Introduction to **Audio Content Analysis**

module 4.1: classification

alexander lerch

introduction
overview

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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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corresponding textbook section

section 4.1

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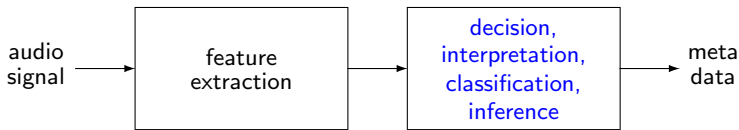 - classifier examples

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

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classification
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remember the flow chart of a general ACA system:

- *classification*:
  - assign class labels to data
- *regression*:
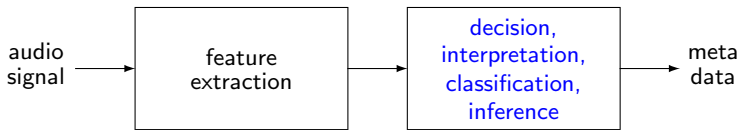 - estimate numerical labels for data
- *clustering*:
  - find grouping patterns in data

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classification
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classification
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remember the flow chart of a general ACA system:

- *classification*:
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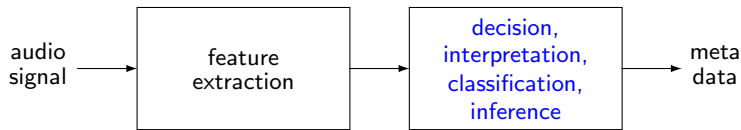 - estimate numerical labels for data
- *clustering*:
  - find grouping patterns in data

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classification
basic example

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hypothetical system:

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

matlab source: plotThresholdClassification.m

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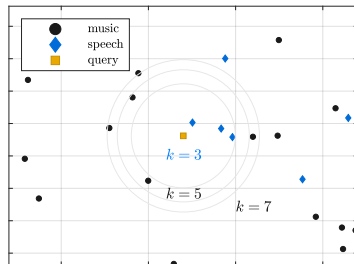
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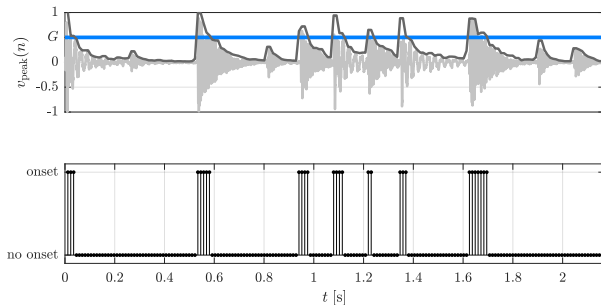
classification
data-driven

- derive classification parameters from data, e.g.,
⇒ learn common feature distributions per class
⇒ learn separation metrics per class

matlab source: plotFeatureSpace.m

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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

matlab source: plotKnn.m

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classifier examples
k-Nearest Neighbor (kNN)

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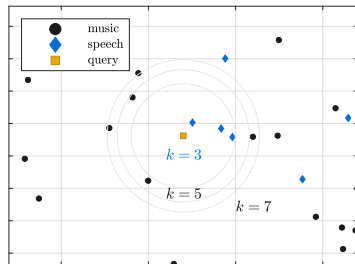Tech | Technology
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- **classifier model**: all training vectors

matlab source: plotKnn.m

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classifier examples
k-Nearest Neighbor (kNN)

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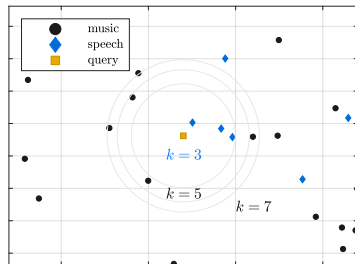 3. choose majority class out of the k closest vectors

- **classifier model**: all training vectors

matlab source: plotKnn.m

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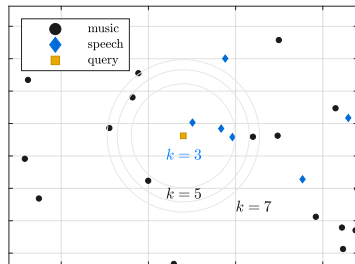## classifier examples
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- **classifier model**: all training vectors

$k = 3 \Rightarrow$ blue majority

matlab source: plotKnn.m

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classifier examples
k-Nearest Neighbor (kNN)

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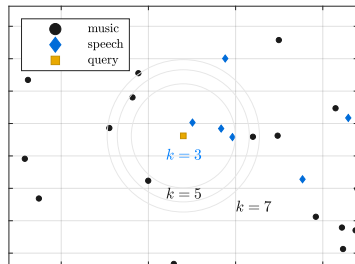- **classifier model**: all training vectors

matlab source: plotKnn.m

$k = 5 \Rightarrow$ black majority

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classifier examples
k-Nearest Neighbor (kNN)

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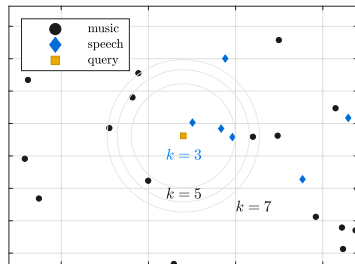- **classifier model**: all training vectors

$k = 7 \Rightarrow$ black majority

matlab source: plotKnn.m

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classifier examples
Gaussian Mixture Model (GMM)

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- **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

matlab source: plotGmm.m

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classifier examples
Gaussian Mixture Model (GMM)

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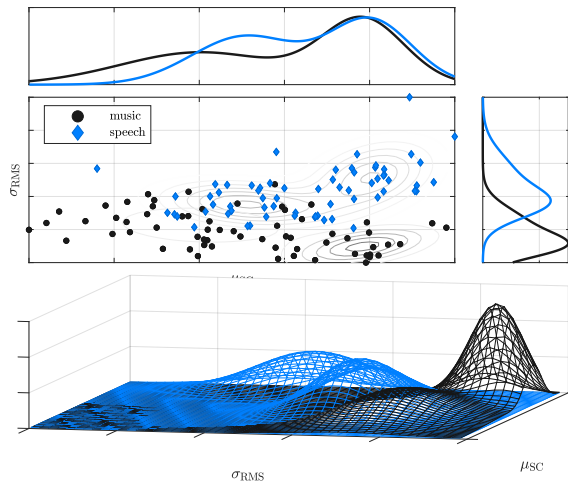College of Design

- **training**:
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- classifier data:
  per class per Gaussian: μ and
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matlab source: plotGmm.m

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classifier examples
Gaussian Mixture Model (GMM)

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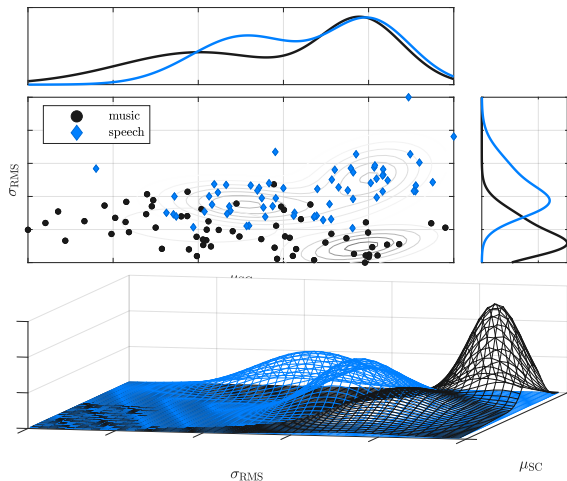Tech **Technology**
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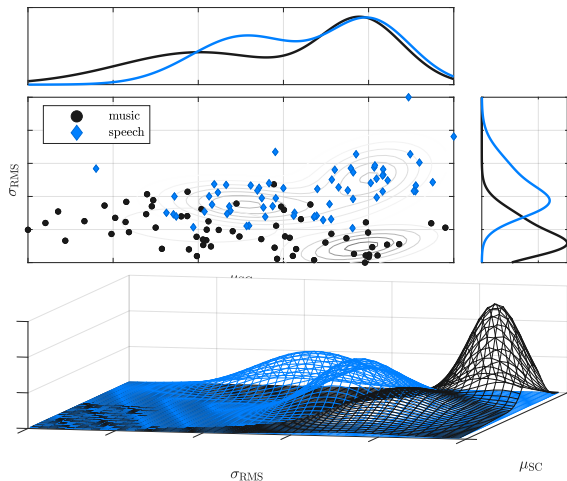 highest probability

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matlab source: plotGmm.m

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classifier examples
Support Vector Machine (SVM)

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- **training**:
  - 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
- **classifier data**: support vectors, kernel, kernel parameters

https://en.wikipedia.org/wiki/Support_vector_machine

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classifier examples
Support Vector Machine (SVM)

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classifier examples
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https://en.wikipedia.org/wiki/Support_vector_machine

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summary
lecture content

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- **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. . . .