Entity-Relation Extraction as Multi-turn Question Answering

Xiaoya Li, Fan Yin, Zijun Sun, Xiayu Li Arianna Yuan, Duo Chai, Mingxin Zhou and Jiwei Li
ACL2019
Overview

• Real-life RE could involve hierarchical entity relations which are not well-captured by current approaches.
• This paper introduces a new way to do entity-relation extraction as multi-terun question answering.
• Error propagation between turns of answering the questions is relieved by reinforcement learning.
Hierarchical entity relations

In 2002, Musk founded SpaceX, an aerospace manufacturer and space transport services Company, of which he is CEO and lead designer. He helped fund Tesla, Inc., an electric vehicle and solar panel manufacturer, in 2003, and became its CEO and product architect. In 2006, he inspired the creation of SolarCity, a solar energy services Company, and operates as its chairman. In 2016, he co-founded Neuralink, a neurotechnology Company focused on developing brain–computer interfaces, and is its CEO. In 2016, Musk founded The Boring Company, an infrastructure and tunnel-construction Company.

- Q: who is mentioned in the text? A: Musk;
- Q: which Company / companies did Musk work for? A: SpaceX, Tesla, SolarCity, Neuralink and The Boring Company;
- Q: when did Musk join SpaceX? A: 2002;
- Q: what was Musk’s Position in SpaceX? A: CEO.
MRC-like model

- **Question:** \( Q = \{q_1, q_2, ..., q_{N_q}\} \)
- **Context:** \( C = \{c_1, c_2, ..., c_{N_c}\} \)
- **BERT:** \([\text{CLS}, \text{Q}, \text{SEP}, \text{C}, \text{SEP}]\)
- **Softmax over BMEO tags.**
- **Training objective:**
  \[ \mathcal{L} = (1 - \lambda)\mathcal{L}(\text{head-entity}) + \lambda\mathcal{L}(\text{tail-entity, rel}) \]
Approach: 2-turn QA

| Relation Type | head-e | tail-e | Natural Language Question & Template Question |
|---------------|--------|--------|-----------------------------------------------|
| GEN-AFF       | FAC    | GPE    | find a geo-political entity that connects to XXX XXX; has affiliation; geo-political entity |
| PART-WHOLE    | FAC    | FAC    | find a facility that geographically relates to XXX XXX; part whole; facility |
| PART-WHOLE    | FAC    | GPE    | find a geo-political entity that geographically relates to XXX XXX; part whole; geo-political entity |
| PART-WHOLE    | FAC    | VEH    | find a vehicle that belongs to XXX XXX; part whole; vehicle |
| PHYS          | FAC    | FAC    | find a facility near XXX? XXX; physical; facility |
| ART           | GPE    | FAC    | find a facility which is made by XXX XXX; agent artifact; facility |
| ART           | GPE    | VEH    | find a vehicle which is owned or used by XXX XXX; agent artifact; vehicle |
| ART           | GPE    | WEA    | find a weapon which is owned or used by XXX XXX; agent artifact; weapon |
| ORG-AFF       | GPE    | ORG    | find an organization which is invested by XXX XXX; organization affiliation; organization |
| PART-WHOLE    | GPE    | GPE    | find a geo political entity which is controlled by XXX XXX; part whole; geo-political entity |
| PART-WHOLE    | GPE    | LOC    | find a location geographically related to XXX XXX; part whole; location |

Table 3: Some of the question templates for different relation types in AEC.
Approach: 4-turn QA

| Q1 Person:       | who is mentioned in the text? | A: $e_1$ |
|------------------|-------------------------------|---------|
| Q2 Company:      | which companies did $e_1$ work for? | A: $e_2$ |
| Q3 Position:     | what was $e_1$’s position in $e_2$? | A: $e_3$ |
| Q4 Time:         | During which period did $e_1$ work for $e_2$ as $e_3$ | A: $e_4$ |

Table 4: Question templates for the RESUME dataset.

In 2002, Musk founded SpaceX, an aerospace manufacturer and space transport services Company, of which he is CEO and lead designer. He helped fund Tesla, Inc., an electric vehicle and solar panel manufacturer, in 2003, and became its CEO and product architect. In 2006, he inspired the creation of SolarCity, a solar energy services Company, and operates as its chairman. In 2016, he co-founded Neuralink, a neurotechnology Company focused on developing brain–computer interfaces, and is its CEO. In 2016, Musk founded The Boring Company, an infrastructure and tunnel-construction Company.
Multi-turn Question Answering

Algorithm 1: Transforming the entity-relation extraction task to a multi-turn QA task.
Reinforcement learning

• Action: text spans being selected.
• Policy:

\[
p(y(w_1, \ldots, w_n) = \text{answer} | \text{question, } s) = p(w_1 = B) \times p(w_n = E) \prod_{i \in [2, n-1]} p(w_i = M)
\]

• Reward: +1 if the selected answer is correct.
• Initialized with pretrained MRC-like models.
• Use REINFORCE to maximize the expected reward:

\[
\nabla E(\theta) \approx [R(w) - b] \nabla \log \pi(y(w) | \text{question } s))
\]
Results

Table 6: Results of different models on the ACE04 test set. Results for pipelined methods are omitted since they consistently underperform joint models (see Li and Ji (2014) for details).

| Models                      | Entity P | Entity R | Entity F | Relation P | Relation R | Relation F |
|-----------------------------|----------|----------|----------|------------|------------|------------|
| Li and Ji (2014)            | 83.5     | 76.2     | 79.7     | 60.8       | 36.1       | 49.3       |
| Miwa and Bansal (2016)      | 80.8     | 82.9     | 81.8     | 48.7       | **48.1**   | **48.4**   |
| Katiyar and Cardie (2017)   | 81.2     | 78.1     | 79.6     | 46.4       | 45.3       | 45.7       |
| Bekoulis et al. (2018)      | -        | -        | 81.6     | -          | -          | 47.5       |
| Multi-turn QA               | **84.4** | 82.9     | **83.6** | 50.1       | **48.7**   | **49.4 (+1.0)** |

Table 5: Results for different models on the RESUME dataset.