Introduction

Statistical techniques are popular in spoken dialogue systems, but they also present a number of challenges, especially for complex, open-ended domains.

One limitation is that the number of parameters to estimate often grows exponentially with the problem size, and can thus require large amounts of training data.

For most dialogue domains, data is however scarce and expensive to acquire.

One way to address this issue is to rely on more expressive representations, able to capture relevant aspects of the problem structure in a compact manner.

We describe here such an abstraction mechanism: probabilistic rules.

The rules are specifically devised to encode the kind of structure found in probabilistic models of dialogue (from understanding to management and to generation).

We have evaluated our approach in a human-robot interaction scenario where the robot was used as experimental platform. The user was instructed to teach the robot a sequence of basic movements (lift the left arm, step forward, bend down, etc.) using spoken commands.

We have used our methodology to create a small Wizard-of-Oz dataset with 1020 system turns.

We describe here such an abstraction mechanism:

We employ probabilistic rules as a unifying framework for encoding dialogue systems based on probabilistic rules.

The initial state contains 3 variables A,B and C, and is expanded with the two rules r1 and r2. These rules output two variables, D’ (updated version of D) and E.

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Statistical approaches for spoken dialogue systems

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<td>Explicit account of uncertainties, increased robustness to errors (e.g., from ASR)</td>
<td>Lack of appropriate data sets: good domain data is scarce and expensive to acquire!</td>
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<td>More natural conversational behaviours, better domain- and user-adaptivity</td>
<td>Scalability to complex domains: a challenge (combinatorial explosion of the state space)</td>
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To test these ideas, we are currently developing a software toolkit called openDial.

openDial employs probabilistic rules as a unifying framework for encoding dialogue processing models and estimating their parameters from interaction data.

Experiments

We have evaluated our approach in a human-robot interaction scenario.

The objective was to learn the parameters of the action selection model (i.e. the dialogue policy) from a small Wizard-of-Oz dataset with 1020 system turns.

Each training sample in the dataset is a pair (dialogue state, action), representing a given (beliefs) state along with the action selected by the Wizard at that state.

Parameter learning was performed with a Bayesian approach, using an initial prior which gradually narrows down to the values providing the best fit for the data.

To assess the fit of the model, we used the approach of testing the model against the test set.

The model was trained on a set of rules extracted from the Wizard-of-Oz data.

The model was evaluated on the same data, and the results were compared to the original Wizard-of-Oz data.

The model was able to capture the essential features of the Wizard-of-Oz data, and was able to generalize to new situations.

Conclusions

Probabilistic rules used to capture the underlying structure of dialogue models.

Allow developers to exploit powerful generalisations and domain knowledge in the dialogue system design without sacrificing the probabilistic nature of the model.

Very general framework that can express a wide spectrum of models.

In the near future, we aim to extend our approach towards model-based Bayesian reinforcement learning, where the parameter distributions are directly updated in a fully online fashion, based on real or simulated interaction experience.

On the practical side, we are also developing the openDial toolkit, which will enable developers to easily prototype dialogue systems based on probabilistic rules.

The toolkit includes algorithms for efficient inference and parameter estimation, as well as development tools for designing dialogue domains and monitoring interactions.