Application and Research Highlights

Hidden Markov Models & Finite State Transducers

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FSA generalization

We introduce new finite state models that are **generalizations** of FSA

- weighted and probabilistic FSA
- hidden Markov models
- finite state transducers

Applications

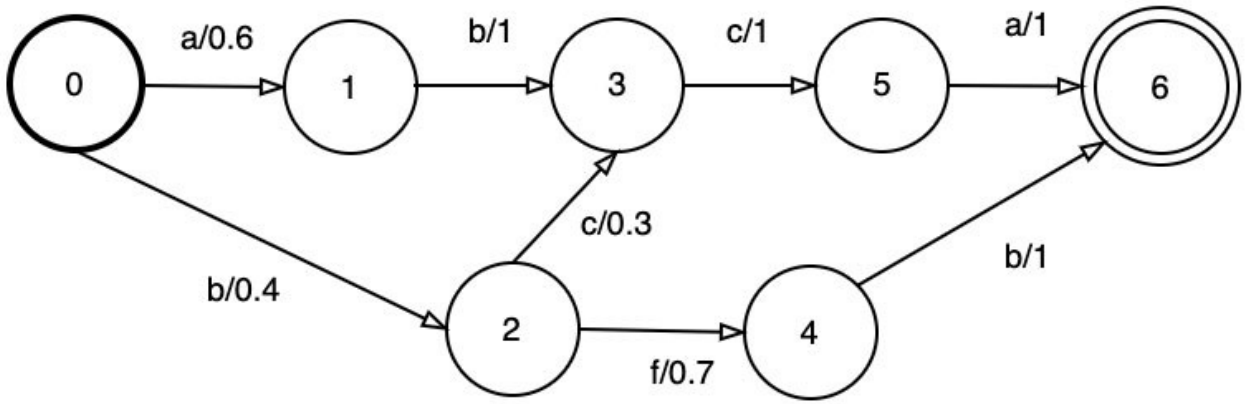
Computational biology: gene prediction, protein folding, DNA motif discovery, alignment of bio-sequences

Speech recognition: Siri & Alexa earlier versions (now replaced by neural networks)

Machine translation: Google translate earlier versions (now replaced by neural networks)

Weighted FSA

In a weighted FSA, each arc is associated with a real number, called **weigth**



Weighted FSA

The weight of a computation γ is the product of the weights of all its arcs α

$$w(\gamma) = \prod_{\alpha:\gamma} w(\alpha)$$

The weight of a string $x \in \Sigma^*$ is the sum of the weights of all of the computations γ for x

$$w(x) = \sum_{\gamma:x} w(\gamma) = \sum_{\gamma:x} \prod_{\alpha:\gamma} w(\alpha)$$

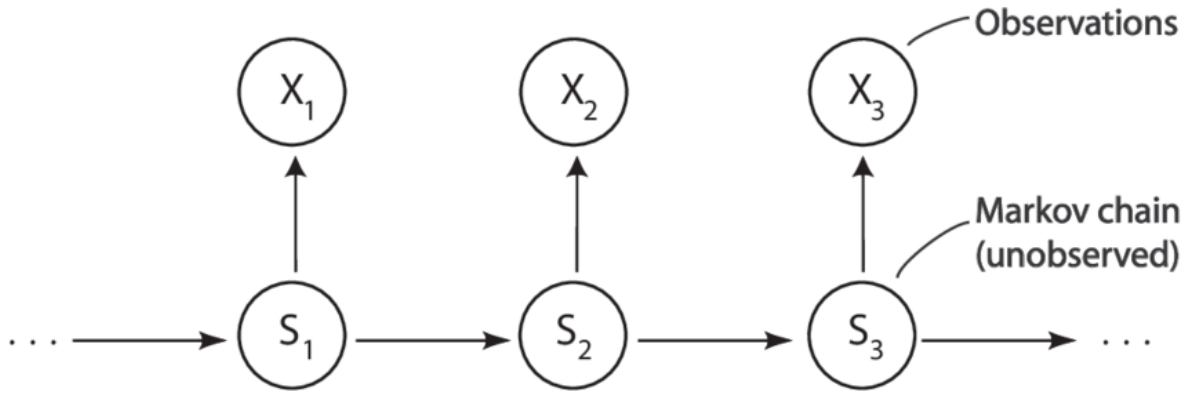
Probabilistic FSA

A probabilistic FSA is a weighted FSA such that the weights are **probabilities**

- real numbers in $[0, 1]$
- at each state q, sum of probabilities at arcs leaving q is always 1

Hidden Markov models

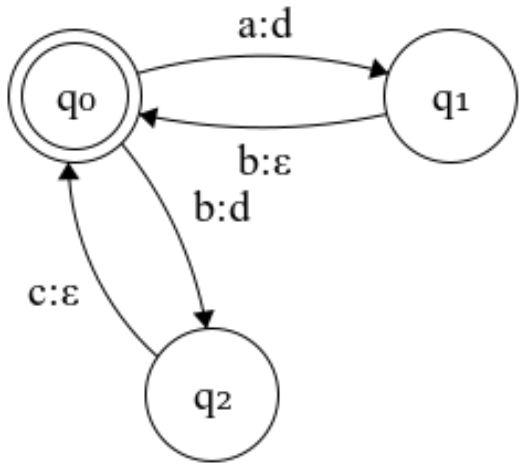
Hidden Markov models (HMM) are special types of probabilistic FSA, where input symbols are associated with states, not with arcs (technical details omitted)



Two type of probabilities: **transition** Pr and **emission** Pr

Finite state transducers

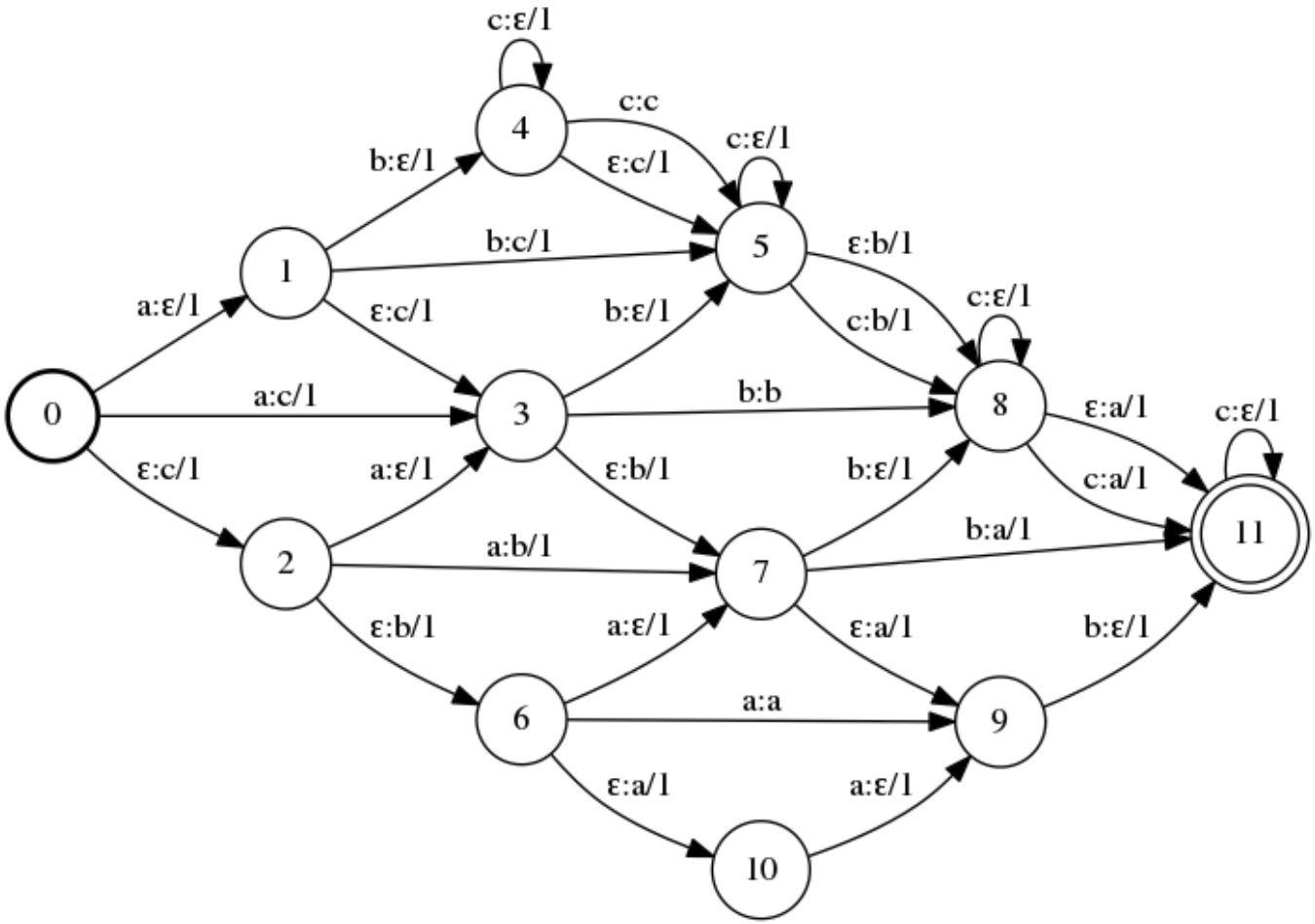
Finite state transducers, or FST for short, have arcs where input symbols are paired with output symbols/strings



FST are **translation models**, that is, they map strings to strings

Weighted finite state transducers

A weighted FST is a FST combined with weights (or probabilities)



Discussion

Model parameters for HMM and probabilistic FST can be **estimated** from data using machine learning techniques

Several libraries implement HMM and WFST

In many applications, these finite state technologies are being replaced by **recurrent neural networks**, such as LSTM