LAB: Audio Transfer Learning
with Scikit-learn and Tensorflow

Jordi Pons and Xavier Favory

https://github.com/jordipons/sklearn-audio-transfer-learning

About us

Music Technology Group

- Research group at Universitat Pompeu Fabra
- Research on **music** and **audio technologies**
- Founded 25 years ago by his current director Xavier Serra
- Four labs:
  - Audio Signal Processing Lab (led by Xavier Serra)
  - Music Information Research Lab (led by Emilia Gómez)
  - Music and Multimodal Interaction Lab (led by Sergi Jordà)
  - Music and Machine Learning Lab (led by Rafael Ramírez)

+ info at www.mtg.upf.edu and @mtg_upf

Jordi Pons

- **Researcher** at Dolby
- **PhD candidate** at the Music Technology Group
- Also worked at:
  - Telefónica Research (Barcelona)
  - Pandora Radio (Bay Area, USA)
  - German Hearing Center (Hannover, Germany)
  - IRCAM (Paris, France)

+ info at www.jordipons.me and at @jordiponsdotme

Xavier Favory

- Music & Web technologies enthusiast
- **PhD candidate** at the Music Technology Group
- **ENSEA** (École nationale supérieure de l'électronique et de ses applications)
- **Master** of engineering at ENSEA (École Nationale Supérieure de l'Électronique et de ses Applications), Cergy.
- **Master** Acoustics, Signal processing, Informatics applied to Music (ATIAM), IRCAM , Paris.

Today’s plan

Today’s schedule

- Setup: download audio data and pre-trained model
- Introduction to Audio Transfer Learning
- Demonstration
- Questions
- **Hands-on example: transfer learning with neural networks**
- **Start competition!**

Audio transfer learning

Training neural audio classifiers with few data

HOW?

- **Strong regularization**
  - We assess the limitations of the standard deep learning pipeline
- **Transfer learning**
  - Enables to leverage external sources of audio data

+ info in our paper:

https://arxiv.org/abs/1810.10274

Methodology

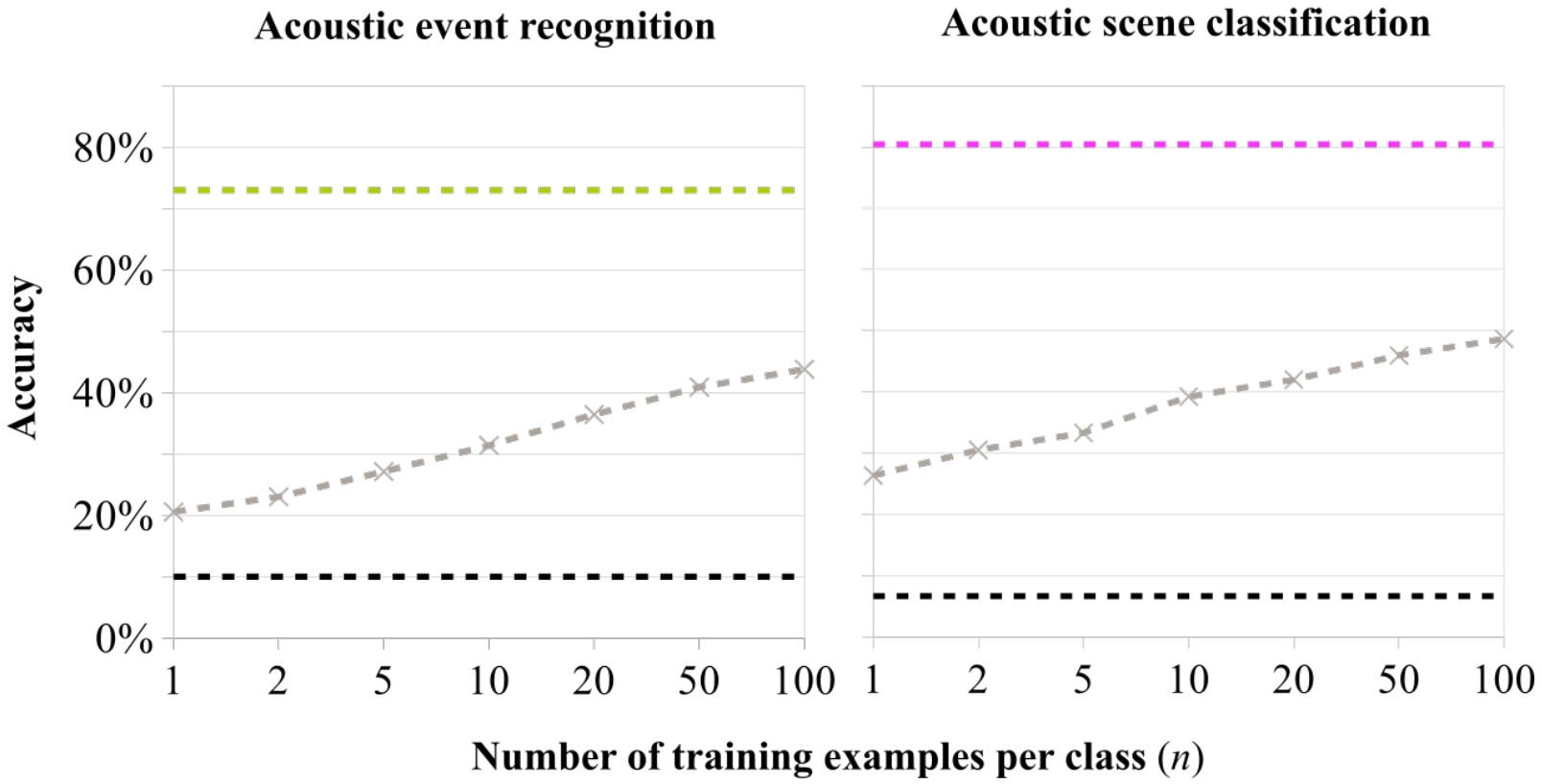
Targeted tasks and our data

- **Acoustic Event Recognition** (US8K dataset)
  - 8,732 urban sounds
  - **10 classes**: *car horn, children playing, dog bark, gun shot, siren, ...*
  - 10 folds

- **Acoustic Scene Classification** (ASC-TUT dataset)
  - 4,680 training audio segments
  - 1,620 evaluation audio segments
  - **15 classes**: *park, home, office, train, bus, ...*

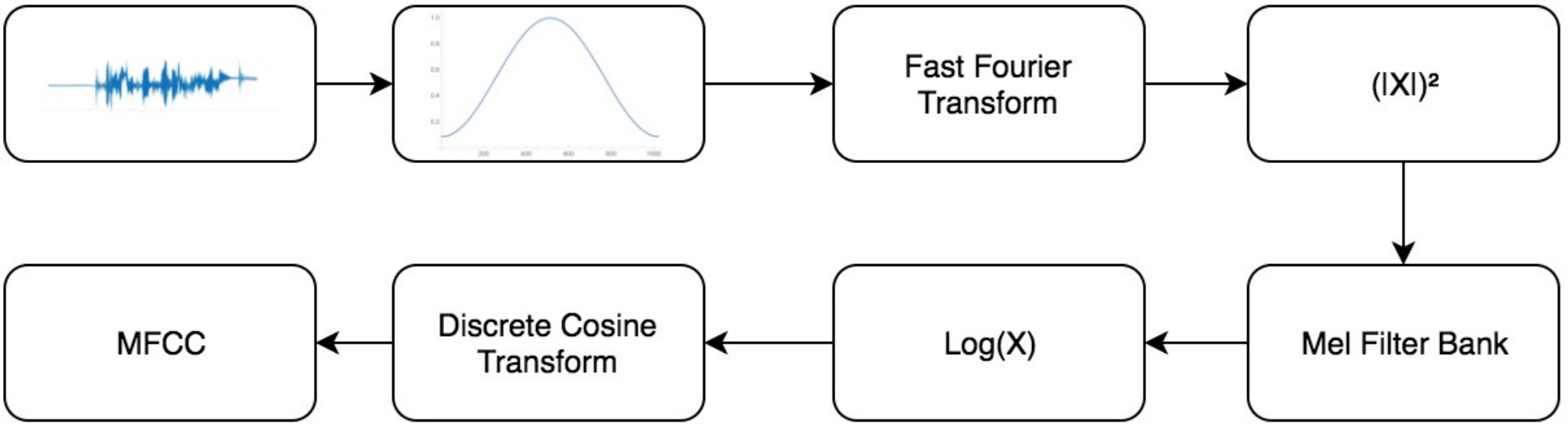
Evaluation

The MFCC's + nearest neighbor baseline



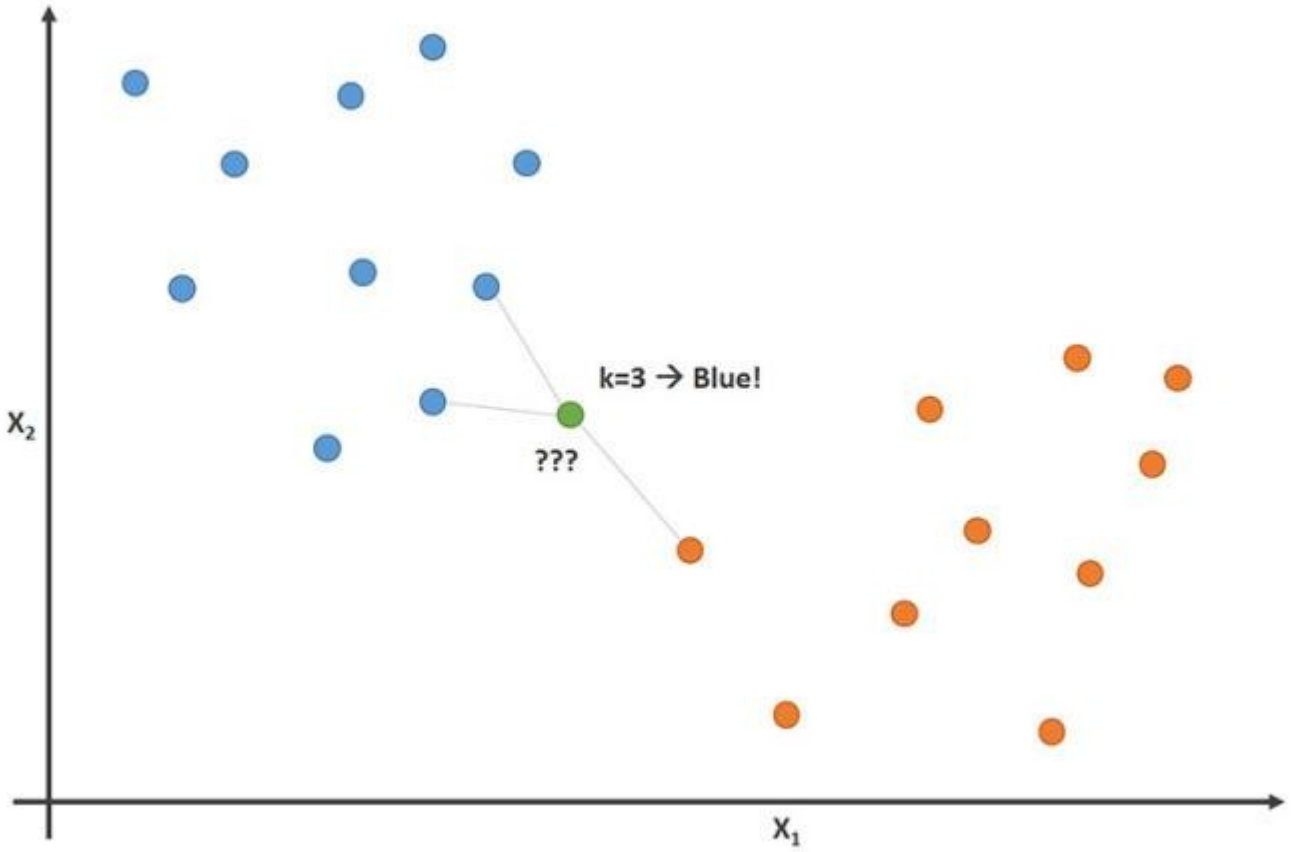
Evaluation

*The **MFCC's** + nearest neighbor baseline*



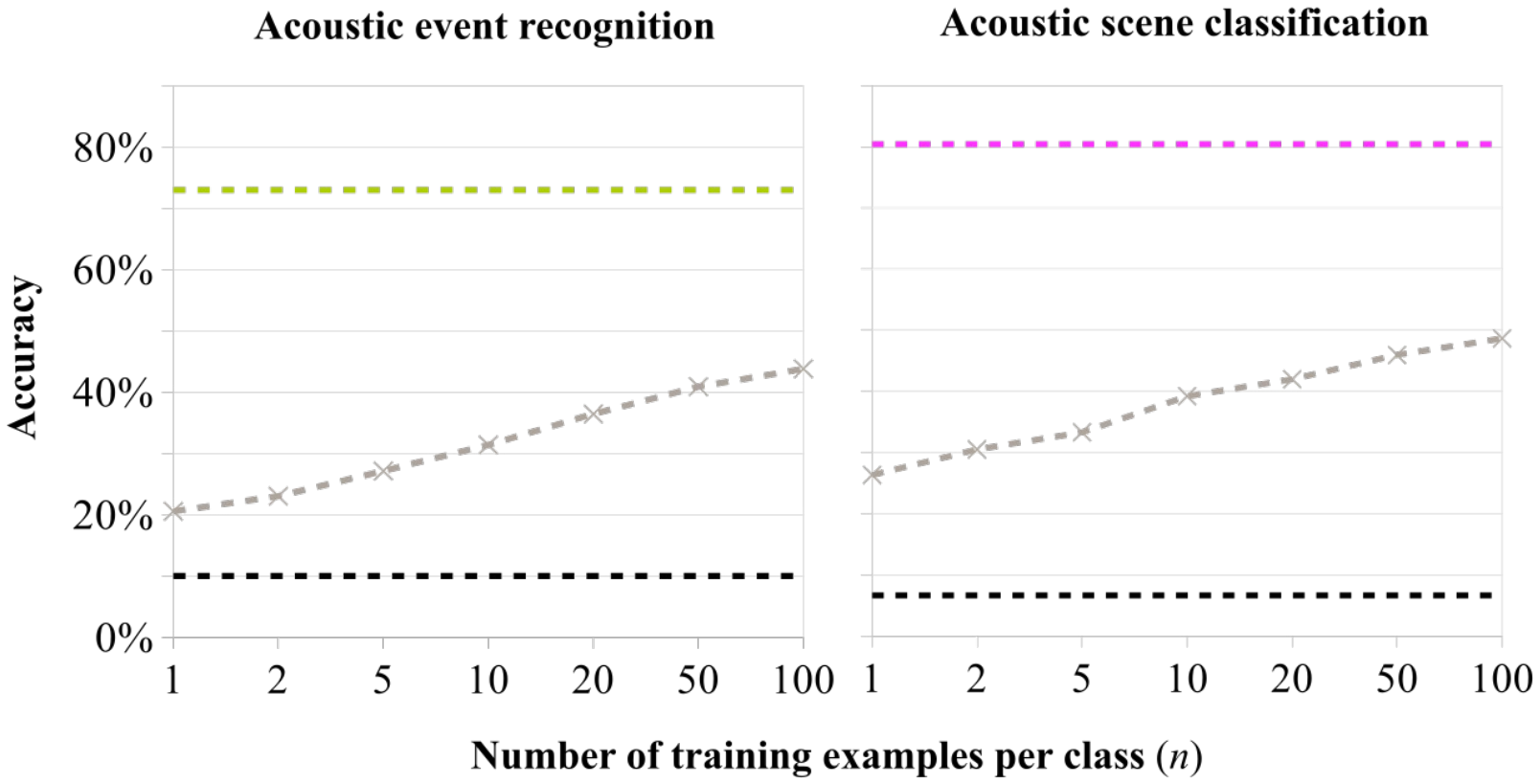
Evaluation

*The MFCC's + **nearest neighbor** baseline*



Evaluation

The MFCC's + nearest neighbor baseline



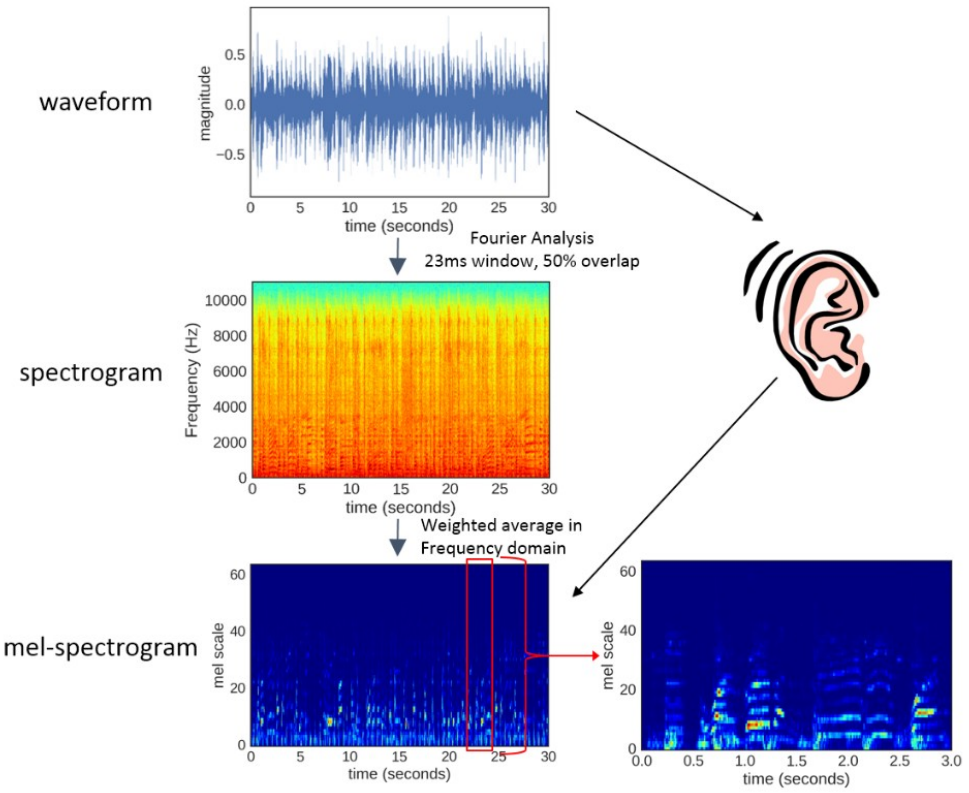
Regularized models

Transfer learning

Regularized models

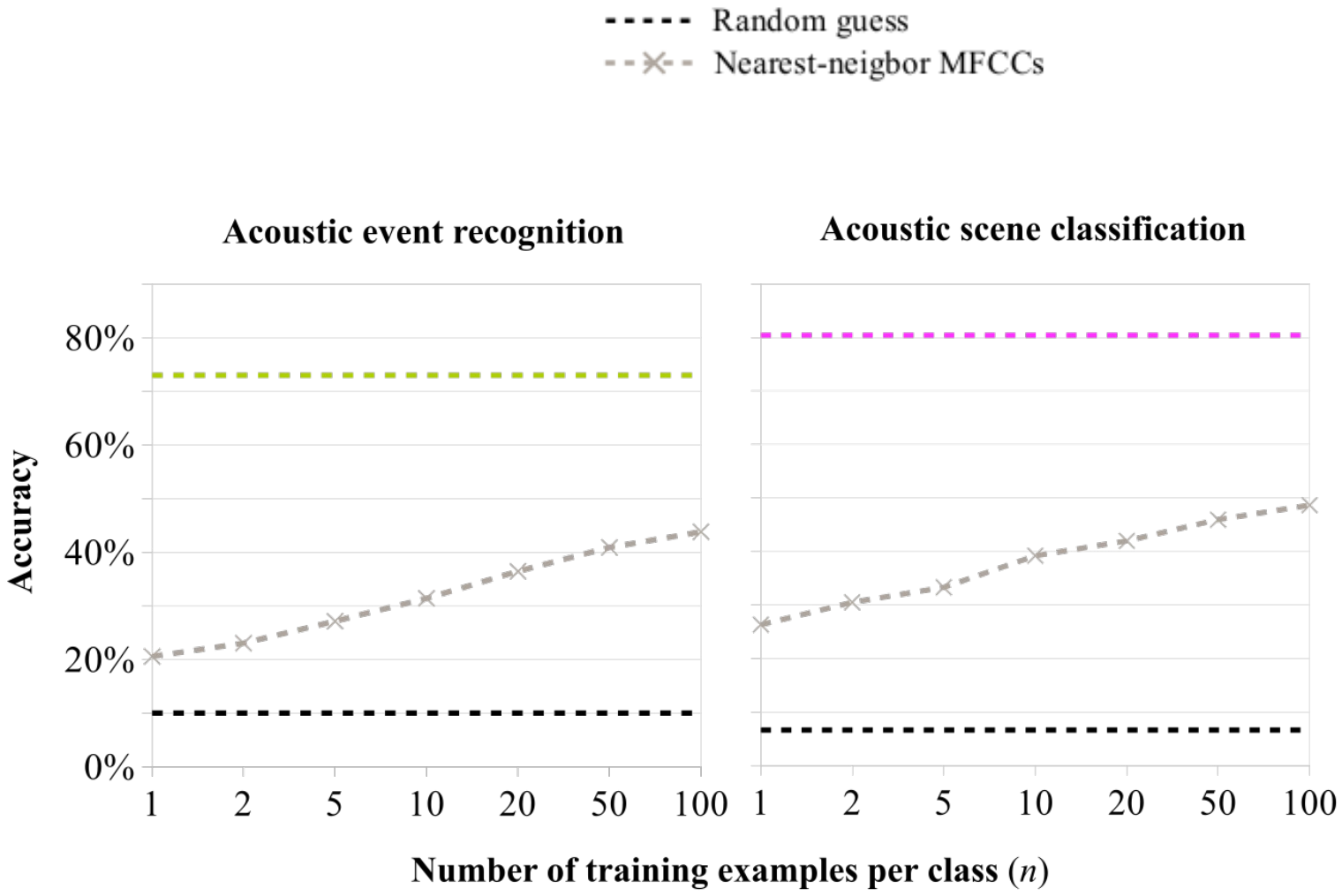
Input

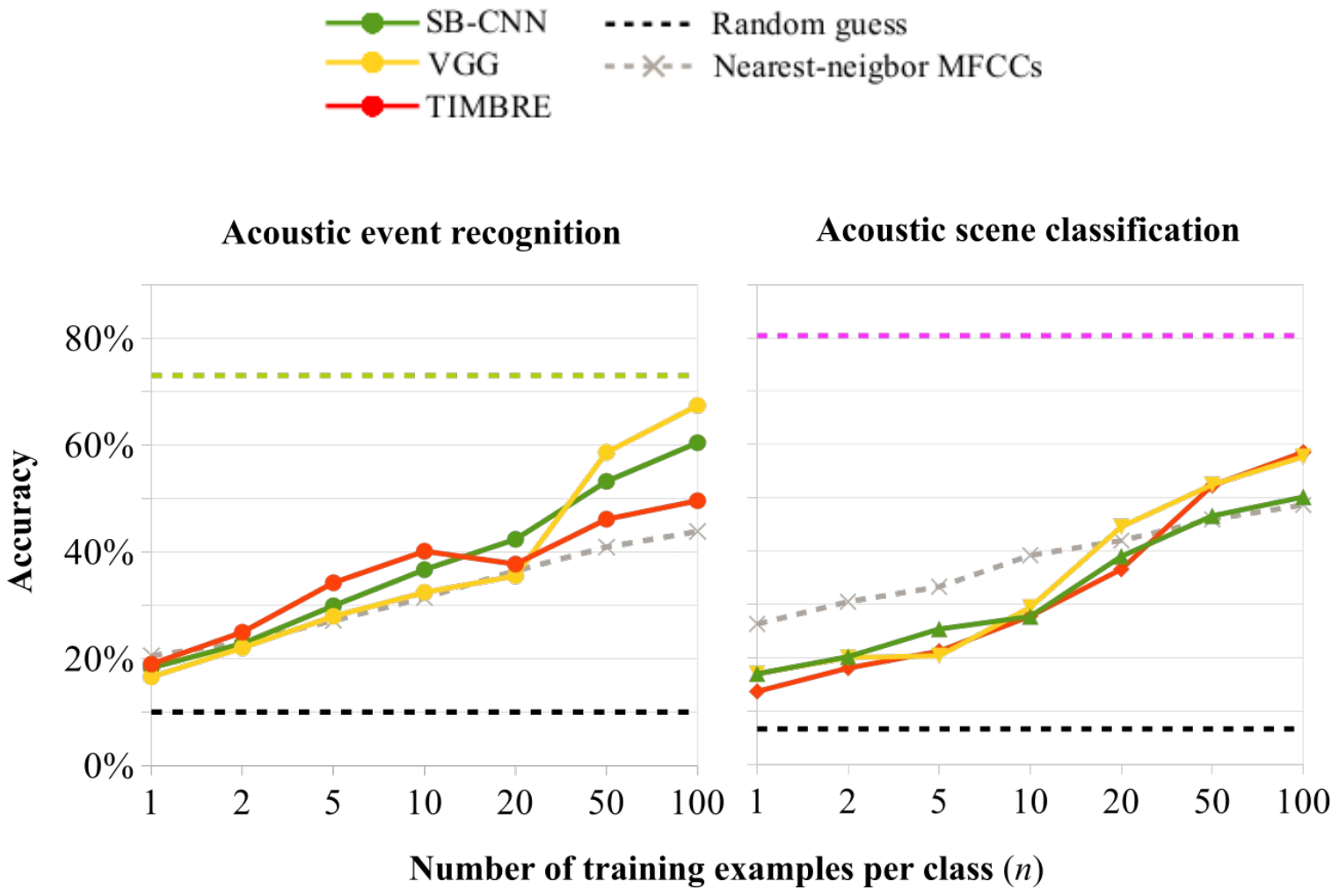
Input: log-mel spectrogram of 128 bins x 3 sec (128 frames)



Regularized models

- **SB-CNN**: **250k** parameters
  - Inspired by AlexNet's computer vision architecture
  - *3 CNN layers (5x5) with max-pool + dense layer + softmax*
- **VGG**: **50k** parameters
  - Yet another computer vision architecture
  - *5 CNN layers (3x3) with max-pool (2x2) + softmax*
- **TIMBRE**: **10k** parameters
  - The smallest CNN one can imagine for learning timbral traces
  - *1 CNN layer (vertical filters 108x7) with maxpool + softmax*

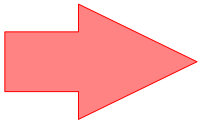

Random guess
Nearest-neigbor MFCCs
Acoustic event recognition
Acoustic scene classification
Accuracy
80%
60%
40%
20%
0%
1
2
5
10
20
50
100
Number of training examples per class (n)


SB-CNN
VGG
TIMBRE
Random guess
Nearest-neigbor MFCCs
Acoustic event recognition
Acoustic scene classification
Accuracy
80%
60%
40%
20%
0%
1
2
5
10
20
50
100
Number of training examples per class (n)

Transfer learning

Transfer learning

Pretrain with source task



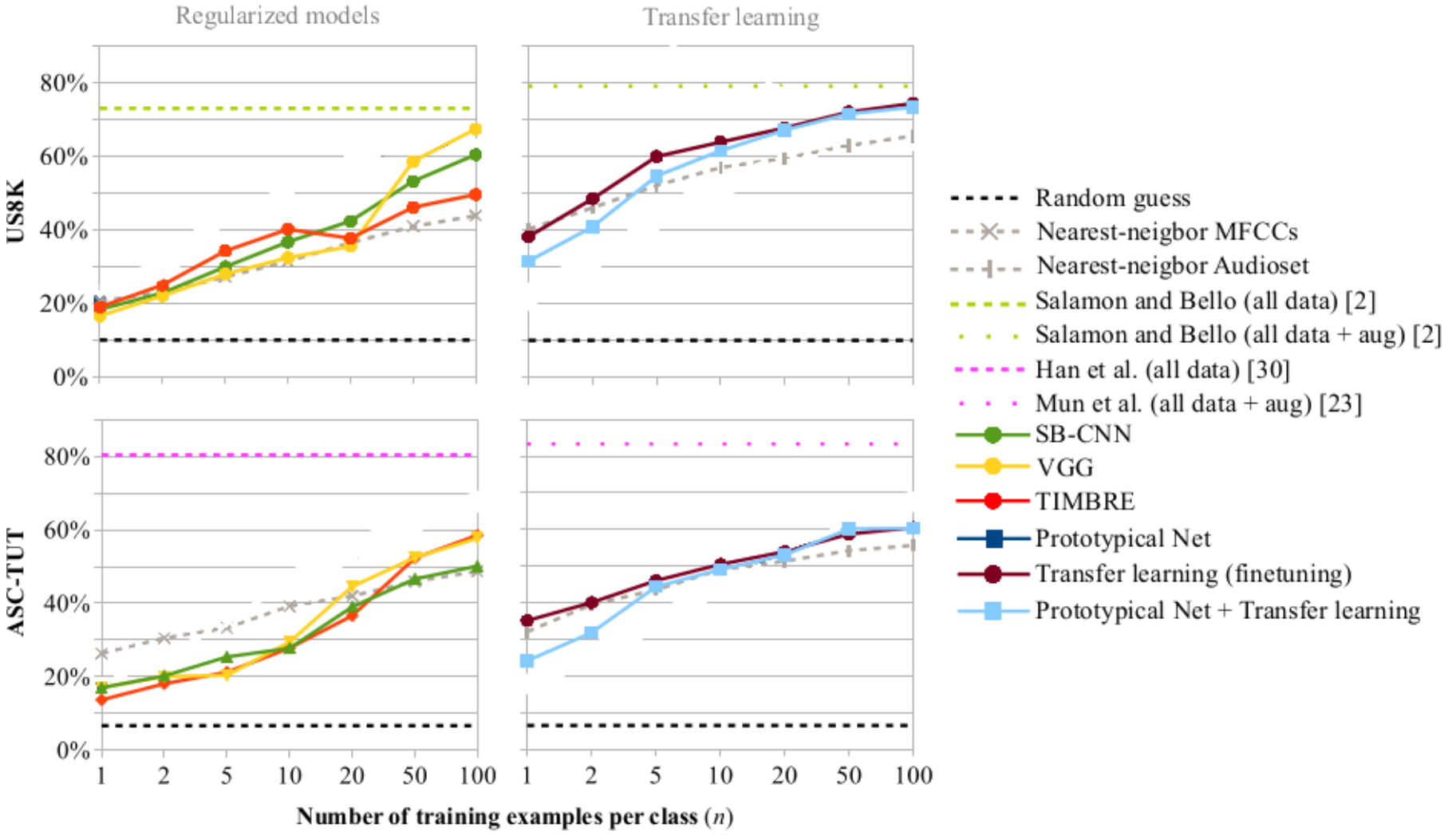
Finetune with target task(s)

AudioSet dataset
(acoustic event recognition)
2M Youtube audios

US8K dataset
(acoustic event recognition)

ASC-TUT dataset
(acoustic scene classification)

Pre-trained **VGGish** on AudioSet:
6 CNN layers (3×3)
with max-pool layers (2×2) +
3 dense layers (4096, 4096, 128)


Regularized models
Transfer learning
US8K
ASC-TUT
80%
60%
40%
20%
0%
1
2
5
10
20
50
100
Number of training examples per class (n)
Random guess
Nearest-neigbor MFCCs
Nearest-neigbor Audioset
Salamon and Bello (all data) [2]
Salamon and Bello (all data + aug) [2]
Han et al. (all data) [30]
Mun et al. (all data + aug) [23]
SB-CNN
VGG
TIMBRE
Prototypical Net
Transfer learning (finetuning)
Prototypical Net + Transfer learning

Conclusions

Training neural audio classifiers with few data

- **Strong regularization**
  - We assess the limitations of the standard deep learning pipeline
- **Transfer learning**
  - Enables to leverage external sources of audio data
  - Be careful with source and target tasks. They need to be similar!

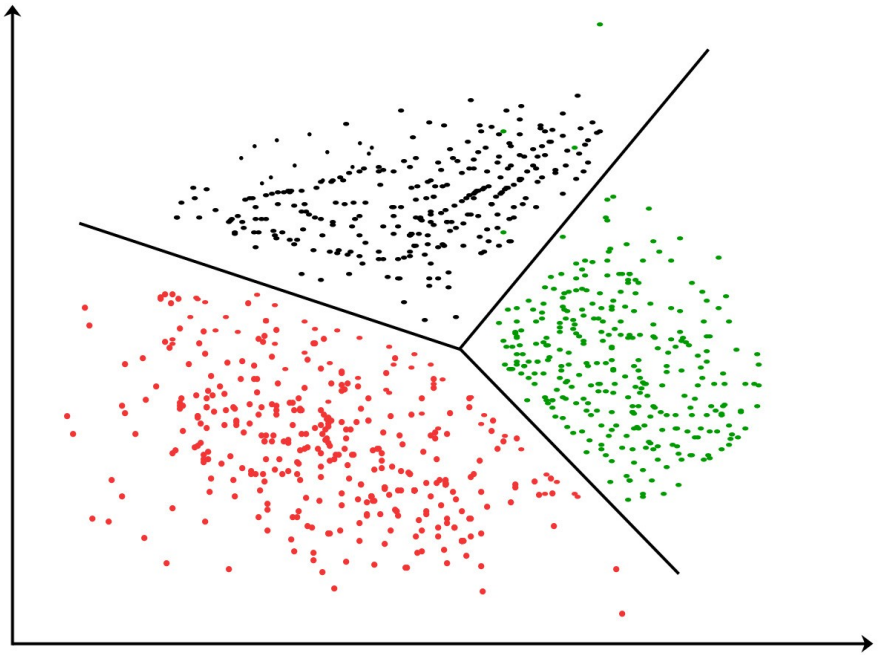
Let’s try it!

Demonstration

Using Deep Embeddings for Unsupervised Tasks

- **Clustering:**
  - Unsupervised classification which consists in organising similar objects in groups called **clusters**
  - exploratory data analysis
  - Requires a notion of **similarity**

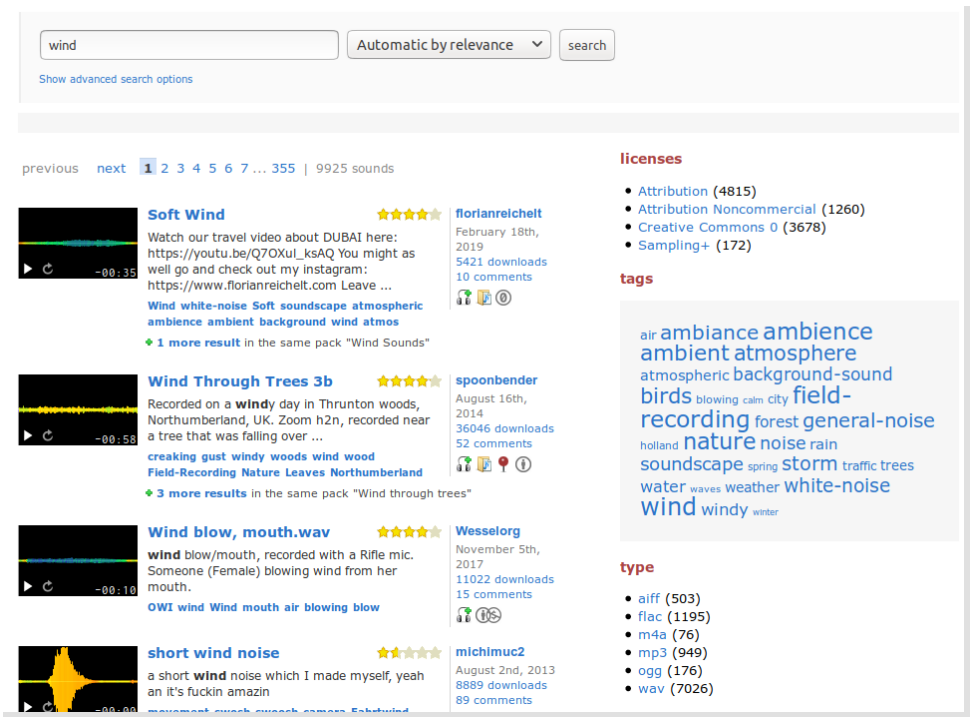
What about using **AudioSet embeddings**?



Using Deep Embeddings for Unsupervised Tasks

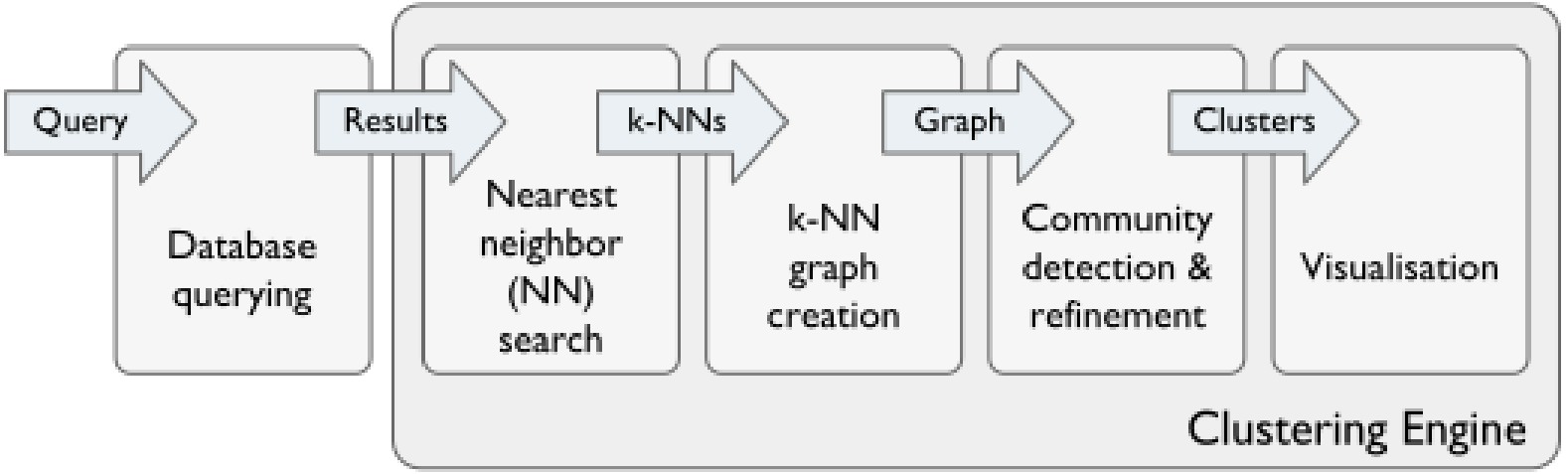
- **Freesound**
  - Sound sharing platform
  - > 400 000 sounds
  - + 1 000 sounds per week
  - Creative Commons licenses

https://freesound.org



Using Deep Embeddings for Unsupervised Tasks

- **Search Result Clustering**



DEMO

Questions?

Today’s schedule

- Setup: download audio data and pre-trained model
- Introduction to Audio Transfer Learning
- Demonstration
- Questions
- **Hands-on example: transfer learning with neural networks**
- **Start competition!**