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Robot Self-Awareness: Formulation of Hypotheses Based on the Discovered Regularities

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Abstract

In this paper, we consider robot self-awareness from the point of view of temporal relation based data mining. In particular, we propose an approach to formulation of hypotheses based on the discovered regularities.

Keywords: robot self-awareness, the farthest string problem, robot

Robot self-awareness is extensively studied in robotics (see e.g. [1] – [3]). We can use different regularities for formulation of hypotheses (see e.g. [4] – [9]). The ability to formulate hypotheses is critical to the creation of a system of self-awareness. To formulate hypotheses based on the discovered regularities the notion of contrast used (see [10]). In [10] presented two ways in which the fluency of a hand-over robot-human interaction can be improved. First, in [10] supposed that humans will be more responsive to the robot if they can easily interpret its intentions. In [10] proposed to achieve this by making the robot's hand-over poses distinct from poses that the robot might have during a different action with the object. Such actions in [10] considered as spatial contrasts. Second, in [10] supposed that the coordination of the hand-over can be improved by making the timing of the hand-over predictable for the human using an intuitive signal. In [10] proposed using the robot's movements to signal the moment of hand-over by transitioning from a pose that is perceived as non-handing to a pose that is perceived as handing. Such transitioning in [10] considered as temporal contrast.

Note that in [10] the concept of contrast is used to evoke anticipation in humans. However, these concept is of considerable interest also for robots. In order to the concepts of spatial contrast and temporal contrast could use the robot we need an efficient method for automatically localization and extraction of instances of spatial contrast and temporal contrast.

For localization and extraction of instances of spatial contrast and temporal contrast the model of farthest string used. Note that in case of the model of farthest string consider sequences already proper aligned. Therefore, Hamming distance is sufficient. To use the model of farthest string it is needed to solve the following problem.

The farthest string problem (FS):

Instance: *Given a set $\mathcal{S}$ of strings of length n over an alphabet Σ, a positive integer D.*

Task: *Find a string X of length n over Σ such that $\delta(X, S) \geq D$ for any S in $\mathcal{S}$.*

The FS problem is **NP**-hard for strings over any alphabet Σ with $|\Sigma| \geq 2$ [11]. However, there is a PTAS for FS based on a linear programming relaxation technique. Using satellite models and FS models the robot can learn sequences of effects of its actions and changes of the environment and find spatial and temporal contrasts. These abilities the robot can use for formulation of hypotheses. Efficiency of satellite model depends critically from the length of data sequence (see e.g. Table 1).

Table 1: The dependence from the length of data sequence.

Model	10^3	10^4	10^5	10^6	10^7
Prefix	23 %	31 %	43 %	56 %	71 %
Consensus	38 %	59 %	78 %	89 %	95 %

On one hand, the hypothesis should reflect a situation which is relatively close to reality. On the other hand, hypothesis should contain an element of novelty. These two conditions can be interpreted using the following model. Let $\mathcal{S} = \{S_1, S_2, \ldots, S_k\}$ be the set of input words, $S_i \in \Sigma^*$, $1 \leq i \leq k$. Let $|\mathcal{S}|$ denote the total length of all words in $\mathcal{S}$. Let $\#occ(U, V)$ be the number of occurrences (as a factor) of the word U in the word V. Consider the following problem.

Multiple occurrences shortest common superstring problem (MOSCS):

INSTANCE: *A fixed alphabet* Σ*, a positive integer* k*, a set of input words* $\mathcal{S} = \{S_1, S_2, \ldots, S_k\}$*, nonnegative integers* $m_1, m_2, \ldots, m_k, n_1, n_2, \ldots, n_k$ *and positive integer* m*.*

TASK: *Find a shortest word* U *such that* $m_i \leq \#occ(S_i, U) \leq n_i$ *for all* $1 \leq i \leq k$ *and* $\sum_{i=1}^{k} \#occ(S_i, U) \geq m$*.*

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