**Related Work**

- Annotations
- Traditional 2-way/3-way RTE
- FraCaS
- Representation
- Bag-of-Words
- Syntactic Tree
- Semantic Role
- Classification
- Direct feature extraction

**Our Contributions**

- Textual Semantic Relations
- Joint Dependency Graph
- Two-Stage Classification

**Four Relations**

- Entailment (E)
- Paraphrase (P)
- Contradiction (C)
- Unknown (U)

**Three Dimensions**

- Relatedness
- Inconsistency
- Inequality

**Preprocessors**

- Dependency Parser: MSTParser (McDonald et al., 2005) and MultiParser (Nivre et al., 2007)
- Semantic Role Labeler: Our own (Zhang et al., 2008)

**System Description**

**Preprocessing**

- Dependency Parsing
- Semantic Role Labeling

**Feature Extraction**

- Path Extraction
- Dependency Triple Extraction

**Recognition & Classification**

- Relatedness
- Inconsistency
- Inequality

**Corpora**

<table>
<thead>
<tr>
<th>Corpora</th>
<th>Paraphrase(P)</th>
<th>Entailment(E)</th>
<th>Contradiction(C)</th>
<th>Unknown(U)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMT (584)</td>
<td>Facts (406)</td>
<td>Counter-Facts (178)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSR (5841)</td>
<td>Paraphrase (3940)</td>
<td>Non-Paraphrase (1901)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PETE (367)</td>
<td>YES (194)</td>
<td>NO (173)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTE (2230)</td>
<td>ENTAILMENT (1100)</td>
<td>CONTRADICTION (330)</td>
<td>UNKNOWN (770)</td>
<td></td>
</tr>
<tr>
<td>Total (9252)</td>
<td>3943</td>
<td>637</td>
<td>525</td>
<td>973</td>
</tr>
</tbody>
</table>

**Joint Dependency Graphs**

**Features**

- H_NULL? (Boolean): whether H has dependencies
- T_NULL? (Boolean): whether T has dependencies
- DIR? (Boolean): whether T, H have the same direction
- MULTI? (Boolean): Add "m_" to REL_PAIR if yes
- DEP.SAME? (Boolean): whether same dependency
- REL_SIM? (Boolean): whether similar relation
- REL_SAME? (Boolean): whether same relation
- REL_PAIR (String): dependency relation names

**Final Remarks**

- Relatedness, Inconsistency, and Inequality; Other possible dimensions?
- Feature engineering for specific TSR recognition tasks
- Lexical resources or knowledge bases, e.g., WordNet

---

**Results**

<table>
<thead>
<tr>
<th>Systems</th>
<th>4-Way (C, E, P, U)</th>
<th>3-Way (C, E&amp;P, U)</th>
<th>2-Way (E&amp;P, Others)</th>
<th>3-D Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct BoW</td>
<td>39.3%</td>
<td>54.5%</td>
<td>63.2%</td>
<td>62.1%</td>
</tr>
<tr>
<td>Direct Joint</td>
<td>42.3%</td>
<td>50.9%</td>
<td>66.8%</td>
<td>77.3%</td>
</tr>
<tr>
<td>3-D Model</td>
<td><strong>45.9%</strong></td>
<td><strong>58.2%</strong></td>
<td><strong>69.9%</strong></td>
<td><strong>79.6%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RTE</th>
<th>Acc.</th>
<th>Prec.</th>
<th>Rec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-D Model</td>
<td>58.2%</td>
<td>69.9%</td>
<td>53.4%</td>
</tr>
<tr>
<td>*M&amp;M, 2007(NL)</td>
<td>59.4%</td>
<td>70.1%</td>
<td>36.1%</td>
</tr>
<tr>
<td>*H&amp;S, 2010</td>
<td>62.8%</td>
<td>61.9%</td>
<td>71.2%</td>
</tr>
<tr>
<td>Our Prev.</td>
<td>59.1%</td>
<td>69.2%</td>
<td>-</td>
</tr>
<tr>
<td>*RTE-4 Median</td>
<td>30.7%</td>
<td>61.0%</td>
<td>-</td>
</tr>
<tr>
<td>*RTE-5 Avg.</td>
<td>52.0%</td>
<td>61.2%</td>
<td>-</td>
</tr>
</tbody>
</table>