Open Relation Modeling: Learning to Define Relations between Entities

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Relationships exist widely

- Data Mining
- Database
- Romeries
- France
- Evaluation
- Machine Learning
To represent relationships...

A fact/reasoning path in KG: (data mining, *facet-of*, database)
A sentence: “we study data mining and database.”

_Not interpretable:_ cannot know exactly how they are related
_Not open:_ may not exist a fact or a sentence containing them
Open Relation Modeling: given two entities, generating a coherent sentence describing the relationship between them, where types of relations do not need to be pre-specified.

E.g., “data mining is a process of extracting and discovering patterns in large data sets involving methods at the intersection of machine learning, statistics, and database systems.”

Interpretable & Open!
Open Relation Modeling: Learning from definitions

“data mining is a process of extracting and discovering patterns in large data sets involving methods at the intersection of machine learning, statistics, and database systems.”

Definitions of entities: informative sentences that capture the most representative characteristics of entities

Find the relation between two entities by defining one entity in terms of the other entity!
Open Relation Modeling: Learning from definitions

- Extract entity pairs from definitions of entities
- Fine-tune BART (Lewis et al., 2020a) to reproduce the definitions of entities with extracted entity pairs as input

Haste is a municipality in the district of Schaumburg, in Lower Saxony, Germany. 

(Haste, Schaumburg) (Haste, Germany) ... 

(Haste, Germany) BART 

Haste is a municipality in the district of Schaumburg, in Lower Saxony, Germany.

=> RelationBART-Vanilla
Augment the input with the shortest reasoning path => RelationBART-SP
Open Relation Modeling with Reasoning Path Selection

\[
\hat{p}(x, y) = \arg \max_{p(x,y) \in \mathcal{P}(x,y)} P(\mathcal{M}(p(x,y))|p(x,y))
\]

Select the best reasoning path with confidence estimation

=> RelationBART-SP/MP + PS
## Experiments: Dataset

| Entity pairs -> First sentences of Wikipedia pages |
|---------------------------------------------------|
| **test** denotes a filtered sub-test set with a higher quality |

|               | train    | dev      | test     | test*    |
|---------------|----------|----------|----------|----------|
| **number**    | 5,434,158| 27,431   | 55,226   | 7,302    |
| **ratio (%)** | 35.14    | 17.80    | 7.33     | 39.73    |
| **1-hop**     | 35.14    | 17.80    | 7.33     | 39.73    |
| **2-hop**     |          |          |          |          |
| **3-hop**     |          |          |          |          |
| **> 3-hop**   |          |          |          |          |
Experiments: Results

|                      | BL  | R-L | MT  | BS  |
|----------------------|-----|-----|-----|-----|
| DefBART              | 25.98 | 47.38 | 22.39 | 83.41 |
| RelationBART-Vanilla (w/o PT) | 34.70 | 59.57 | 28.85 | 88.01 |
| RelationBART-SP (w/o PT)     | 35.48 | 60.55 | 29.40 | 88.43 |
| RelationBART-SP (w/o PT) + PS | 38.62 | 62.60 | 31.07 | 89.05 |
| RelationBART-MP (w/o PT) + PS | **40.52** | **63.73** | **32.06** | **89.53** |
| RelationBART-Vanilla     | 35.45 | 59.92 | 29.33 | 88.25 |
| RelationBART-SP         | 36.58 | 61.15 | 30.04 | 88.75 |
| RelationBART-SP + PS    | 39.93 | 63.32 | 31.80 | 89.39 |
| RelationBART-MP + PS    | **41.43** | **64.15** | **32.45** | **89.64** |
| RelationBART-Vanilla (Large) | 36.53 | 60.54 | 29.90 | 88.50 |
| RelationBART-SP (Large) | 37.65 | 61.34 | 30.57 | 88.89 |
| RelationBART-SP (Large) + PS | 41.21 | 63.56 | 32.41 | 89.53 |
| RelationBART-MP (Large) + PS | **41.46** | **64.36** | **32.62** | **89.79** |

Qualitative

|                      | Rating (1-4) |
|----------------------|--------------|
| RelationBART-Vanilla (Large) | 2.67         |
| RelationBART-SP (Large)     | 2.82         |
| RelationBART-MP (Large) + PS | **3.01**    |

Refer to the paper for more results and details.
## Experiments: Generation Examples

| Input | Reasoning Path (Encoding) | Output |
|-------|---------------------------|--------|
| Romeries [reference] | - | Romeries is a commune in the Nord department in northern France. |
| (Romeries, France) | Romeries; country: France [NOT selected] | Romeries is a commune in the Somme department in Hauts-de-France in northern France. |
| | Romeries; located in the administrative territorial entity: Nord; country: France [selected] | Romeries is a commune in the Nord department in northern France. |
| | Romeries; shares border with: Solesmes; country: France [NOT selected] | Romeries is a commune in the Marne department in north-eastern France. |
| data mining [reference] | - | Data mining is a process of extracting and discovering patterns in large data sets involving methods at the intersection of machine learning, statistics, and database systems. |
| (data mining, artificial intelligence) | data mining; facet of: machine learning; subclass of: artificial intelligence | Data mining is a subfield of machine learning and artificial intelligence concerned with the collection, processing, and analysis of large amounts of data. |
| (data mining, database) | data mining; facet of: database | Data mining is the process of extracting information from a data set, such as a database. |
| (data mining, statistics) | data mining; facet of: machine learning; partially coincident with: statistics | Data mining is the process of collecting, processing, and analyzing large amounts of data in the form of statistics and machine learning. |
| (data mining, data) | data mining; facet of: machine learning; partially coincident with: statistics; studies: data | Data mining is the process of extracting useful information from data. |
| evaluation [reference] | - | Evaluation is a systematic determination of a subject’s merit, worth and significance, using criteria governed by a set of standards. |
| (evaluation, machine learning) | evaluation; unknown: machine learning | In computer science, evaluation is the process of evaluating a machine learning algorithm to determine whether the algorithm is performing well. |
| (evaluation, algorithm) | evaluation; unknown: algorithm | In computer science, evaluation is the process of evaluating an algorithm to determine whether it is correct. |
| (evaluation, robotics) | evaluation; unknown: robotics | In robotics, evaluation is the process of determining whether or not a particular component of a system is working properly. |
| (evaluation, software engineering) | evaluation; unknown: software engineering | In computer science and software engineering, evaluation is the process of determining whether a particular feature or feature should be added to a product or service. |
| (evaluation, computer security) | evaluation; unknown: computer security | In computer security, evaluation is the process of determining the security of a computer system. |
Conclusion

• We introduce *open relation modeling* – generating coherent sentences describing entity relationships;

• To solve this task, we propose to teach machines to generate definition-like relation descriptions by letting them learn from producing definitions conditioned on extracted entity pairs;

• We apply PLMs and design reasoning path-enriched PLMs for open relation modeling;

• Experimental results show that our methods can generate sentences that well capture entity relationships.
Email: jeffhj@illinois.edu
Code and data: https://github.com/jeffhj/open-relation-modeling

Thanks!