Ergänzungen zum maschinellen Übersetzen
natürlicher Sprachen
2. Übungsblatt
2016-04-19

Exercise 1
Let $X = \{h, t\}$ and $c$ be an $X$-corpus such that $c(h) = 4$ and $c(t) = 6$. Moreover, let $p$ be a probability distribution of $X$ such that $p(h) = 0.3$ and $p(t) = 0.7$. Then

$$p(c) =$$

Determine $\tilde{c}$:

Let $p \in \mathcal{M}(X)$. Determine $p(c)$:

Exercise 2
Let $\mathbb{N}_{\geq 1}$ be the set of positive integers. The corpora $c_1, c_2, c_3 : \mathbb{N}_{\geq 1} \to \mathbb{R}_{\geq 0}$ are defined as follows:

$$c_1(1) = 5, \quad c_1(2) = 10, \quad c_1(3) = 5, \quad \text{and 0 otherwise;}$$

$$c_2(n) = 2^{-n};$$

$$c_3(n) = \frac{1}{n}.$$

Determine $\bar{p}(c_i)$ for every $i \in \{1, 2, 3\}$ and arbitrary $p \in \mathcal{M}(\mathbb{N}_{\geq 1})$.

Exercise 3
Consider the context-free grammar $G = (Z, \Sigma, S, P)$ with nonterminal symbols $Z = \{S, A\}$, terminals $\Sigma = \{a, b\}$, start symbol $S$, and a set of productions $P = \{z \to x \mid z \in Z, x \in X\}$ where $X = \{AS, aA, b\}$. We observe the following sequence of parse trees:

![Parse trees](image)

a) Specify an $X \times Y$-corpus $c$ that reflects this observation.
Compute $c_S(AS) = \ldots$, $c_S(a) = \ldots$, $c_A(aA) = \ldots$, $c_A(a) = \ldots$.

b) Let $p \in \mathcal{M}(X|Z)$ be such that

\[
p(AS \mid S) = 0.3 \quad p(aA \mid A) = 0.5 \\
p(a \mid S) = 0.7 \quad p(a \mid A) = 0.5.
\]

Compute $p(c)$:

\[
p(c) = \ldots
\]

c) Let $p \in \mathcal{M}(X \mid Z)$. Then

\[
\tilde{p}(c)(S) = \ldots \quad |c_S| = \ldots \\
\tilde{c}_S(AS) = \ldots \quad \tilde{c}_S(a) = \ldots \\
\tilde{p}(c)(A) = \ldots \quad |c_A| = \ldots \\
\tilde{c}_A(aA) = \ldots \quad \tilde{c}_A(a) = \ldots .
\]

d) Now assume, that we observe the following sequence of parse trees.

\[
\begin{array}{cc}
S & S \\
| & \\
a & a
\end{array}
\]

Specify an $X \times Y$-corpus $c'$ that reflects this observation and repeat tasks [b] and [c] with $c'$.

e) Let $\Omega = \{(u, v) \mid u, v \in [0, 1]\}$ and $p : \Omega \to \mathcal{M}(X \mid Z)$ such that

\[
(p(u, v))(AS \mid S) = u \quad (p(u, v))(aA \mid A) = v \\
(p(u, v))(a \mid S) = 1 - u \quad (p(u, v))(a \mid A) = 1 - v.
\]

Instantiate the optimization problem cmle$_p(c)$ for $p$ and $c$.

\[
\text{cmle}_p(c) = \ldots
\]