Introduction to **Audio Content Analysis**

Module 4.1: Classification

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introduction

overview

corresponding textbook section

section 4.1

- **lecture content**
  - intuitive intro to machine learning
  - classifier examples

- **learning objectives**
  - describe the basic principles of data-driven machine learning approaches
  - implement a kNN classifier in Python

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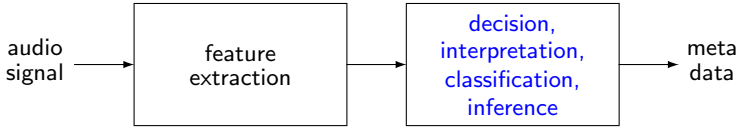
classification
introduction

remember the flow chart of a general ACA system:



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- *regression*:
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- *clustering*:
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classification
introduction

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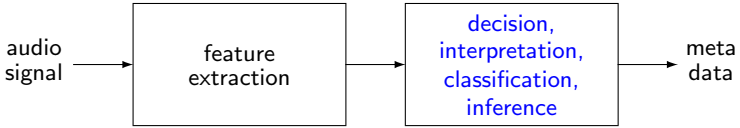

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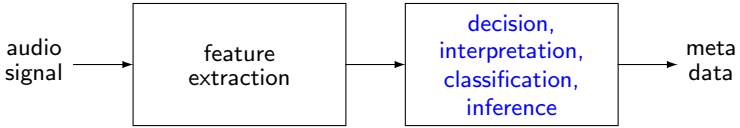

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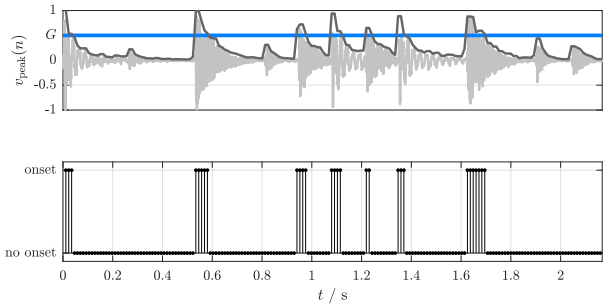
classification
basic example

hypothetical system:

- one feature (envelope)
- predefined threshold
  - higher than threshold ⇒ class 1 (onset)
  - lower than threshold ⇒ class 0 (no onset)



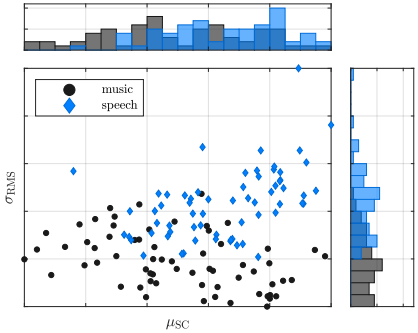
matlab source: plotThresholdClassification.m

classification
data-driven

- derive classification parameters from data, e.g.,

⇒ learn common feature distributions per class

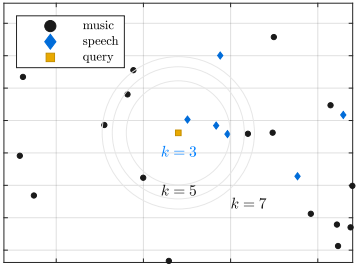
⇒ learn separation metrics per class



matlab source: plotFeatureSpace.m

classifier examples
k-Nearest Neighbor (kNN)

- **training**: extract reference vectors from training set
  - store coordinates and class labels
- **classification**: extract query vector and set class to majority of k nearest reference vectors
  1. compute distance between query and all training vectors
  2. sort distances to find closest vectors
  3. choose majority class out of the k closest vectors
- **classifier model**: all training vectors



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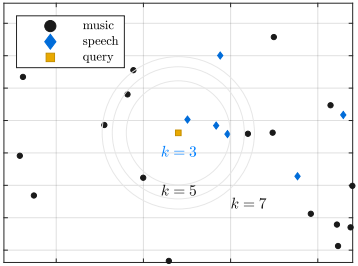

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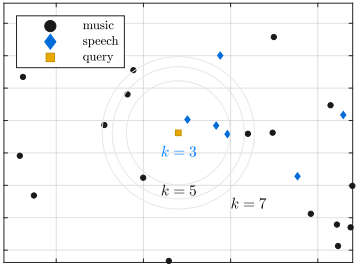

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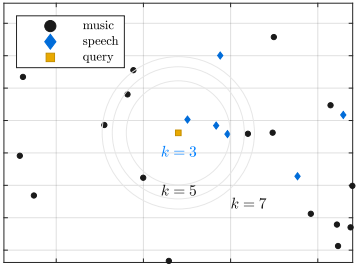

$k = 3 \Rightarrow$ blue majority

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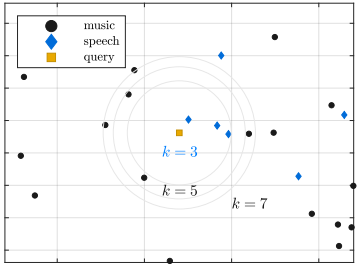

$k = 5 \Rightarrow$ black majority

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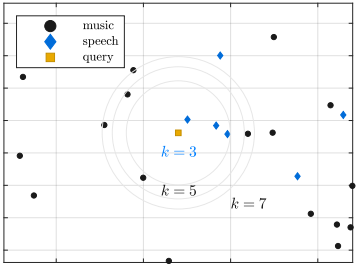

$k = 7 \Rightarrow$ black majority

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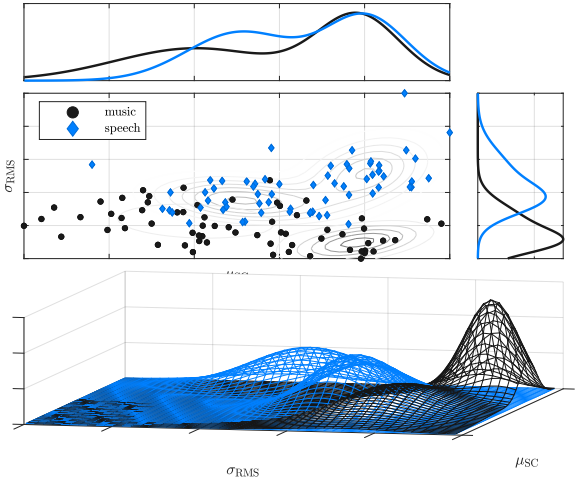
classifier examples
Gaussian Mixture Model (GMM)

- **training**:
  model each class distribution as superposition of Gaussian distributions
- **classification**:
  compute output of each Gaussian and select class with highest probability
- **classifier data**:
  per class per Gaussian: μ and covariance, mixture weight



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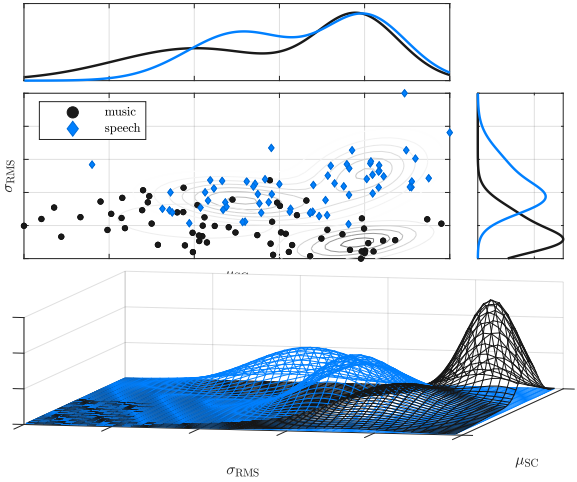

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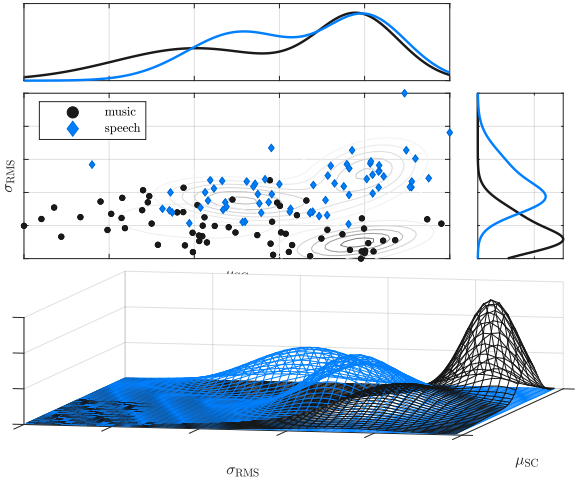

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classifier examples
Support Vector Machine (SVM)

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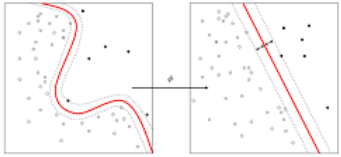
  - map features to high dimensional space



  - find separating hyperplane through maximum distance of support vectors (data points)
- **classification**: apply feature transform and proceed with 'linear' classification
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https://en.wikipedia.org/wiki/Support_vector_machine

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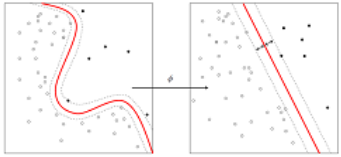

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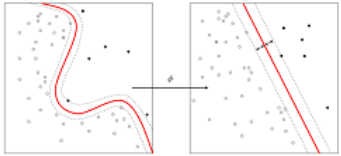

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summary
lecture content

- **data-driven approach**
  - 'general' system learns parameters/behavior from data
  - human interaction through
    - parametrization and procedures
    - data selection

- **many classifiers with different levels of complexity**
  1. kNN
  2. GMM
  3. SVM
  4. RandomForest
  5. DNN
  6. ...