

# Computational Intelligence SEW SS17

## Homework 6

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## Hidden Markov Models

### Viterbi Algorithm and optimal State Sequence

Table 1: Optimal State Sequence

	<b>X1</b>	<b>X2</b>
HMM1	['r', 'r', 's', 's', 's', 's']	['r', 'r', 'f', 'f', 'f', 'r']
HMM2	['r', 'r', 'f', 'f', 'f', 'r']	['r', 'r', 'f', 'f', 'f', 'r']

When working with probabilities, for example in the iteration phase of the Viterbi algorithm, a lot of multiplication of probabilities is involved. The problem is that these probabilities sometimes are very close to zero. Computers only have a finite amount of storage to store numbers and therefore cannot distinguish very small numbers from zero. This problem can be bypassed by using the log function and the rule that:

$$\log(a) + \log(b) = \log(ab)$$

### Sequence Classification

The formula for  $P(X|\Theta_i)$  is:

$$P(X|\Theta) = \sum_{Q \in Q^N} P(X, Q|\Theta) = \sum_{Q \in Q^N} \left( \pi_{q_1} \cdot b_{q_1}(x_1) \cdot \prod_{n=2}^N a_{q_{n-1}, q_n} \cdot b_{q_n, x_n} \right)$$

The problem with this formula and the reason why it is so computationally expensive to solve is because there a lot of multiplications which aren't necessary. With recursion and the product rule it is possible to reuse calculations and reduce the computation time.

## Markov Model

### Graphical representation

