Morfessor 2.0: Toolkit for Statistical Morphological Segmentation – Model

Probabilistic Model definition

- Full description in (Virpioja, 2012; Virpioja et al., 2013)
- Generative model
  $p(\underset{analyses}{A}, \underset{words}{W} \mid \underset{parameters}{\theta})$
  The model generates pairs of words and analysis (the segmentation of a word into morphs)
- Tokenization function
  $a = \phi(w; \theta)$
- Cost derivation

$$\theta_{\mathrm{MAP}} = \arg\max_{\theta} p(\theta) p(\underset{data}{D} \mid \theta)$$

$$L(\theta, D) = -\log \underset{prior}{p(\theta)} - \log \underset{data\ likelihood}{p(D \mid \theta)}$$

The data (D) is a list of (non-segmented) words to learn the model from in unsupervised manner.

Data Likelihood

$$\log p(D \mid \theta) = \sum_{j=1}^{N} \log p(W = w_j \mid \theta)$$

$$= \sum_{j=1}^{N} \log \sum_{a \in \Phi(w_j)} p(A = a \mid \theta),$$

Morfessor Baseline assumes independence of words. Also, only valid tokenisations of need to be considered. Morfessor selects only one tokenisation (analysis) for each word at a time, by introducing a hidden variable $\mathbf{Y}$.

$$\log p(D \mid \theta, \mathbf{Y}) = \sum_{j=1}^{N} \log p(y_j \mid \theta)$$

$$= \sum_{j=1}^{N} \log \underset{selected\ analysis}{p(m_{j1}, \ldots, m_{j|y_j|}, \#_w \mid \theta)}$$

Prior

(Creutz and Lagus, 2007) The parameters of Morfessor Baseline encode the properties of the morph lexicon:

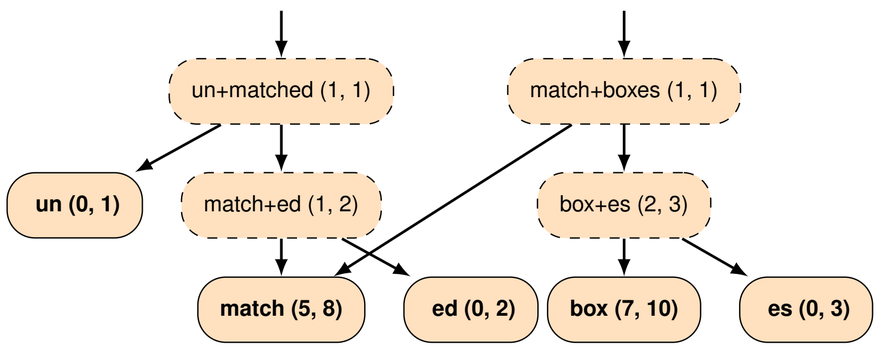
$$p(\theta) = p(\underset{\#morphs}{\mu}) \times \underset{\#morph\ permutations}{\mu!} \times p(\mathrm{properties}(m_1), \ldots, \mathrm{properties}(m_\mu)).$$

$$p(\underset{morph}{\sigma_i}) = \underset{length\ prior}{p(L = |\sigma_i|)} \prod_{j=1}^{|\sigma_i|} \underset{character\ distribution}{p(C = \sigma_{ij})}$$

Algorithm

(Creutz and Lagus, 2002)

function LOCALBATCHTRAIN(D, ϵ)
  $\theta, \mathbf{Y} \leftarrow$ INITMODEL(D_W)
  $L_{\mathrm{old}} \leftarrow \infty$
  $L_{\mathrm{new}} \leftarrow L(D_W, \theta, \mathbf{Y})$
  while $L_{\mathrm{new}} < L_{\mathrm{old}} - \epsilon$ **do**
    $J \leftarrow$ RANDOMPERMUTATION($1, \ldots, N$)
    for $j \in J$ **do**
      $\theta, \mathbf{Y} \leftarrow$ LOCALSEARCH($w_j, D, \theta, \mathbf{Y}$)
    $L_{\mathrm{old}} \leftarrow L_{\mathrm{new}}$
    $L_{\mathrm{new}} \leftarrow L(D, \theta, \mathbf{Y})$
  return θ, $\mathbf{Y}$



unmatched, **matchboxes**, **matched**, **boxes**, **match**, and **box**

Likelihood weighting and Semi-supervised training

Likelihood weighting with α (Virpioja et al., 2011)

$$L(\theta, D) = -\log p(\theta) - \alpha \log p(D \mid \theta)$$

α can be determined in different ways, e.g using a development set, or some explicit knowledge like average morph length. Higher α reduces segmentation, lower α increases segmentation.

Semi-supervised (Kohonen et al., 2010)

$$L(\theta, D) = -\log p(\theta) - \alpha \log p(D \mid \theta) - \beta \log p(\underset{annotated\ data}{D_A} \mid \theta).$$

For semi-supervised learning another term is added to the cost, the likelihood of a set of annotations coming from the model. Also here a weight β is introduced to control the effect.

References

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