Übungen zur Vorlesung

Algorithms for context prediction in ubiquitous systems

3 Markov prediction approaches

3.1 HMM Evaluation

To solve the evaluation task for a HMM, the forward algorithm can be utilised:

```
1 initialise t ← 0, p_ij, b_jk, V^T, α_j(o)
2    for t ← t + 1
3        α_j(t) ← b_jk v(t) Σ_{i=1}^{c} α_i(t − 1) p_ij
4    until t = T
5 return P(V^T) ← α_0(T) for the final state
6 end
```

Assume a HMM with the following transition probabilities:

$$a_{ij} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0.2 & 0.3 & 0.1 & 0.4 \\ 0.2 & 0.5 & 0.2 & 0.1 \\ 0.8 & 0.1 & 0 & 0.1 \end{pmatrix} \tag{1}$$

and

$$b_{jk} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0.3 & 0.4 & 0.1 & 0.2 \\ 0 & 0.1 & 0.1 & 0.7 & 0.1 \\ 0 & 0.5 & 0.2 & 0.1 & 0.2 \end{pmatrix} \tag{2}$$

a) calculate the probability that this model generates the sequence $V^T = \{v_1, v_3, v_2, v_0\}$, supposing that the initial state is ω_1.

3.2 HMM Decoding

For the decoding problem we have introduced the HMM decoding algorithm:

```
1 initialise path ← {}, t ← 0
2    for t ← t + 1
3        j ← j + 1
4        for j ← j + 1
5            α_j(t) ← b_jk v(t) Σ_{i=1}^{c} α_i(t − 1) p_ij
6        until j = c
7        j' ← arg max_j α_j(t)
```

```
8        append ω_{j'} to path
9     until t = T
10 return path
11 end
```

a) For the HMM specified in exercise 3.1, calculate the path generated by the deconding algo-
   rithm.

b) Is the path a legal path in the HMM?

3.3 Properties of the CRF prediction approach

a) Derive and explain the properties of the CRF prediction approach in the table

	IPAM	ONISI	Markov	CRF
Numeric Contexts	yes	no	yes	
Non-numeric Con-texts	yes	yes	yes	
Complexity	$O(k)$	$(\ )$	$O(C^2)$	
Learning ability	(no)	yes	yes	
Approximate mat-ching	no	no	no	
Multi-dim. TS	(no)	(no)	(no)	
Discrete data	yes	yes	yes	
Variable length pat-terns	no	yes	no	
Multi-type TS	yes	no	(no)	
Continuous data	no	no	no	
Pre-processing	$O(k)$	–	$O(k)$	
Context durations	no	no	no	
Continuous time	no	no	yes	