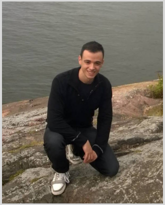
Speech Recognition - EQ2340

HMM (Hidden Markov Models)

Alessio Russo



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Content

Speech Recognition of a limited speech corpus

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- High demand in industry
- Usage in current systems (e.g. Siri)
- Easy to understand general principle

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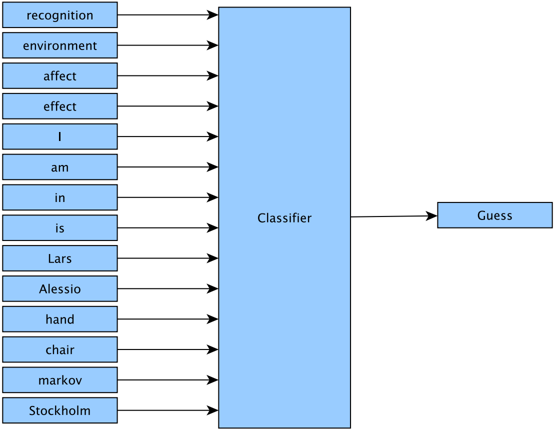
Speech Corpus

- General speech corpus to form sentences
- Multisyllabic, similar and short words to challenge the system

Speech Recognition of a limited speech corpus

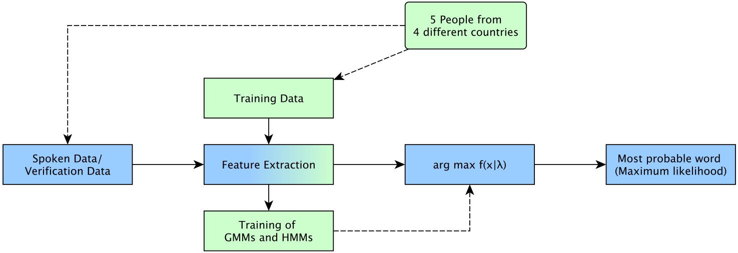


Speech Recognition of a limited speech corpus

- Two examples...

Lars: affect
Natalie: recognition

Overview of the Implementation



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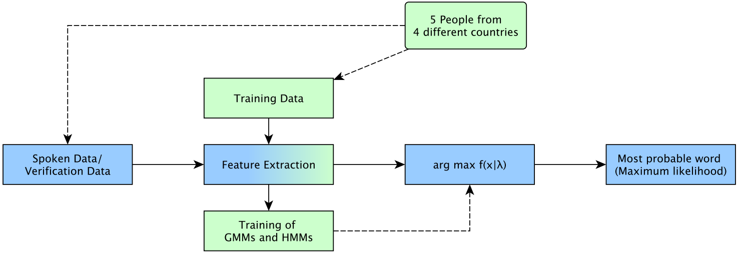

- Distinguish between training and validation/live demonstration

Content

Possible problems

- Pitch
- Different speakers (absolut output value)
- Noise

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Continuous feature vectors

- 13 MFCC (Mel-frequency cepstrum coefficients)
- 26 dynamical features (independent of absolute value)
- 30 ms time frame

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Number of States for left-right HMM

- Trade off: too few parameters vs. amount of training data
- Also: Limited training data
- State assignment due to syllables + start/end state

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System Design, Training and Testing

HMM

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environmnent: 6 states *chair*: 4 states

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Output distributions

- GMM (Gaussian Mixture Models)

Recorded data

- 5 people: 15 recordings per word
- One person has been disregarded
- 840 recordings in total, 60 per word

System Design, Training and Testing

Training data and validation set

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k-fold approach

- k=5 sets
- 48 training and 12 validation samples

Final HMM

- 5 sets have been tweaked on their validation set and compared on the whole set.
- Recognition rate in table below

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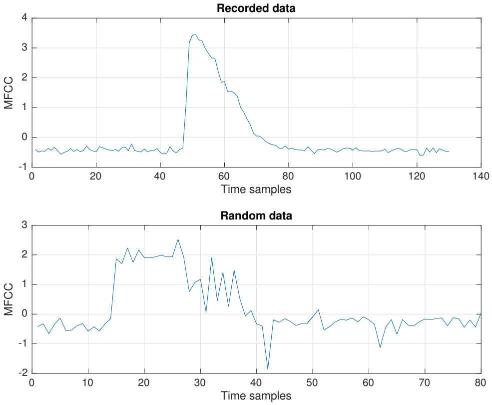
word	1	2	3	4	5	6	7
validation set	1.00	1.00	1.00	1.00	1.00	1.00	1.00
overall	0.76	0.95	1.00	1.00	1.00	1.00	1.00
word	8	9	10	11	12	13	14
validation set	1.00	1.00	1.00	0.833	1.00	1.00	1.00
overall	1.00	0.95	1.00	0.7	1.00	0.95	1.00

System Design, Training and Testing

Testing and tweaking

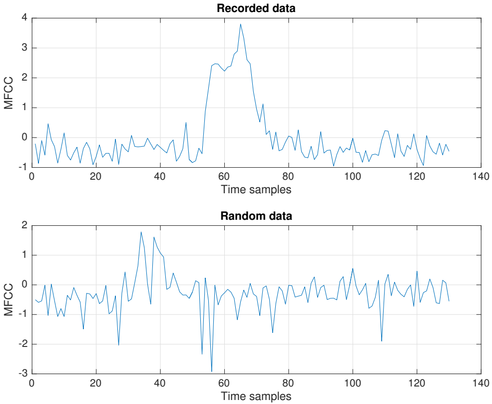
Some realizations

- word *I* and 1st MFCC coefficient



Some realizations

- word *I* and 2nd MFCC coefficient



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Classification Errors

- Average Classification Error: 1.2 %(validation) and 4.9 % (overall)
- Most commonly missclassified: *hand* with 16.6 % and 30 %

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Results

System Performance

C =

$$\begin{pmatrix}
46 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 14 & 0 & 0 & 0 & 0 \\
0 & 57 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 60 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 60 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 60 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 60 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 60 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 60 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 57 & 0 & 1 & 0 & 0 & 2 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 60 & 0 & 0 & 0 & 0 \\
0 & 0 & 7 & 0 & 0 & 11 & 0 & 0 & 0 & 0 & 42 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 60 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 57 & 2 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 60
\end{pmatrix}$$

Results

System Performance

Lars: recognition
Martin: recognition
Natalie: recognition

Take aways

- If data is rare, use smaller k in k-fold approach
- Good training data is important
- Collect more training data (remember trade-off)
  but: then be aware of overfitting!

The system

- Satisfying overall recognition rate
- Problems with the words *hand* and *recognition*
- less problems with *affect* and *effect* or short words

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Live Demonstration

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