Segmentation of hidden Markov tree models with hybrid decoders

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Hidden Markov models have proven useful in practice for partitioning a sequence of given observations $\bar{\mathbf{X}} = (X_1, X_2, \ldots, X_T)$ into segments according to unobserved discrete variables $\bar{\mathbf{S}} = (S_1, S_2, \ldots, S_T)$. Many different optimality criteria and corresponding computational algorithms have been proposed to recover the hidden $\bar{\mathbf{S}}$, most famous of them are the Viterbi algorithm and the posterior decoding algorithm. A computationally feasible interpolation between the two (a *hybrid decoder*) was presented in [1], which combines favourable aspects of both methods.

We will show that the hybrid decoder can be directly generalised to the case when the observations have a tree structure rather than a sequence structure. Hidden Markov tree models were introduced in [2] and are defined to have similar conditional independence properties to those of hidden Markov (chain) models. For example, the hidden $\bar{\mathbf{S}}$ is assumed to satisfy the global Markov property with respect to the tree with vertex set V. The hybrid decoder works by maximising the product

$$\left(\prod_{v \in V} p(S_v = s_v \mid \bar{\mathbf{X}} = \bar{\mathbf{x}}) \right)^{\alpha} p(\bar{\mathbf{S}} = \bar{\mathbf{s}} \mid \bar{\mathbf{X}} = \bar{\mathbf{x}})^{1-\alpha}$$

over hidden states $\bar{\mathbf{s}} = (s_v)_{v \in V}$ for a fixed interpolation parameter $\alpha \in [0, 1]$ and fixed observations $\bar{\mathbf{x}} = (x_v)_{v \in V}$. The task can be viewed as minimisation of a certain risk function endowed with an interpretation comparable to that of Rabiner's k-blocks in [3]. The computational feasibility is fully retained, owing much to the methods described in [4].

References

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