基于低维表示的大规模实体关系挖掘

Large-scale relation extraction based on low-dimensional representation

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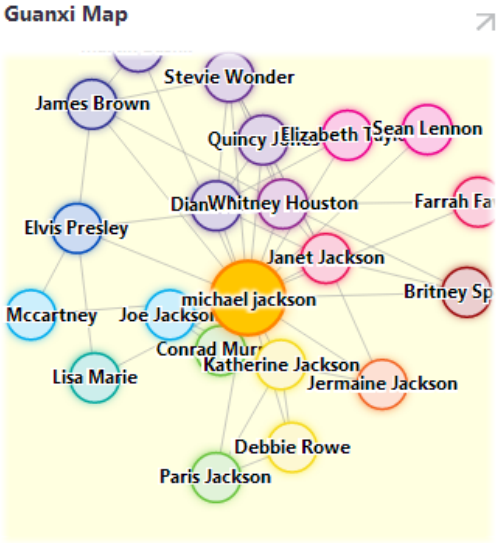
1. 领域综述

- 信息抽取 **(Information Extraction)**在自然语言处理领域有长达近20年的研究历史，始终致力于将无结构化的文本转换为结构化的信息，而有便于给诸如：**问答系统 (Question-Answering System)**、**信息检索(Information Retrieval)**等其他应用领域提供更加便利的知识表示。

Google 知识图谱



Microsoft 关系图谱

1. 领域综述

- 信息抽取 (Information Extraction) 主要分为**命名实体识别** (Named Entity Recognition, **NER**) 和**关系抽取** (Relation Extraction, **RE**) 两大任务。
- NER主要致力于从无结构的文本中识别*人名 (PER)*、*地名(LOC)*、*机构名称 (ORG)* 等名词实体，目前技术比较成熟，识别率都在90%上下，目前**微软亚洲研究院，聂再清**研究员领导的小组持有的识别工具已经投入商用。
- 关系抽取（**实体关系挖掘**，RE）是目前研究的主题，同时也是工业界关注的热点话题。该研究在NER的基础上，用于发现实体之间的关系，目前最受关注的是识别实体对（$< e_i, e_j >$）之间的关系**r** 。

维基百科

Barack Hussein Obama II (/bəˈrɑːk huːˈseɪn oʊˈbɑːmə/; born August 4, 1961) is the 44th and current President of the United States,

<Barack Obama, *President of*, **U.S.**>

1. 领域综述

- **实体关系挖掘技术**的研究在**2008年之前**分为两种不同的研究方向：
  - 固定关系挖掘
  - 开放关系挖掘 (Open RE)
- 上述两种关系挖掘技术的不同点在于：是否有**新关系 (new relationship discovery)** 的发现。
- 学生的研究方向主要关注于**固定关系挖掘**。
- 固定关系挖掘**基本假设**于我们在**圈定种类**的关系类别中，对实体之间的关系进行**预测**，因此属于**监督学习**范畴 (Supervised Learning based Relation Extraction Approaches)。

1. 领域综述

- **2008年之前**的关系挖掘的研究大多集中在**ACE, MUC**两类关系标注语料库中探讨如何利用规则方法、统计监督学习方法不断提升对多类别关系分类（预测）的精度。
- ACE和MUC两个人工标注数据库的规模都比较小。以ACE语料为例，共有大约1000篇文本，包含16771个关系实例，23种关系类型。
  - 代表工作有：
    - **基于规则的方法：**
      - J. Aitken, “Learning information extraction rules: An inductive logic programming approach”, **ECAI’02**.
      - D. McDonald, H.Chen, H. Su, and B. Marshall, “Extracting gene pathway relations using a hybrid grammar: The Arizona relation parser”, **Bioinformatics 2004**.
    - **特征选择的方法：**
      - J. Jiang and C. Zhai, “A systematic exploration of the feature space for relation extraction.”, **NAACL’ 07**.
    - **基于句法分析（核函数）的方法：**
      - Guodong Zhou, Min Zhang, Donghong Ji and Qiaoming Zhu. Tree kernel based relation extraction with context-sensitive structure parse tree Information. **EMNLP’07**.
- **2008年**Sunita Sarawagi在*Foundations and Trends in Databases* 发表知名综述长篇论文(117页)“Information Extraction”，对信息抽取，特别是**关系抽取**的研究做了深入总结，特别指出了现有基于语料库标注数据的**局限**。

1. 领域综述

- **2009年**， 斯坦福大学的几位知名教授在ACL上提出一种新的信息抽取方法的范式(*Distant supervision for relation extraction without labeled data*) Google Sites: 315.

Entity pair	<Barack Obama, U.S.>
Relation instances from knowledge bases	**1. President of (Barack Obama, U.S.)** **2. Born in (Barack Obama, U.S.)**
Relation mentions from free texts	**1. Barack Obama** is the 44th and current President of the **U.S.**. (President of & **Born in**) **2. Barack Obama** ended **U.S.** military involvement in the Iraq War. (**President of** & **Born in**) **3. Barack Obama** was born in Honolulu, Hawaii, **U.S.**. (**President of** & Born in) **4. Barack Obama** ran for the **U.S.** Senate in 2004. (**President of** & **Born in**)

1. 领域综述

- 之后，DSRE（Distant Supervision for Relation Extraction）蓬勃兴起，后续的工作也逐渐被各大高校和IT公司的研究部门争相学习和进一步探索。

Distant Supervision (Mintz2009): Mike Mintz, Steven Bills, Rion Snow, and Dan Jurafsky. 2009. *Distant supervision for relation extraction without labeled data*. *ACL'09.*

MIL (Riedel2010): Sebastian Riedel, Limin Yao, and Andrew McCallum. 2010. *Modeling relations and their mentions without labeled text*. *ECML 2010*.

MultiR (Hoffman2011): Raphael Hoffmann, Congle Zhang, Xiao Ling, Luke Zettlemoyer, and Daniel S. Weld. *2011. Knowledge-based weak supervision for information extraction of overlapping relations. ACL'11.*

MIML (Surdeanu2012): Mihai Surdeanu, Julie Tibshirani, Ramesh Nallapati, Christopher D. Manning. *Multi-instance Multi-label Learning for Relation Extraction. EMNLP-CoNLL'12*.

Incomplete Knowledge (Bonan2013): Bonan, Ralph Grishman, Li Wan, Chang Wang, David Gondek. *Distant Supervision for Relation Extraction with an Incomplete Knowledge Base*. *NAACL'13.*

2. 研究动机

- **2008**年之前的研究，传统的基于人工标注语料库（ACE、MUC）的规则和监督学习方法的
  - 缺陷：
    - 人工标注任务量庞大，开销巨大，不适合大规模应用。
    - 模型泛化能力太弱，因为标注数据量较少。
- **2009**年至今，**Stanford University**, Mike Mintz在ACL'09的论文（The most solid paper in ACL）提出的基于弱标记（**知识库对齐**）的关系挖掘方法的优势和缺陷：
  - 优势：
    - 自动通过知识库对齐假设，获取大规模弱标记样本，真正使关系挖掘模型能够应用于实际系统。
  - 缺陷：
    - 弱标记(weakly labeled)方法的基本假设容易产生一部分**误标记样本**。
    - 大规模的弱标记数据同时产生**高维、稀疏特征**，给训练模型带来极高的**参数复杂度**。

3. 科学问题

- 综上，我们的对**固定关系挖掘**的**探究点**在于如何寻找能够处理**弱标记（Weakly Labeled）噪音(Noisy)、稀疏(Sparse)，同时**还能有效应对**大规模数据(Large-scale)**下的计算方法。

- 因此学生的**研究题目为：**
  - **基于低维表示的大规模实体关系挖掘**
  - **Large-scale relation extraction based on low-dimensional representation.**

- 研究的**着眼点**在于如何通过**低维表示**寻找**真正**对**实体关系预测**有价值的信息，同时由于低维表示降低了**模型复杂度**并且改善了**特征的稀疏性，**能够在**大数据规模的**环境下应用。

4. 研究计划

- 首先探究**低维表示的有效性**：
  - Miao Fan, Deli Zhao, Qiang Zhou, Zhiyuan Liu, Thomas Fang Zheng, Edward Y. Chang. 2014. Distant supervision for relation extraction with *matrix completion*. **ACL 2014**. ***long paper, oral presentation***.
  - 该论文从低维矩阵补完的角度，采用直推式模型，充分利用测试样本的特征信息，取得突破，主要处理从**自由文本**中抽取关系实例。

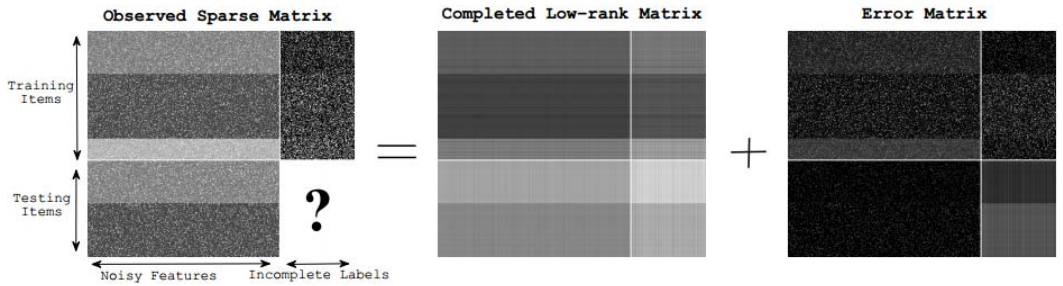


Figure 2: The procedure of noise-tolerant low-rank matrix completion. In this scenario, distantly supervised relation extraction task is transformed into completing the labels for testing items (entity pairs) in a sparse matrix that concatenates training and testing textual features with training labels. We seek to recover the underlying low-rank matrix and to complete the unknown testing labels simultaneously.

4. 研究计划

- 然后探究**低维表示**的**大规模易计算框架**：
  - Miao Fan, Deli Zhao, Qiang Zhou, Thomas Fang Zheng, Edward Y. Chang. 2014. Transition-based Knowledge Graph Embedding with Reltaional Mapping . **CIKM 2014**. *long paper submitted*.
  - 该论文依然从低维表示的角度切入，设计计算机易于计算的框架，便于处理大规模关系数据，主要应用在**知识图**自身的关系推理（***Link prediction***）。

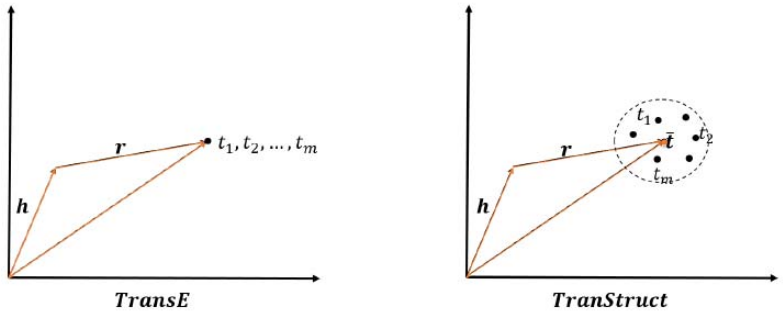
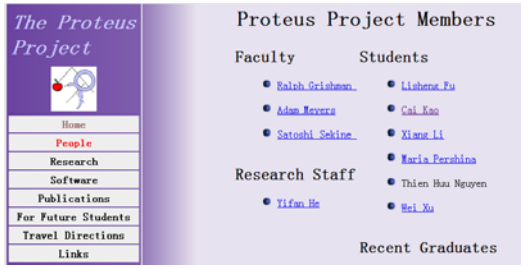


Figure 1: The differences between TransE and TransM when modeling ONE-TO-MANY relation instances, i.e. (h, r, t_1), (h, r, t_2), ..., (h, r, t_m).

4. 研究计划

- 学生另一篇相关工作：
  - Miao Fan, Qiang Zhou, Deli Zhao, Thomas Fang Zheng, Edward Y. Chang. 2014. Distant supervision for Entity Linking. **WISE 2014**. *long paper submitted*.
- 后续计划：
  - 2014年9月-2015年3月，结合ACL, CIKM的工作，尝试整合两个模型各自的优势，提出统一的框架。
  - 2015年3月-2016年3月，赴美NYU学习交流，在**关系挖掘研究领域**的知名教授 Ralph Grishman (曾任ACL, NAACL主席，**Google H-index：49**）的联合指导下从事相关科研，加入其创建的“海神计划”。



  - 而后回国完成博士论文答辩。

5. 发表（在审）论文

- [1] Miao Fan, Deli Zhao, Qiang Zhou, Zhiyuan Liu, Thomas Fang Zheng, Edward Y. Chang. 2014. Distant supervision for relation extraction with *matrix completion*. ACL 2014: 839-849. ***long paper, oral presentation***.
- [2] Miao Fan, Deli Zhao, Qiang Zhou, Thomas Fang Zheng, Edward Y. Chang. 2014. Transition-based Knowledge Graph Embedding with Reltaional Mapping . CIKM 2014. *long paper submitted*.
- [3] Miao Fan, Qiang Zhou, Deli Zhao, Thomas Fang Zheng, Edward Y. Chang. 2014. Distant supervision for Entity Linking. WISE 2014. *long paper submitted*.
- [4] Miao Fan, Qiang Zhou, Thomas Fang Zheng: Mining the Personal Interests of Microbloggers via Exploiting Wikipedia Knowledge. CICLing (2) 2014: 188-200.
- [5] Miao Fan, Qiang Zhou, Thomas Fang Zheng: Content-Based Semantic Tag Ranking for Recommendation. Web Intelligence 2012: 292-296.
- [6] Miao Fan, Yingnan Xiao, Qiang Zhou: Bringing the associative ability to social tag recommendation. ACL'12 Workshop on Textgraph-7.

6. 参考文献 (部分)

- [1] J. Aitken, “Learning information extraction rules: An inductive logic programming approach”, **ECAI’02**.
- [2] D. McDonald, H.Chen, H. Su, and B. Marshall, “Extracting gene pathway relations using a hybrid grammar: The Arizona relation parser”, **Bioinformatics 2004**.
- [3] J. Jiang and C. Zhai, “A systematic exploration of the feature space for relation extraction.”, **NAACL’ 07**.
- [4] Guodong Zhou, Min Zhang, Donghong Ji and Qiaoming Zhu. Tree kernel based relation extraction with context-sensitive structure parse tree Information. **EMNLP’07**.
- [5] Sunita Sarawagi. Information Extraction. 2008. Foundations and Trends in Databases.

6. 参考文献 (部分)

- **[6]** Mike Mintz, Steven Bills, Rion Snow, and Dan Jurafsky. 2009. *Distant supervision for relation extraction without labeled data*. *ACL'09.*
- **[7]** Sebastian Riedel, Limin Yao, and Andrew McCallum. 2010. *Modeling relations and their mentions without labeled text*. *ECML 2010*.
- **[8]** Raphael Hoffmann, Congle Zhang, Xiao Ling, Luke Zettlemoyer, and Daniel S. Weld. *2011*. *Knowledge-based weak supervision for information extraction of overlapping relations*. *ACL'11*.
- **[9]** Mihai Surdeanu, Julie Tibshirani, Ramesh Nallapati, Christopher D. Manning. *Multi-instance Multi-label Learning for Relation Extraction*. *EMNLP-CoNLL'12*.
- **[10]** Bonan, Ralph Grishman, Li Wan, Chang Wang, David Gondek. *Distant Supervision for Relation Extraction with an Incomplete Knowledge Base*. *NAACL'13.*

6. 参考文献 (部分)

- [11] Miao Fan, Deli Zhao, Qiang Zhou, Zhiyuan Liu, Thomas Fang Zheng, Edward Y. Chang. 2014. Distant supervision for relation extraction with *matrix completion*. ACL 2014: 839-849. ***long paper, oral presentation***.
- [12] Miao Fan, Deli Zhao, Qiang Zhou, Thomas Fang Zheng, Edward Y. Chang. 2014. Transition-based Knowledge Graph Embedding with Reltaional Mapping . CIKM 2014. *long paper submitted*.
- [13] Miao Fan, Qiang Zhou, Deli Zhao, Thomas Fang Zheng, Edward Y. Chang. 2014. Distant supervision for Entity Linking. WISE 2014. *long paper submitted*.
- [14] Miao Fan, Qiang Zhou, Thomas Fang Zheng: Mining the Personal Interests of Microbloggers via Exploiting Wikipedia Knowledge. CICLing (2) 2014: 188-200.
- [15] Miao Fan, Qiang Zhou, Thomas Fang Zheng: Content-Based Semantic Tag Ranking for Recommendation. Web Intelligence 2012: 292-296.
- [16] Miao Fan, Yingnan Xiao, Qiang Zhou: Bringing the associative ability to social tag recommendation. ACL'12 Workshop on Textgraph-7.

谢谢各位老师！

求知若饥、虚心若愚
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