Interpreting Questions with a Log-Linear Ranking Model in a Virtual Patient Dialogue System

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Introduction
Objective: Train medical students using virtual standardized patients (VSPs)
Current Approach: ChatScript pattern matching engine
Problems: Low accuracy, authoring burden, no confidence measure
Proposed Solution: Log-linear ranking model is data-driven and provides a confidence measure

Background and Related Work
- Paraphrase Identification - Microsoft Research Paraphrase Corpus (Dolan et al., 2004)
- Binary classifier vs. Ranking (Ravichandran et al., 2003)
- Strong Lexical Overlap baseline (Das and Smith, 2009)

Classification
- Maxent multiclass classifier (DeVault et al., 2011)
- Current ChatScript system

Features
- Align - Meteor alignment overall score
- Lexical Overlap
  - 1-gram precision/recall exact/term n-gram matching
  - Binary indicator features for matching or failing to match a given word
- Weighting
  - IDF weighting (canonical plus its variants as a document)
  - Corpus frequency weighting (negative log probability)
- Concept
  - 1-2 gram precision/recall lexical overlap matching that substitutes words or phrases for their matching 'concept' (hand-crafted hypernym)

The Model

\textbf{Eq 1: Probability of a class c given an input sentence} \[ P(c|x) = \frac{1}{Z(x)} \sum_{v \in c} \exp \left( \sum_{j} w_j f_j(x, v) \right) \]

\textbf{Eq 3: Test Objective} \[ c^* = c(v^*), \text{ where } v^* = \text{argmax}_v \sum_j w_j f_j(x, v) \]

Interpretation Experiment
- 52 dialogues, 918 user turns, mean 29 turns per dialogue
- Asked question, canonical question, current topic and question response are annotated for each turn
- 193 canonical questions
- 787 question variants, mean 4.1 variants per canonical question
- Feature subsets generate a number of models, accuracy shown below

Table 1: Accuracy by model

<table>
<thead>
<tr>
<th>Model Name</th>
<th>Features Included</th>
<th>% Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Align</td>
<td>Meteor score feature alone</td>
<td>75.3</td>
</tr>
<tr>
<td>LexOverlap</td>
<td>Das and Smith-style lexical overlap baseline</td>
<td>74.9</td>
</tr>
<tr>
<td>LexOverlap+lex</td>
<td>adds lexical features</td>
<td>74.1</td>
</tr>
<tr>
<td>LexOverlap+align</td>
<td>adds Meteor score feature</td>
<td>75.8</td>
</tr>
<tr>
<td>LexOverlap+weighting</td>
<td>adds weighting features</td>
<td>77.8</td>
</tr>
<tr>
<td>LexOverlap+concept</td>
<td>adds concept features</td>
<td>78.1</td>
</tr>
<tr>
<td>LexOverlap+concept+weighting</td>
<td>adds weighting and concept features</td>
<td>78.5</td>
</tr>
<tr>
<td>Full</td>
<td>all features</td>
<td>77.0</td>
</tr>
<tr>
<td>Full-no-meteor</td>
<td>full minus Align and Meteor features</td>
<td>78.6</td>
</tr>
</tbody>
</table>

Conclusions
- Log-linear ranking model (~78%) outperforms DeVault-style multiclass classifier (~67%)
- Concept features most useful addition
- Confidence measure correlates with accuracy

Further Study
- Collect larger training corpus (100 dialogue set, 5000 user turns in progress)
- Robustness to noisy ASR input
- Vector-space models of word meaning to better identify paraphrases

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