II-Probabilities
Gibbs Sampling
Foundations of Neuro-Symbolic AI

Alex Goessmann

University of Applied Science Würzburg-Schweinfurt

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How to draw random samples?

Sampling a distribution $\mathbb{P}$

Sampling is a random procedure to get index pairs
$x_0, \ldots, x_{d-1} \in \times_{k \in [d]}[m_k]$ such that the probability of $x_0, \ldots, x_{d-1}$ is
$\mathbb{P}(x_0, \ldots, x_{d-1})$.

A naive approach would not succeed: Typically, the tensors $\mathbb{P}$ is too large to be created.

Approach

Use the representations like Markov Networks

$$\mathbb{P} = \langle \{\tau^e : e \in \mathcal{E}\} \rangle_{[\mathcal{V}|\varnothing]}$$

to draw samples.

Gibbs Sampling

Draw State for atom k a state x_k from marginalized distribution

$$\mathbb{P}^{X_k} = \frac{\langle \mathbb{P} \rangle_{[X_k]}}{\langle \{\mathbb{P}\} \rangle_{[\varnothing]}}$$

Iterate over $k \in [d]$ and draw x_k from

$$\mathbb{P}\big[X_k \big| \{\epsilon_{x_l} : l \neq k\}\big] = \frac{\big\langle \{\mathbb{P}\} \cup \{\epsilon_{x_l} : l \neq k\} \big\rangle_{[X_k]}}{\big\langle \{\mathbb{P}\} \cup \{\epsilon_{x_l} : l \neq k\} \big\rangle_{[\varnothing]}}$$

Intuition

While we initialize with an independent sample, the resampling iterations implement the dependencies of the variables with respect to each other.

Implementation in tnreason:
Subpackage reasoning

The subpackage reasoning implements algorithms such as Gibbs Sampling.