Active Learning for Dependency Parsing with Partial Annotation

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Contributions
- First applying a probabilistic parser to active learning (AL) for dependency parsing
- Investigating uncertainty metrics for both full annotation (FA) and partial annotation (PA)
- Simulation experiments show AL with PA needs much less annotated dependencies than AL with FA (62.2% less on Chinese, 74.2% less on English)
- Human annotation experiments lead to several interesting findings

CRF-based Dependency Parsing
$$p(d|x; w) = \frac{e^{\text{Score}(x, d; w)}}{\sum_{d' \in \mathcal{Y}(x)} e^{\text{Score}(x, d'; w)}}$$

Marginal Probability of Dependencies
$$p(h \sim m|x; w) = \sum_{d \in \mathcal{Y}(x)} p(d|x; w)$$

Learn from Partial Annotation
- Convert partial trees into forests
$$p(F|x; w) = \sum_{d \in \mathcal{F}} p(d|x; w) = \frac{\sum_{d \in \mathcal{F}} e^{\text{Score}(x, d; w)}}{\sum_{d' \in \mathcal{Y}(x)} e^{\text{Score}(x, d'; w)}}$$

Uncertainty Metrics for AL with FA
- Normalized tree score:
  $$\frac{\text{Score}(x, d)}{n^{0.5}}$$
- Normalized tree probability:
  $$\sqrt{p(d|x)}$$
- Averaged marginal probability:
  $$\frac{1}{n} \sum_{h \sim m \in \mathcal{E}} p(h \sim m|x)$$

Uncertainty Metrics for AL with PA
- Marginal probability max:
  $$p(h^0 \sim i|x)$$
- Marginal probability gap:
  $$p(h^0 \sim i|x) - p(h^1 \sim i|x)$$
- Marginal probability entropy:
  $$\sum_{h \sim i \in \mathcal{E}} p(h \sim i|x) \log p(h \sim i|x)$$

Simulation Experiments
- Chinese: CTB5.1; English: PTB

| & FA vs. PA on CTB5-dev |
|---|---|---|
| Chinese | English |
| #Dep labeled | UAS | #Dep labeled | UAS |
| ZPar | 318,408 | 77.97 | 908,154 | 91.45 |
| This parser | 318,408 | 78.36 | 908,154 | 91.66 |
| FA (random) | 187,123 | 77.43 | 395,199 | 90.67 |
| FA (best) | 149,051 | 77.32 | 197,907 | 90.66 |
| PA (single) | 50,958 | 77.22 | 61,448 | 90.72 |
| PA (batch) | 56,389 | 77.38 | 51,016 | 90.70 |

Human Annotation Experiments
- 100 sentences: each receives 3 FA and 3 PA

Try our annotation system at http://hlt-service.suda.edu.cn/syn-dep-batch