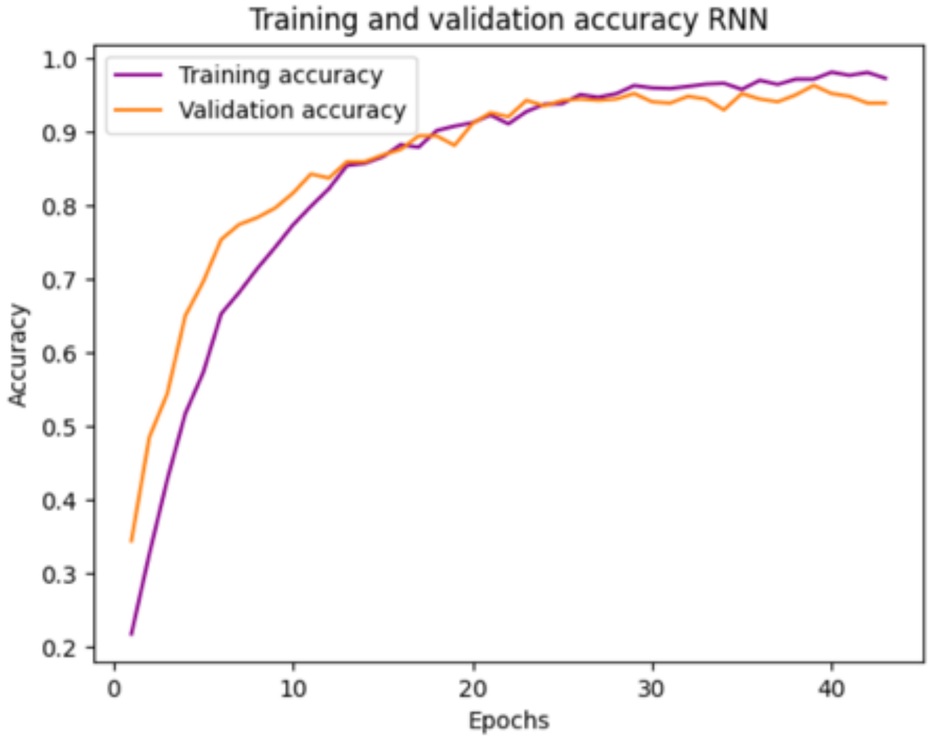
LSTM ON MFCC

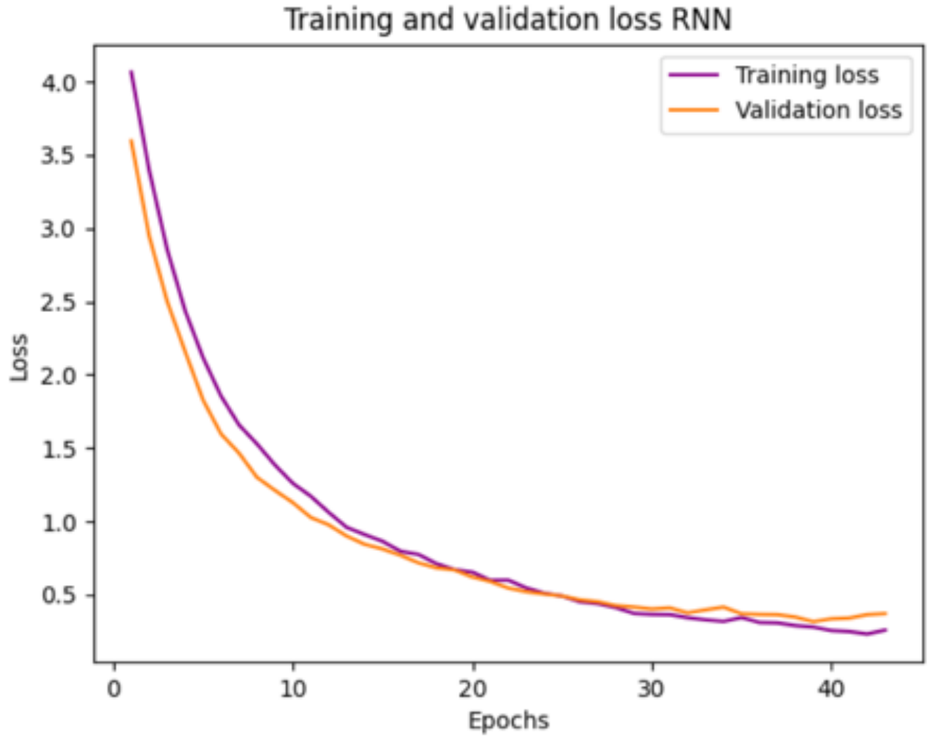


Moreover, the use of:

- **L1 regularizer (0.001)**
- **Dropout (0.2)**
- **43 epochs**

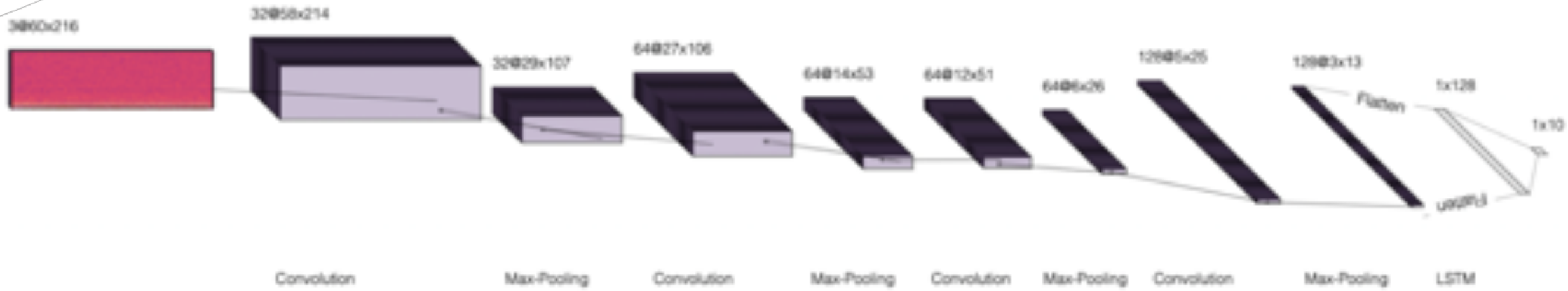
PERFORMANCE





Accuracy	Size of model (KB)	Inference time (s)
95.93	1334.07	0.2

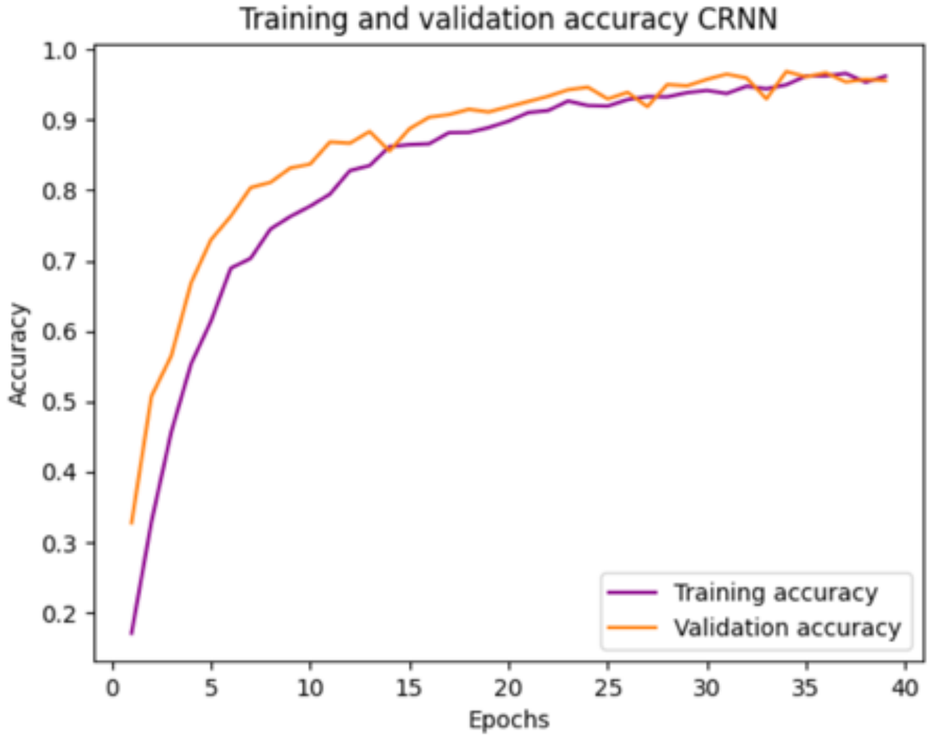
CRNN ON MFCC

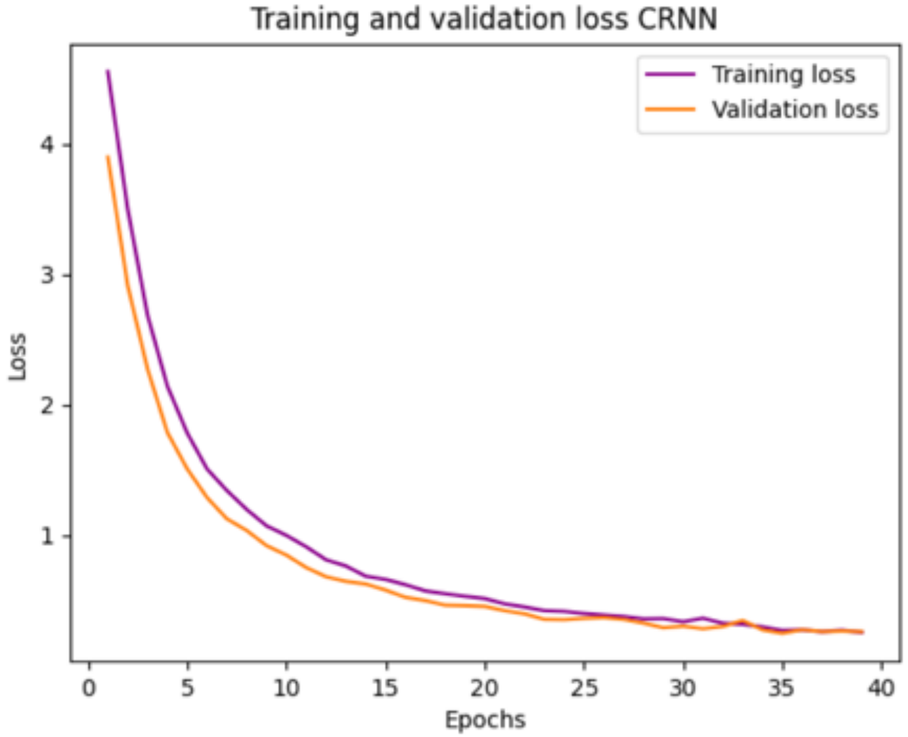


Moreover, the use of:

- **L1 regularizer (0.001)**
- **Dropout (0.2), (0.3)**
- **39 epochs**

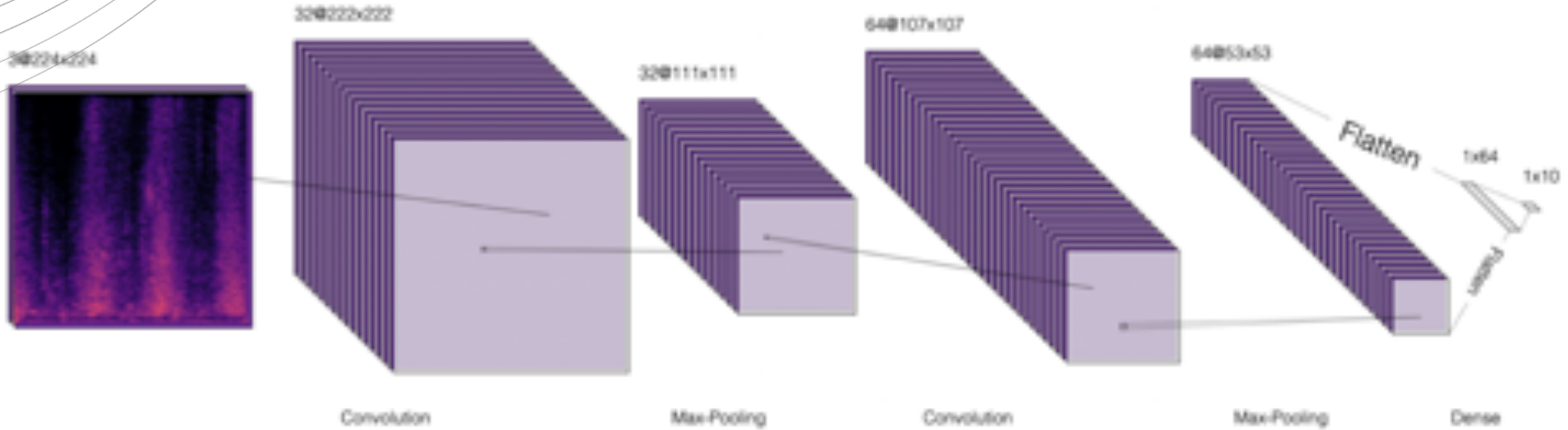
PERFORMANCE





Accuracy	Size of model (KB)	Inference time (s)
94.81	1100.95	0.28

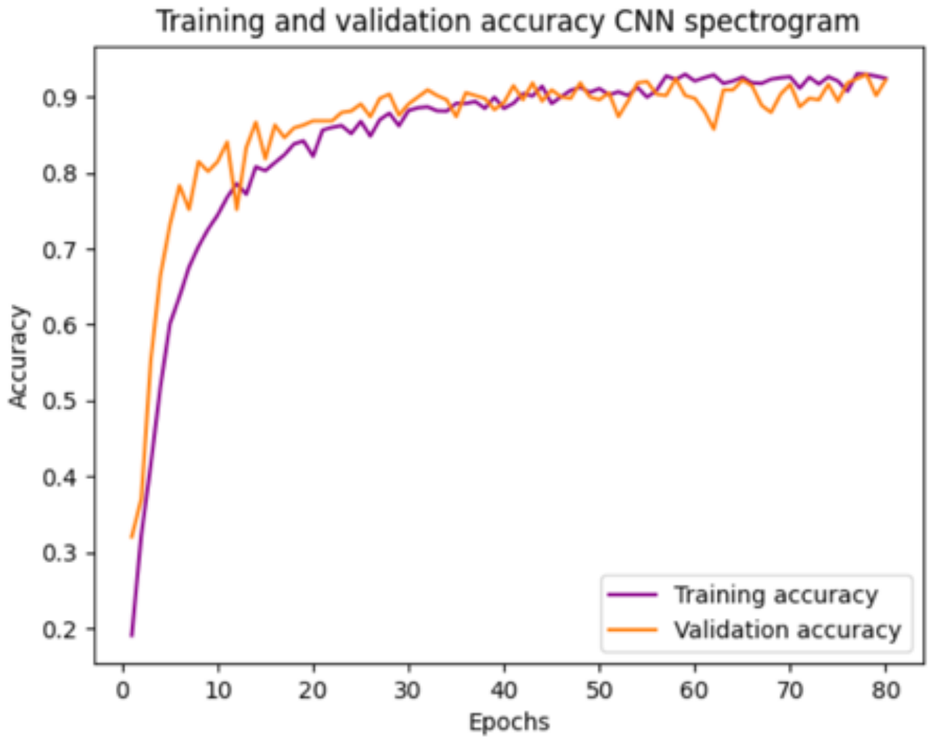
CNN ON SPECTROGRAM

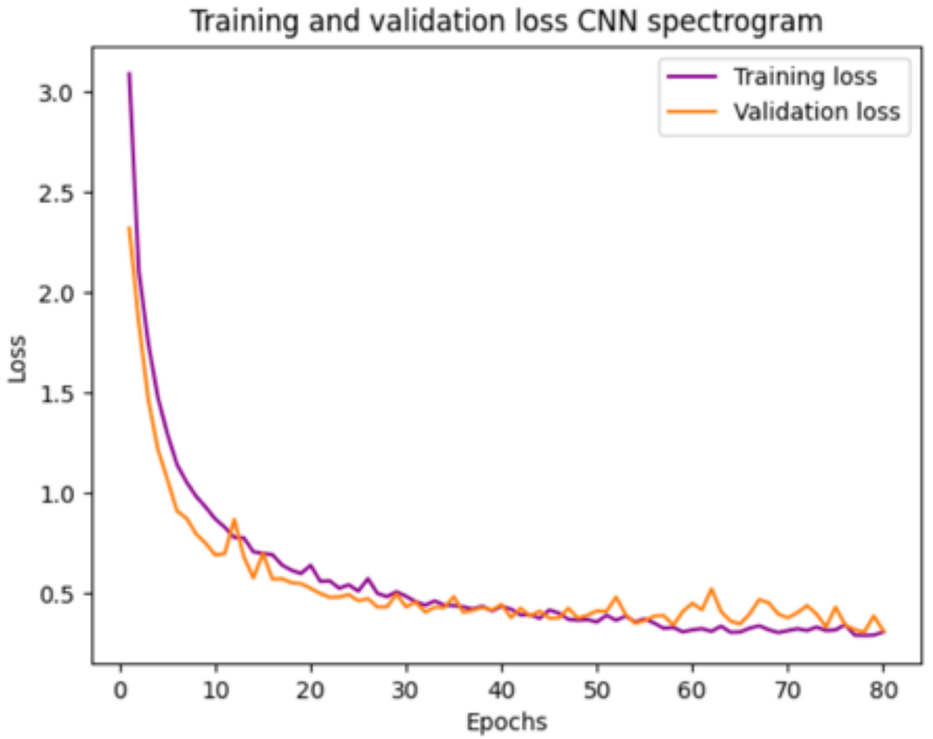


Moreover, the use of:

- **L1 regularizer (0.01)**
- **Dropout (0.4)**
- **80 epochs**

PERFORMANCE



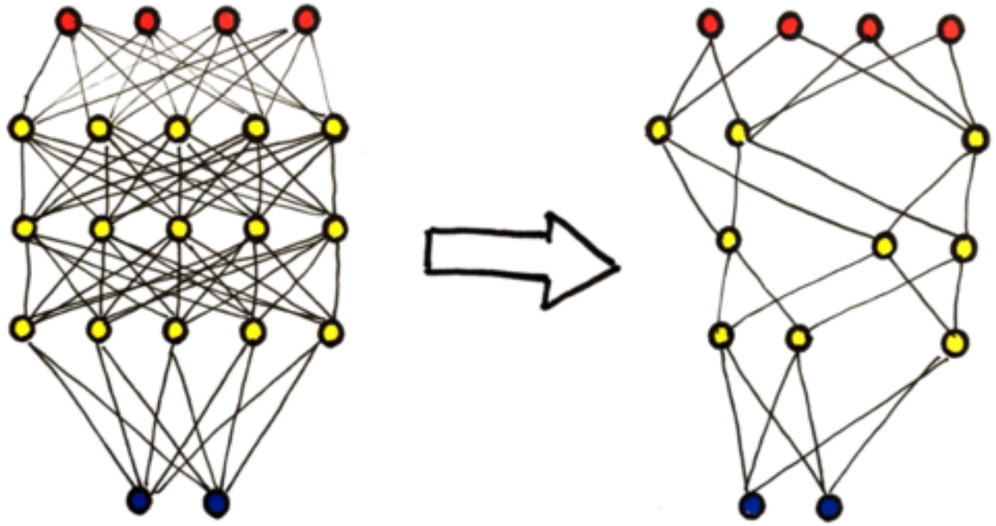


Accuracy	Size of model (KB)	Inference time (s)
93.33	957.85	0.85

PRUNING

Optimization technique to remove unnecessary connections, parameters, or filters from the network.

- reducing model size
- computational complexity reduction
- maintaining performance.

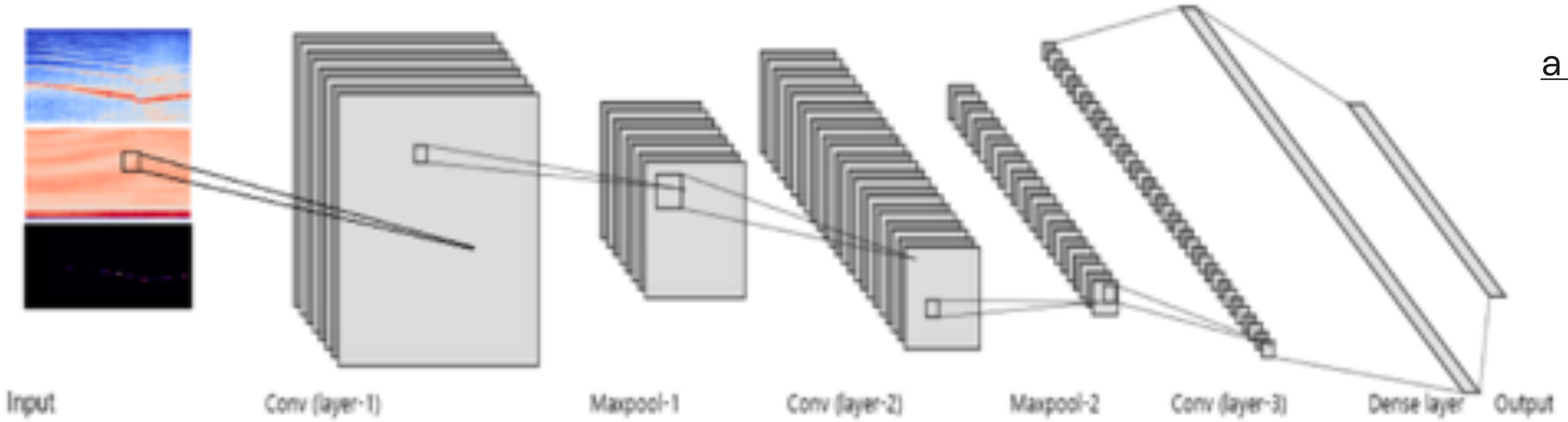


	WITHOUT PRUNING	WITH PRUNING	PERFORMANCE GAIN
ACCURACY	93.33%	93.33%	-
MODEL SIZE	957KB	589KB	38%
INFERENCE TIME	85S	72S	15%

CNN ON SPECTROGRAM: PAPER COMPARISON

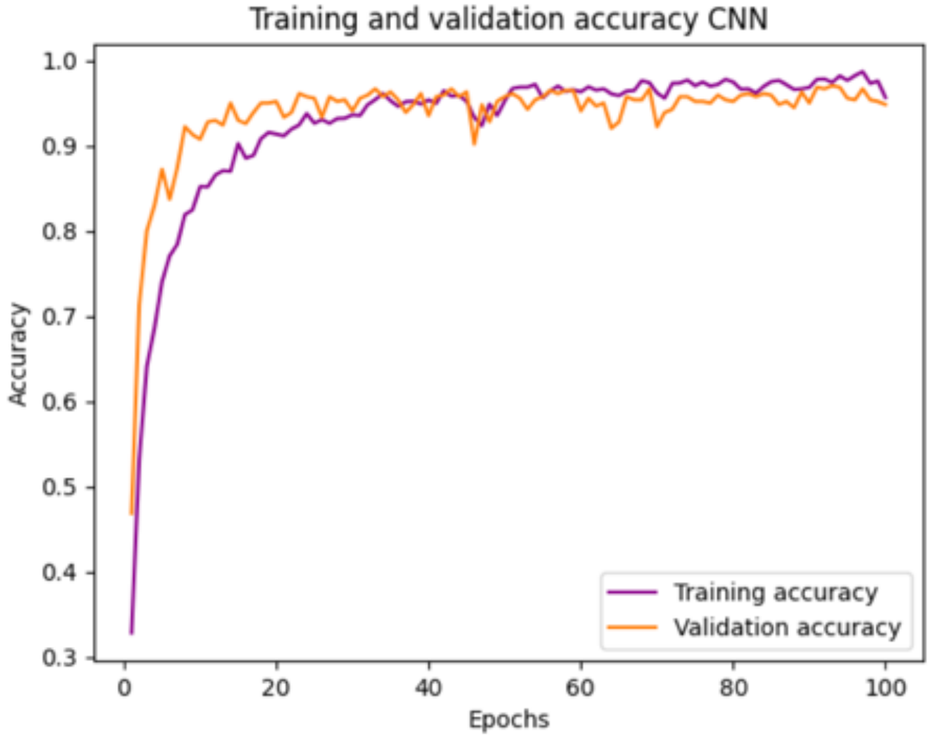
REFERENCE:

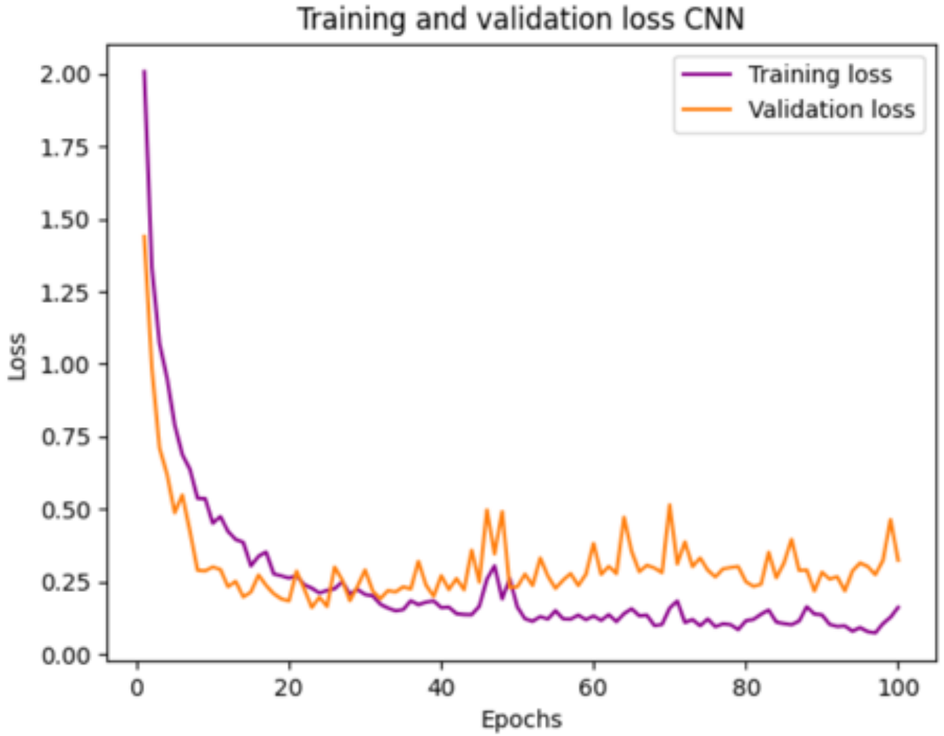
Z. Mushtaq and S. F. Su, "Environmental sound classification using a regularized deep convolutional neural network with data augmentation", 2020.



Similarities	Differences
CNN architecture	1 less Conv Layer
Use of Drop-out	greater Drop-out (0.5)
Use of Max-Pooling	different pool-sizes
Activation functions	larger filter sizes
Adam and cat-crossentropy	fewer tot. parameters

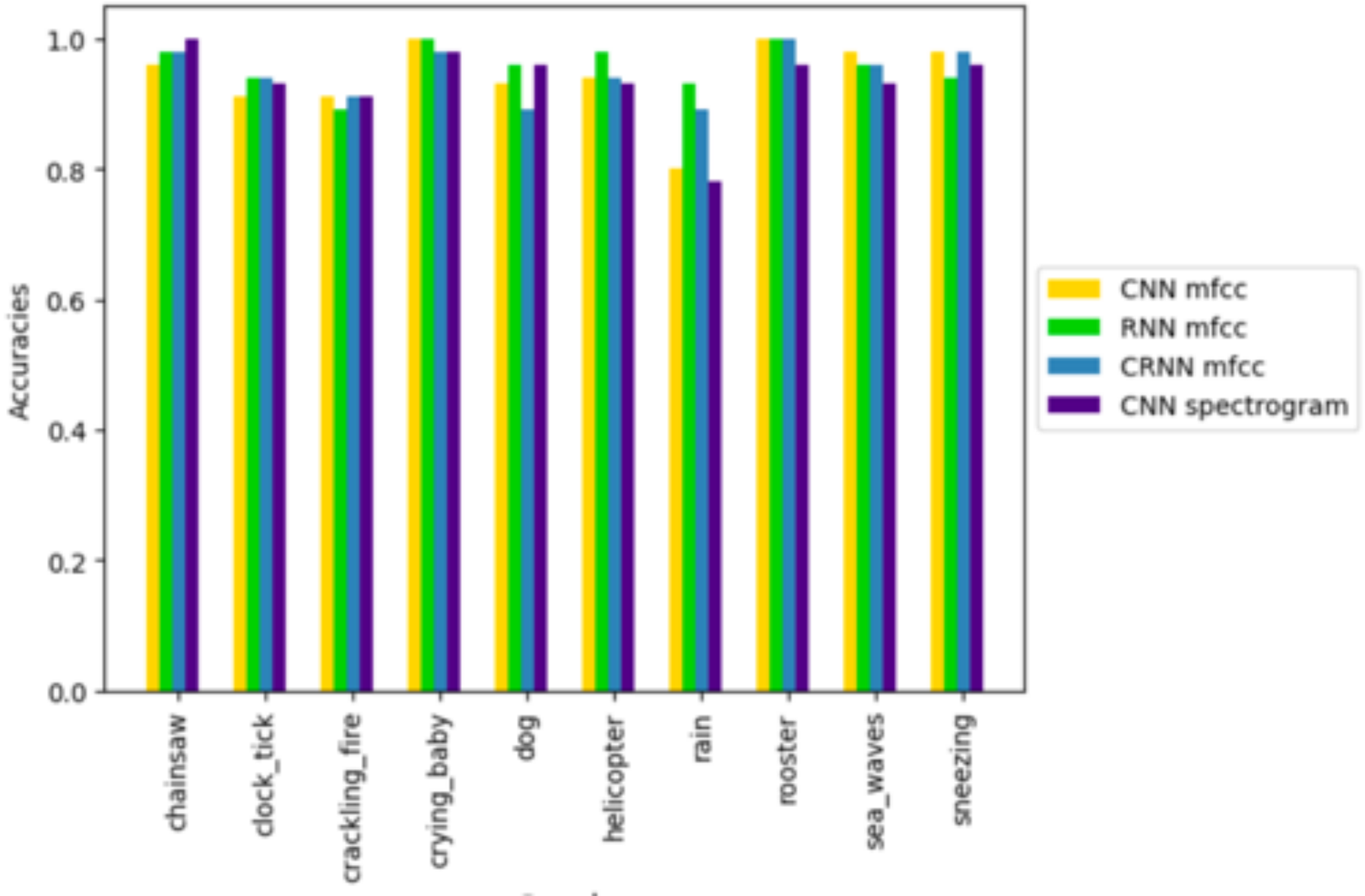
PERFORMANCE





Accuracy	Size of model (KB)	Inference time (s)
92.96	2545.88	0.36

FINAL RESULTS.



FINAL RESULTS.

Input data	Model	Accuracy	Size of model (KB)	Inference time (s)
MFFC	CNN	94.07	1622.69	0.28
MFFC	RNN	95.93	1334.07	0.2
MFFC	CRNN	94.81	1100.95	0.28
Spec	CNN w/o prun	93.33	957.85	0.85
Spec	CNN w/ prun	93.33	589.68	0.72
MFCC	CNN(paper)	92.96	2545.88	0.36

CONCLUSION