AUTOMATIC RECOGNITION OF UNDERWATER ACOUSTIC SIGNATURE FOR NAVAL APPLICATIONS

E.Artusi, PhD. Student, eva.artusi@naval-group.com , eva.artusi@mines-paristech.fr
F.Chaillan, PhD., fabien.chaillan@naval-group.com

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POWER AT SEA

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INTRODUCTION

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Underwater acoustic signature recognition

- To be aware in real time of the evolution of the threats lying in the environment
- To disitinguish between mechanical noises and normal biological activities

Issues

- Need for rapid classification
- Mental overlead of the operator
- Very stressfull discomfort → 90 seconds to take a decision

↳ Providing efficient assistance

↳ Designing an automatic underwater acoustic signature recognition system ➔ use of AI techniques

METHODOLOGY

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Why Mel-Frequency Cepstral Coefficient (MFCC) ?

- Capturing the important characteristic of audio signals
- Identify tiny details of underwater noises
- Used in speech and sound event recognition ➔ human ear mimicking

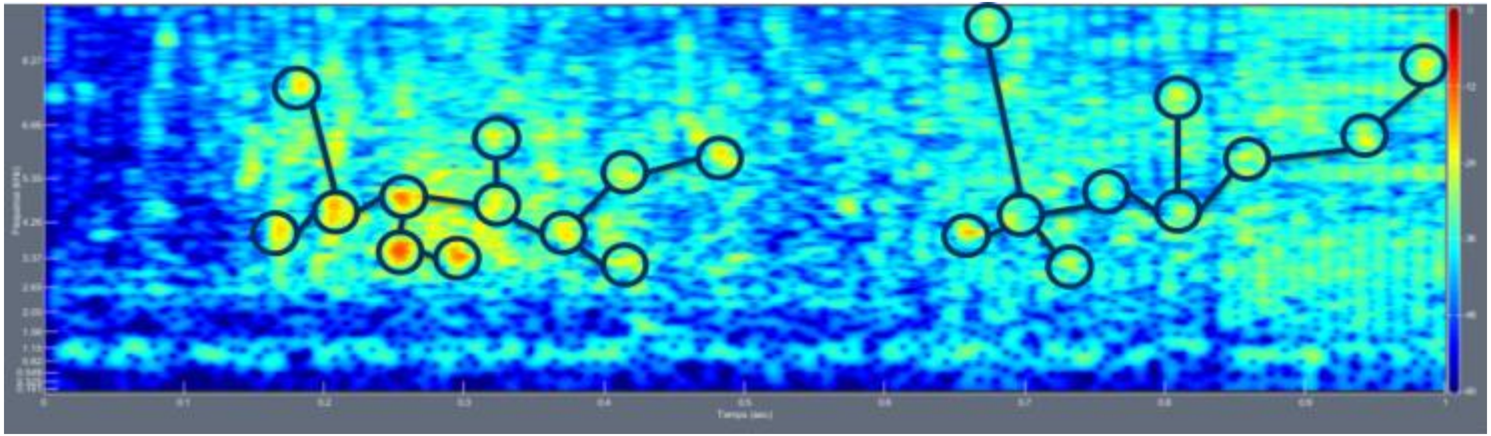


Illustration of the capability of MFFC to identify tiny details of underwater acoustic signal. X-axis correspond to Time and Y-axis corresponds to Mel frequencies

METHODOLOGY
PRESENTATION OF THE THREE ARCHITECTURES

- MFCC and SVM

Andrey Temko, Robert Malkin, Christian Zieger, Dusan Macho, Climent Nadeu, and Maurizio Omologo, "CLEAR Evaluation of Acoustic Event Detection and Classification Systems" (2007)

Xiaodan Zhuang, Xi Zhou, Mark A. Hasegawa-Johnson, Thomas S. Huang, "Real-world acoustic event detection" Pattern Recognition Letters 31 1543–1551, (2010)

Machine learning algorithms

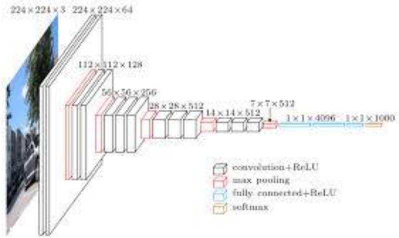
- VGGish

K. Simonyan and A. Zisserman - "Very deep convolutional networks for large-scale image recognition" (2015)

Shawn Hershey, Sourish Chaudhuri - « CNN ARCHITECTURES FOR LARGE-SCALE AUDIO CLASSIFICATION » (2017)

- An enhanced version : VGGish and one dense layer

Deep neural networks architectures

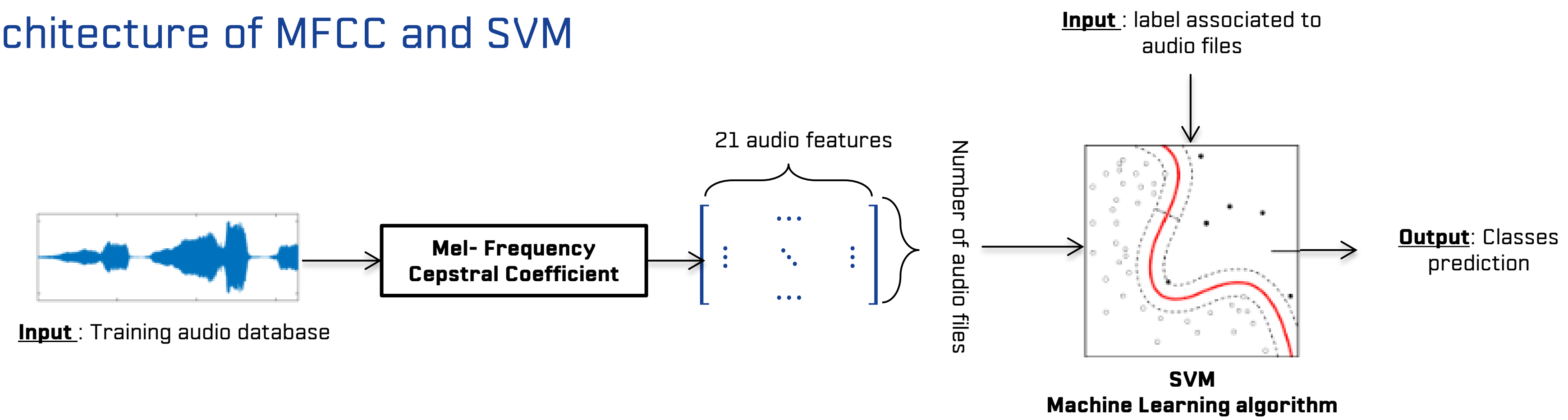


METHODOLOGY
MFCC FEATURES AND SVM METHOD

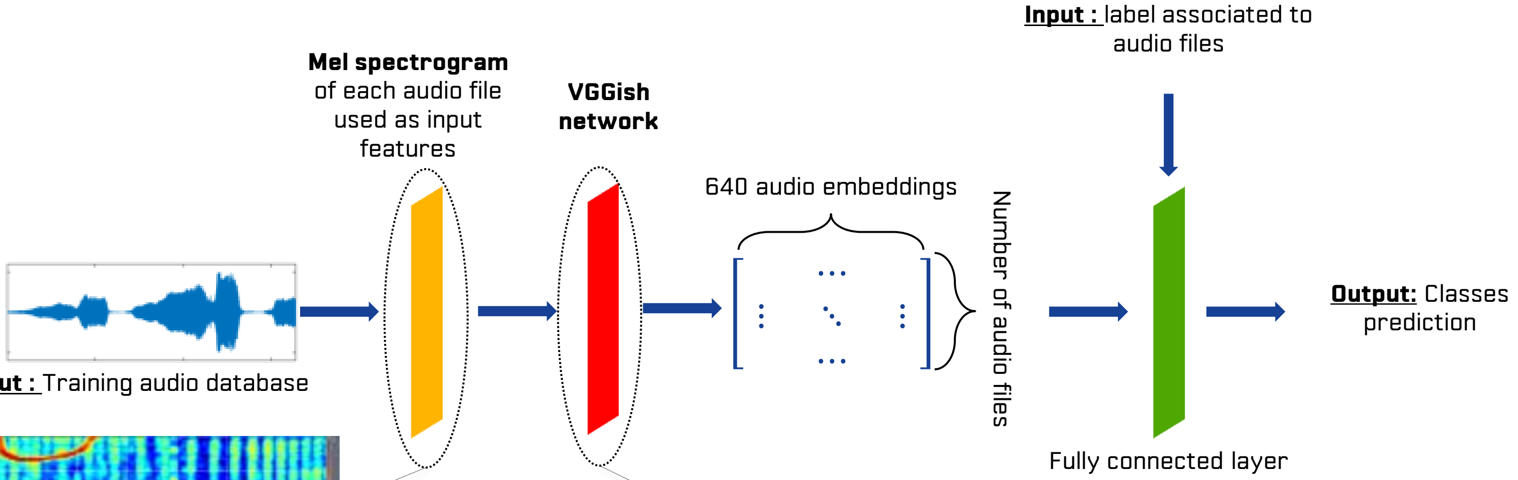
Computation of MFCC

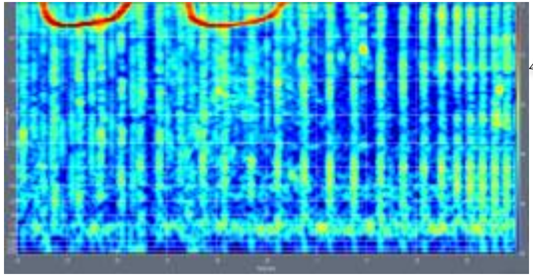
Audio signal → Framing Windowing → Fast Fourier Transform → Mel filter bank → Discrete Cosine Transform → MFCC

Architecture of MFCC and SVM



METHODOLOGY
THE VGGISH NETWORK

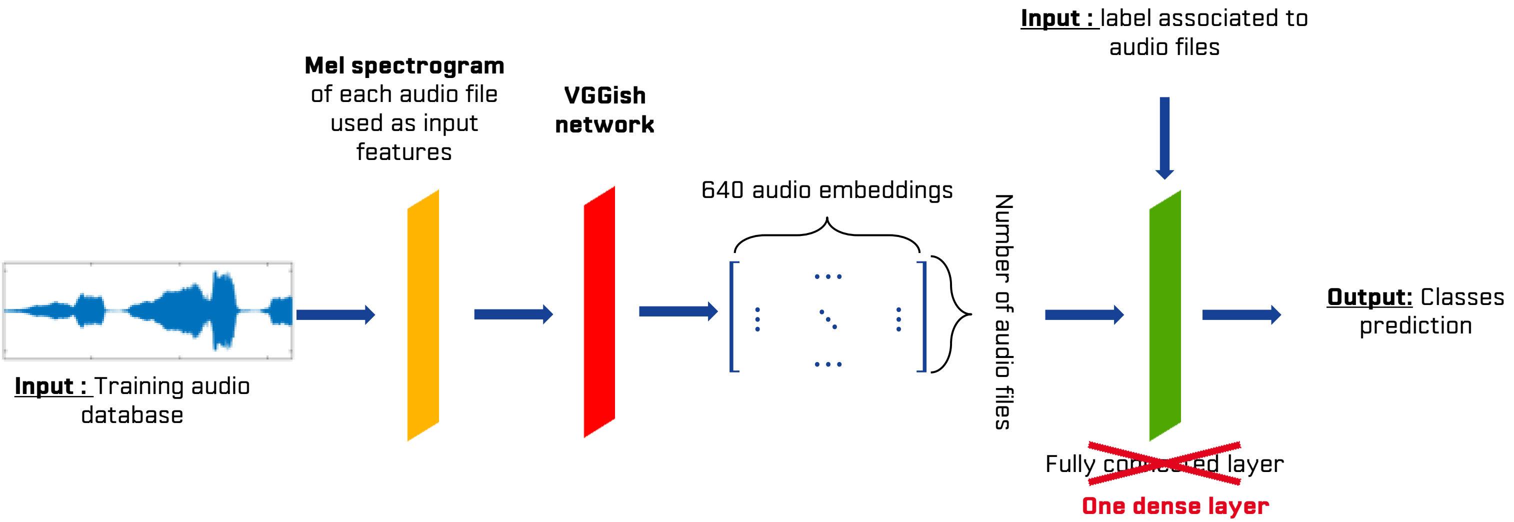




Example of a Mel spectrogram of a biological signal. X-axis correspond to Time and Y-axis corresponds to Mel frequencies

Architecture of VGGish network. The input size is 96x64 for log Mel spectrogram audio inputs

METHODOLOGY
THE VGGISH NETWORK AND ONE DENSE LAYER



Addition of one dense layer

➔ fine-tune and adapt VGGish to our data

EXPERIMENTS AND RESULTS

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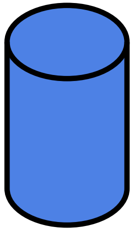
Database composition



Initial database

signals for training → 80% for the training, 20% for evaluation →

test signals

Classes	BIOLOGICAL	SURFACE SHIP	SUBMARINE
Occurrences	134	158	174

Repartition of training dataset

BIOLOGICAL : **BIO**, SURFACE SHIP : **SS**, SUBMARINE : **SM**

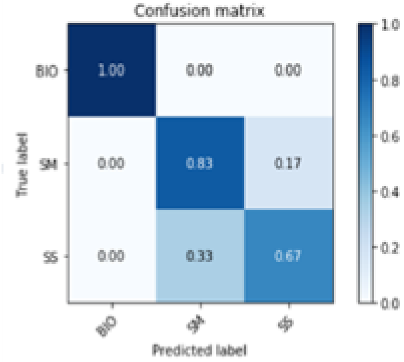
Performance assessments

- Train and validation accuracy
- Confusion matrix
- AUC-ROC curve

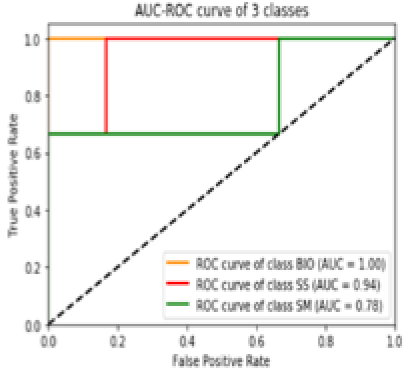
BIO

SS

SM



Example of a confusion matrix



Example of an AUC-ROC Curve

Train and validation accuracy

Architecture	Train_accuracy %	Validation_accuracy %
MFCCs and SVM	100.00	86.96
VGGish	93.80	91.30
VGGish and one dense layer	99.03	92.03

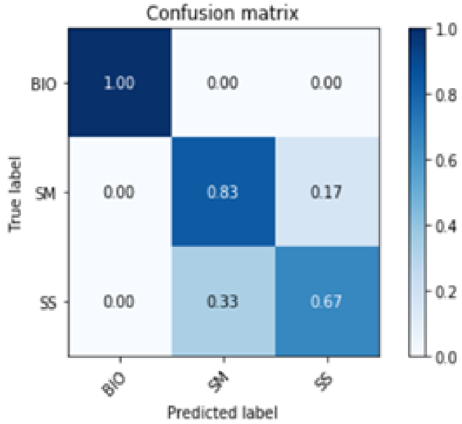
Accuracy of the train and validation dataset for the 3 architectures

Main results

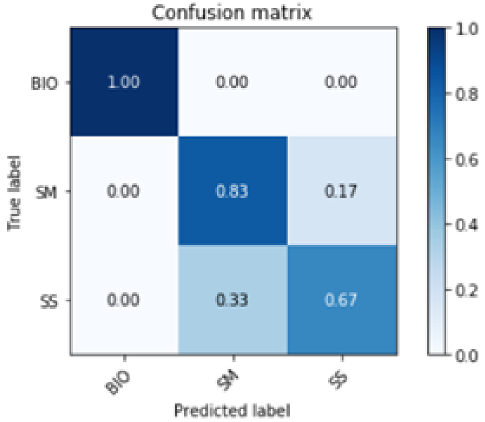
- MFCCs and SVM architecture seem to overfit in this case
- VGGish and VGGish + one dense layer generalize well

Confusion matrices

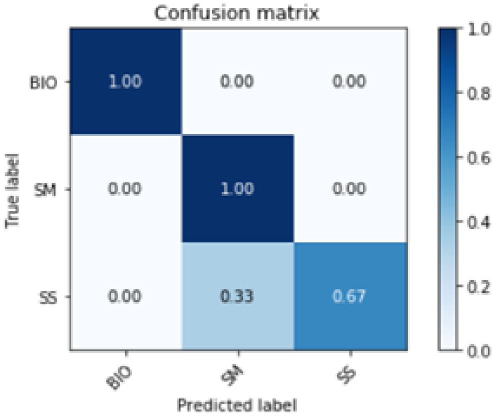
MFCCs + SVM



VGGish



VGGish + 1 Dense Layer

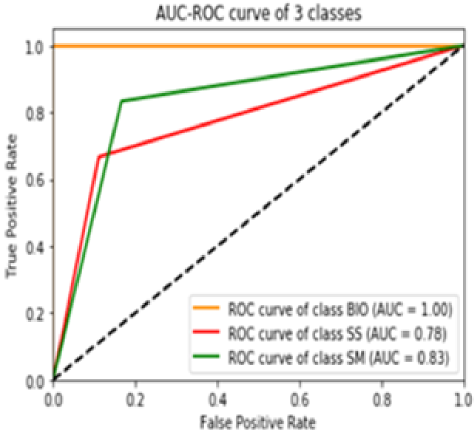


Main results

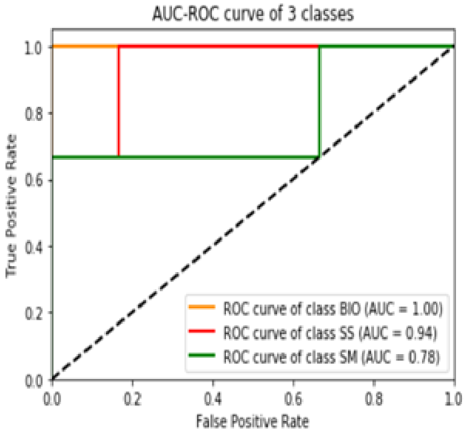
- Training again VGGish with one dense layer shows better performance
- Difficulty predicting the SS class, often confused with SM class

AUC-ROC curves

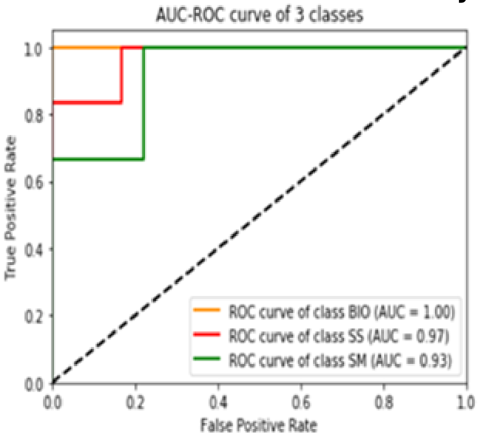
MFCCs + SVM



VGGish



VGGish + 1 Dense Layer



Main result

- VGGish + one dense layer has the better performance

CONCLUSION AND FUTURE WORKS

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CONCLUSION AND FUTURE WORKS

Achieved works

- ✓ Creation of a public database with operational classes
- ✓ Selection of architectures and performance assessment
- ✓ Validation of at least one architecture

→ VGGish and one dense layer architecture is the most efficient

Future works

- Database extension
  - Creation of new examples with signal processing techniques
  - Optimization of the constitution of classes
- Modification of the neural network architecture
  - Use of shallower networks
- Addition of heuristic rules
- Enhancing performance in generalization

Thank you for your attention

E. Artusi : eva.artusi@naval-group.com , eva.artusi@mines-paristech.fr
F.Chaillan : fabien.chaillan@naval-group.com