Speaker Recognition

An Outline of Neural Network-Based Approaches

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Overview

What is Speaker Recognition?

Preliminary Principles

A detailed look at the process.

Neural Network Methods

Two Different Approaches

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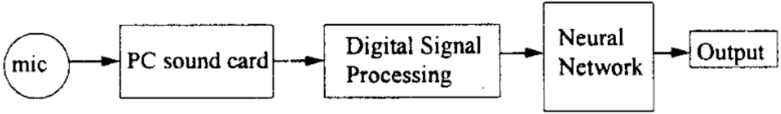
In General

- **Input**: Audio encoding of speech
- **Output**: Information that classifies speaker



Applications:

- User authentication
- Biometrics
- Caller ID
- ...

Paradigms

- **Speaker Recognition**
  Recognize that a member of a known population spoke
- **Speaker Verification**
  Verify that a given subject is who he claims to be
- **Speaker Identification**
  Detect a particular speaker from a known population
  - **Text Dependent**
  - **Text Independent**

Approaches

- **Acoustic Phonetic**
  Based on theory that speech can be broken down uniquely into phonemes that can then be easily characterized and used to categorize future inputs
- **Pattern Recognition**
  The 'brute force' approach: if enough samples are trained, common features will be accentuated and recognized
- **Artificial Intelligence**
  Combination of the above; systematic approach to emulate human recognition and extraction of signal features for pattern matching

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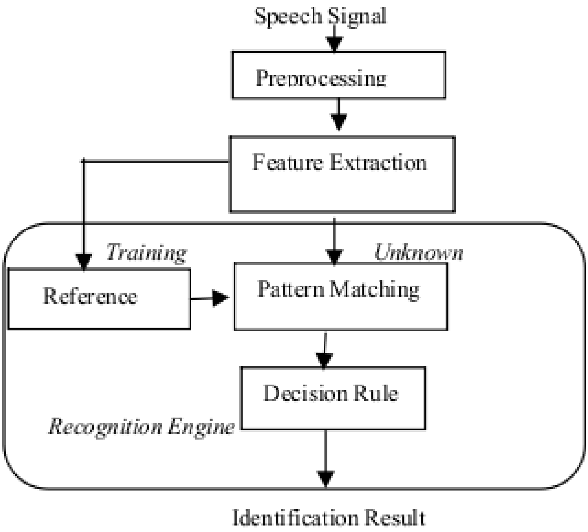
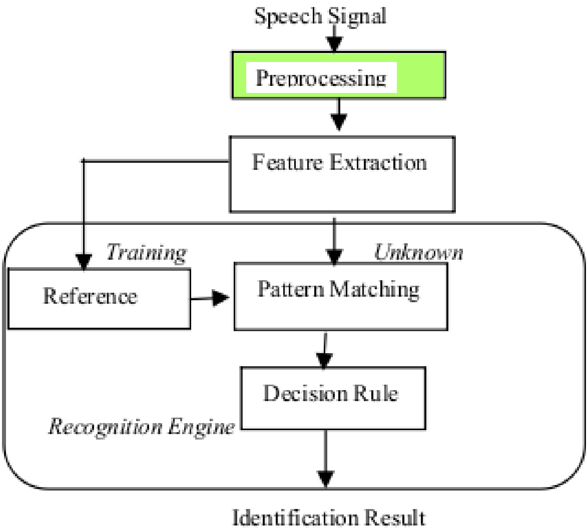

Speech Signal
Preprocessing
Feature Extraction
Training
Unknown
Reference
Pattern Matching
Decision Rule
Recognition Engine
Identification Result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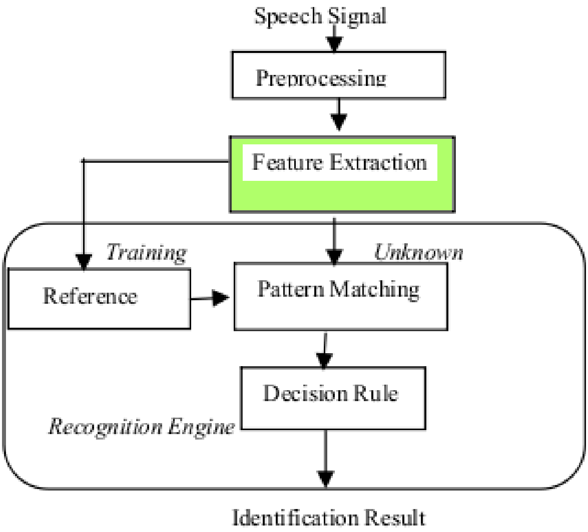
Preprocessing

- Digital filtering
  - Noise Removal
  - Level Adjustment
  - Frequency Attenuation
- Endpoint detection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Feature Extraction

We need to obtain characteristic values of the sound sample.
Why? How?

- Discrete Fourier Transform
- Power Spectral Density
- Linear Predictive Coding
- Average Mean Distance function

All three methods give us *numbers*, which Neural Networks like for input. These numbers should be unique and characteristic of the sound samples they were generated from.

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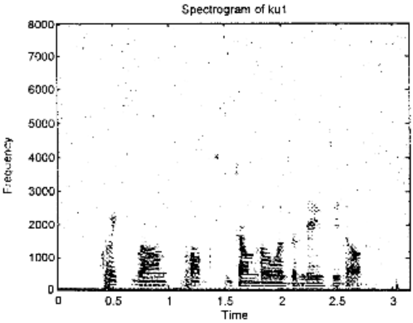
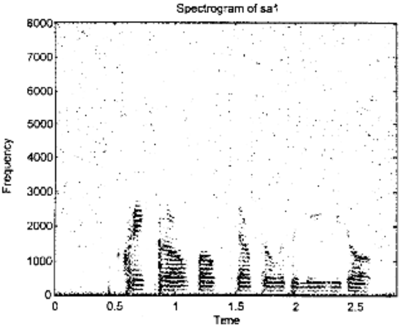
What are they?

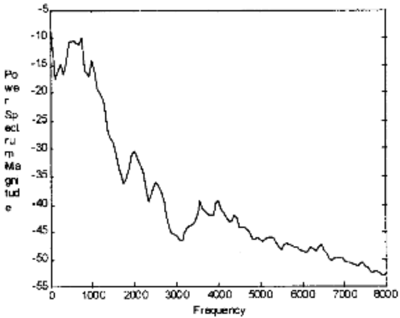
- **Discrete Fourier Transform**
  Algorithm to move from continuous signal to discrete frequency domain
- **Power Spectral Density**
  Computed from the DFT, unique spectral representation of a signal
- **Linear Predictive Coding**
  Used to represent the logarithmic power spectrum of a signal in compressed form
- **Average Mean Distance function**
  Used to find the fundamental frequency of a signal

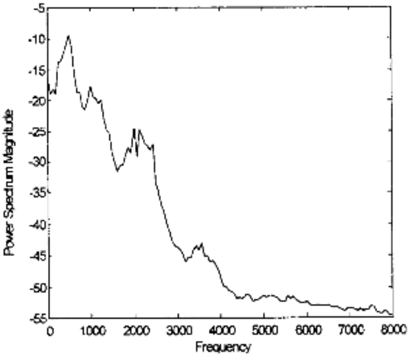
Example of DFT spectra





Example of PSD graphs





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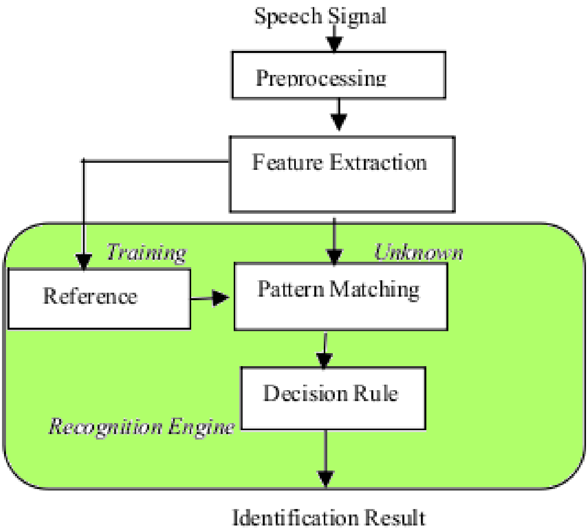
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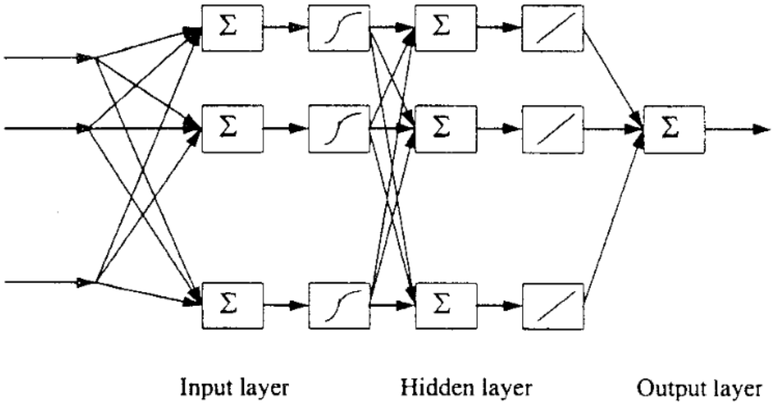
Multi-Layer Perceptrons

Basic three-layer feed-forward network



Multi-Layer Perceptrons

Basic three-layer feed-forward network

Positives:

- Simple to train
- Simple to understand
- Good accuracy on trained samples; up to 100%

Negatives:

- Possibility of overfitting data
- Bad results on untrained or new data
- Better suited to text-dependent recognition

Self Organizing Maps

- **Much more robust than MLP**
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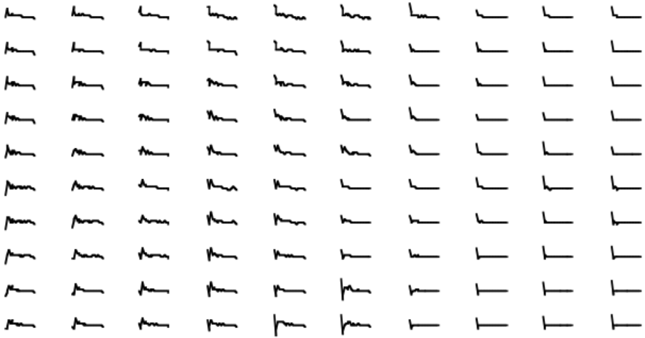

Figure 1: The topological property of the SOM: neighboring units on the SOM are associated with neighboring codewords.

Self Organizing Maps

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- Similar words will be neighbors in the map
- Sample input can then be made into an occupancy histogram

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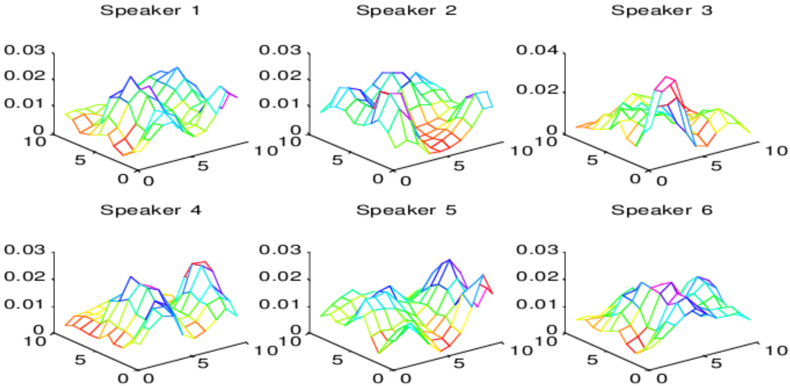
Speaker 1
Speaker 2
Speaker 3
Speaker 4
Speaker 5
Speaker 6
0.03
0.02
0.01
0
0.04
10
5
0

SOM Experiment Results

SNR(DB)	clean	30 dB	20 dB	10 dB
LPC/SOM	98,2	95,0	55,0	8,0
MFCC/SOM	100	95,5	53,0	19,5
LPC/AHSM	97,3	85,14	36,5	5,6
MFCC/AHSM	98,6	96,4	68,9	27,6

- 100 speakers, 100 speech samples per speaker
- 25x25 Self-Organizing Map

Summary

- Speaker/Voice recognition can be accurately done by clever usage of a neural network
- Multi-Layer Perceptrons and Self Organizing Maps are two network types that have been adapted for this purpose