

# Language Technology

<http://cs.lth.se/edan20/>  
Chapter 19: Speech Recognition

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# Speech Recognition

Conditions to take into account:

- Number of speakers
- Fluency of speech.
- Size of vocabulary
- Syntax
- Environment



# Structure of Speech Recognition

Words:

$$W = w_1, w_2, \dots, w_n.$$

Acoustic symbols:

$$A = a_1, a_2, \dots, a_m,$$

$$\hat{W} = \arg \max_W P(W|A).$$

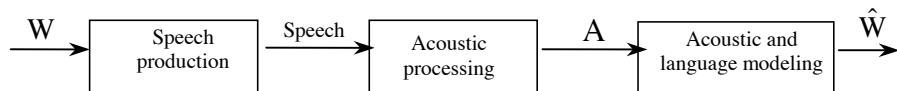
Using Bayes' formula,

$$P(W|A) = \frac{P(A|W)P(W)}{P(A)}.$$



# Two-Step Recognition

$$\hat{W} = \arg \max_W P(A|W)P(W).$$



# Speech Parameters

Recognition devices derive a set of acoustic parameters from speech frames.

Parameters should be related to “natural” features of speech: voiced or unvoiced segments.

A simple parameter giving a rough estimate of it: the energy: the darker the frame, the higher the energy.

$$E(F_k) = \sum_{n=m}^{m+N-1} s^2(n).$$

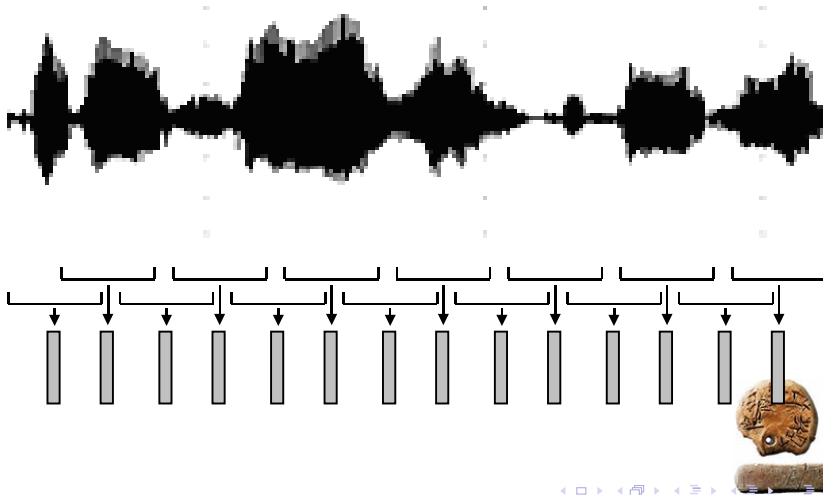
Linear prediction coefficients:

$$\hat{s}(n) = a(1)s(n-1) + a(2)s(n-2) + a(3)s(n-3) + \dots + a(m)s(n-m),$$



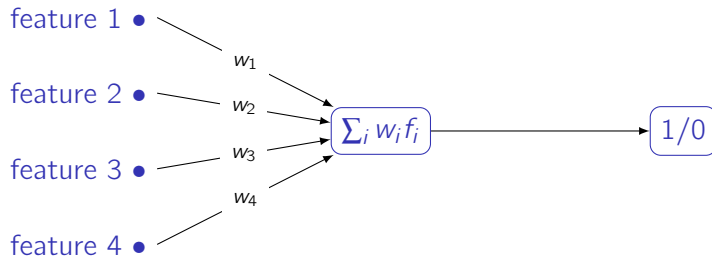
# Extraction of Speech Parameters

Features are extracted every 10 ms over a 20 s frame



# Neural Networks: Representation

Another representation of the perceptron:

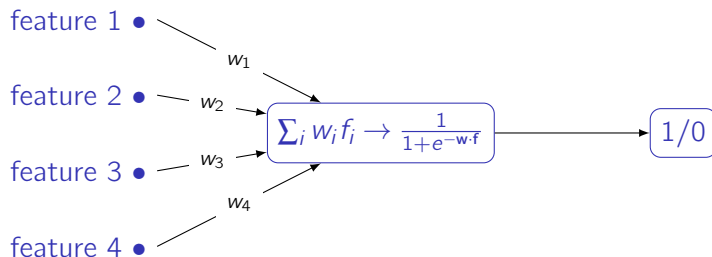


The base network: An input layer and an output layer



# Neural Networks: Activation Function

And logistic regression:

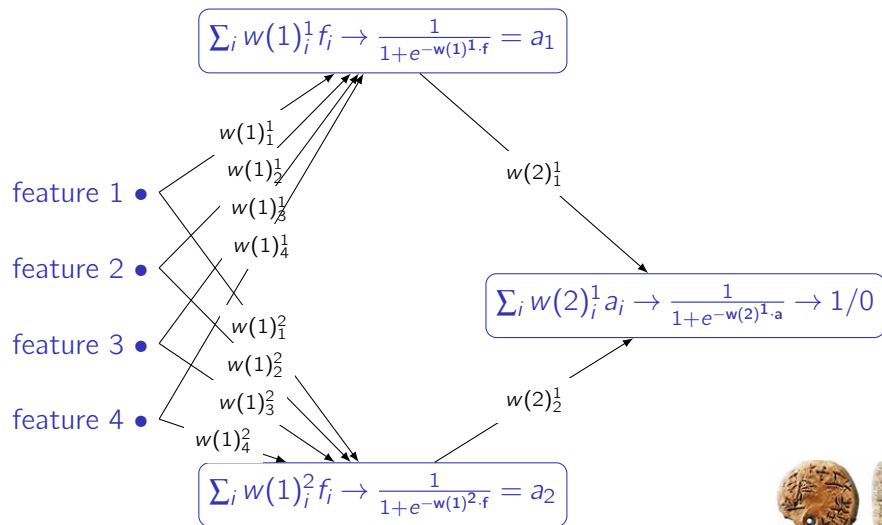


The logistic function is the activation function of the node



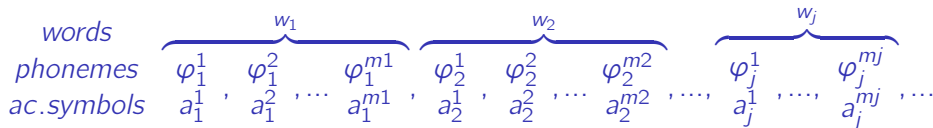


# Neural Networks: Hidden Layers



# Word Decoding

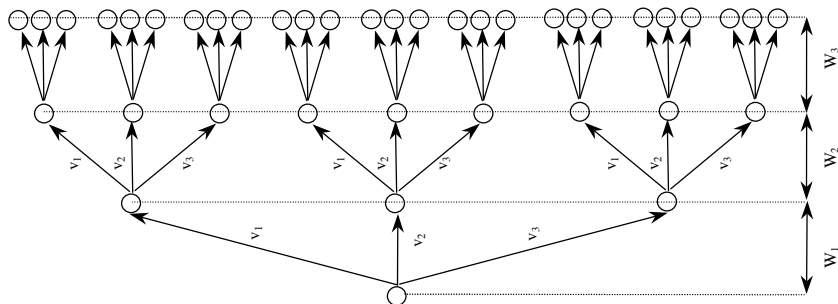
Markov models are a probabilistic mapping of a string of acoustic symbols  $a_1, a_2, \dots, a_m$  onto a string of phonemes  $\varphi_1, \varphi_2, \dots, \varphi_m$ . A language model applies a second probability to a word sequence. The complete speech recognition then consists in decoding word sequences  $w_1, w_2, \dots, w_n$  from phonemic strings and weighting them using the language model.



# Searching Words

A hypothesis search.

If the vocabulary contains  $k$  words  $v_1, v_2, \dots, v_k$ ,  $w_1$  is to be selected amongst  $k$  possibilities,  $w_2$  amongst  $k$  possible choices again and so on.

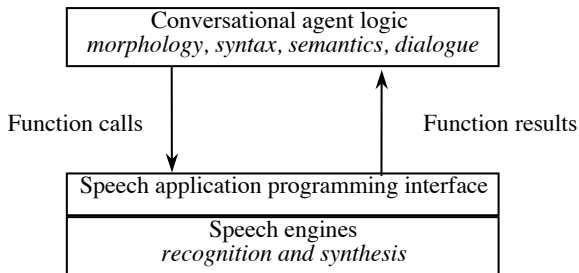


Decoding uses the  $A^*$  algorithm



# Commercial Systems

Speech recognition systems are accessible using an API



In addition to a language model, speech engines often give the possibility to use a phrase-structure grammar

