哈爾濱工業大學
社会计算与信息检索研究中心

从知识图谱到事理图谱

From Knowledge Graph to Event Evolutionary Graph

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Outline

- **Motivation of Event Evolutionary Graph**
- Related Work
- Our Efforts on Event Evolutionary Graph
- Conclusion

Motivation of Event Evolutionary Graph

- Most existing knowledge bases foucs on “concepts and their relations”, and failed to mine “event evolutionary logics”
- Event evolutionary logics (development principles and patterns between events) are valuable commonsense knowledge, mining this kind of knowledge is crucial for understanding human behaviour and social development

Knowledge Graph

Nodes Are Entities

yago select knowledge

DBpedia

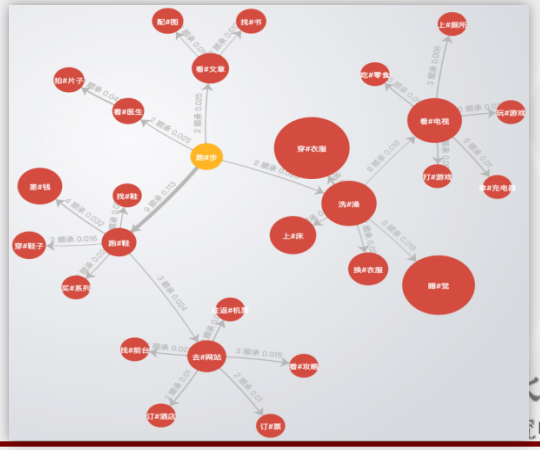
freebase

WIKIDATA

Google Knowledge Graph

Event Evolutionary Graph

Nodes Are Events



What is Event Evolutionary Graph?

- Event Evolutionary Graph (EEG)： 事理图谱
  - EEG is a knowledge base of event evolutionary logics, which describes the event evolutionary principles and patterns
  - 事理图谱是一个事理逻辑知识库，描述事件之间的演化规律和模式

- Structurally: EEG is a Directed Cyclic Graph, whose nodes are events, and edges stand for the sequential and causal relations (顺承和因果) between events.
- Essentially: EEG is a knowledge base of event evolutionary logics, which describes the event evolutionary principles and patterns

Applications of Event Evolutionary Graph

- EEG can be applied to several downstream tasks, including event prediction, commonsense reasoning, consumption intention mining, dialogue generation, question answering, decision making system and so on.

- Large-scale EEG can have big application potentials as traditional Knowledge Graph.

Differences and Relations between EEG and KG

	Event Evolutionary Graph	Knowledge Graph
Research Target	Predicate-Events (谓词性事件) and their relations	Noun-Entities (名词性实体) and their relations
Organization Form	Directed Graph	Directed Graph
Main Knowledge Form	Event evolutionary logics and transition probability	Entities' attributes and their relations
Determinary of Knowledge	Most event evolutionary logics are not deterministic	Most relations between entities are deterministic

Event Definition in EEG

- Events in ACE: An event is a specific occurrence involving participants. An event is something that happens. An event can frequently be described as a change of state
  - Traditional event extraction and classification tasks, ACE, KBP
  - Topic detection and tracking

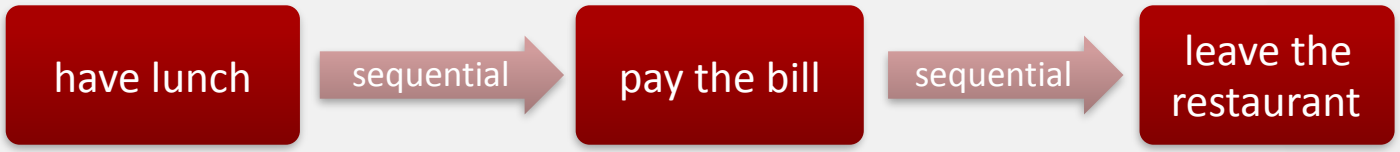
- Events in EEG:
  - Not specific but abstract events
  - Represent as general, semantic complete predicate-phrases or segments
  - “have hot pot”, “watch movies”, “go to the airport” are reasonable event representations
  - “go to somewhere”, “do things”, “eat”are unreasonable or incomplete events representations

Sequential Relation between Events

- The sequential relation (顺承关系) between two events refers to their partial temporal orderings

After having lunch, Tom paid the bill and left the restaurant.

吃过午饭后，汤姆到前台买单，然后离开了餐馆。



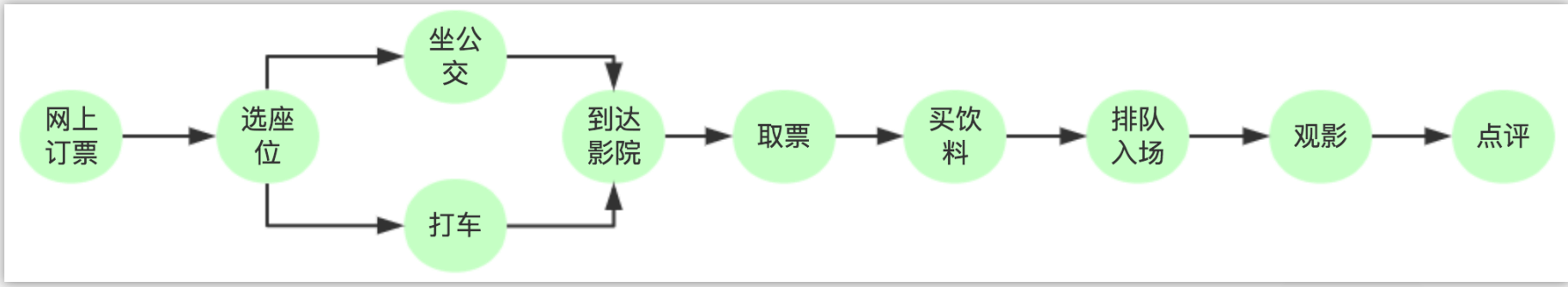
Causal Relation between Events

- Causal relation (因果关系) is the relation between one event (the cause) and a second event (the effect), where the second event happens as a consequence of the first.
- Causal relation is a subset of sequential relation
  - Satisfy the constraint of partial temporal order

The nuclear leak in Japan led to serious ocean pollution

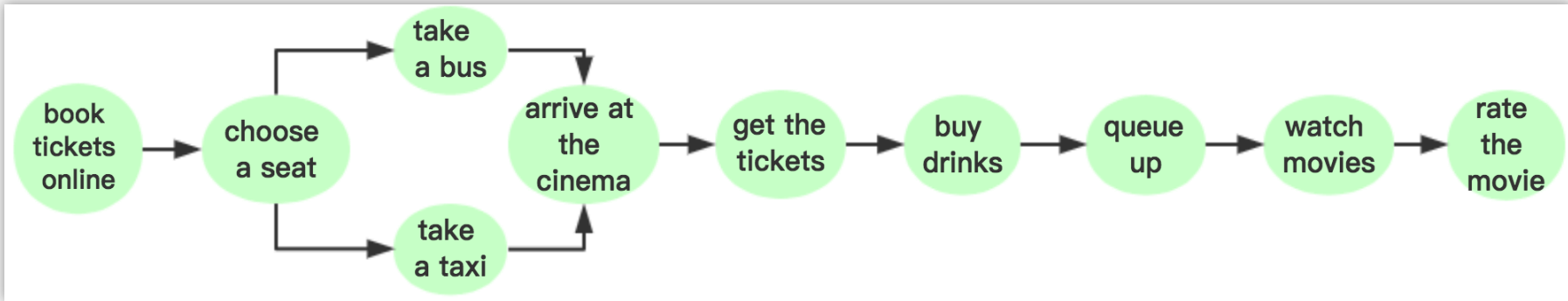
日本核泄漏引起了严重的海洋污染。

Three Topology Structures of EEG



Chain structured EEG under the scenario of “watch movies”.

Three Topology Structures of EEG



Chain structured EEG under the scenario of “watch movies”.

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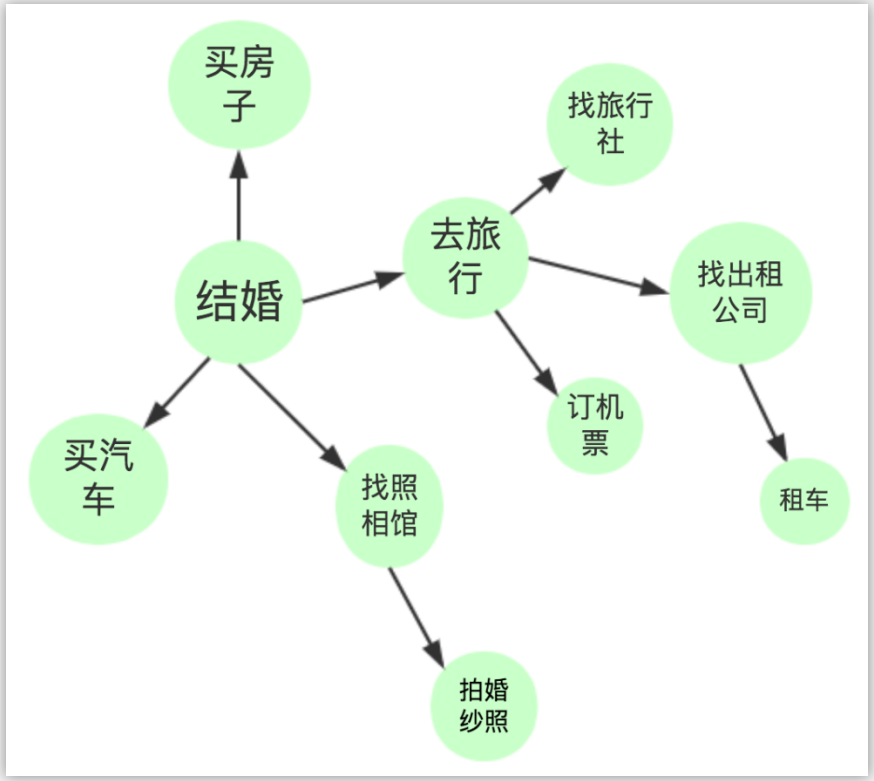
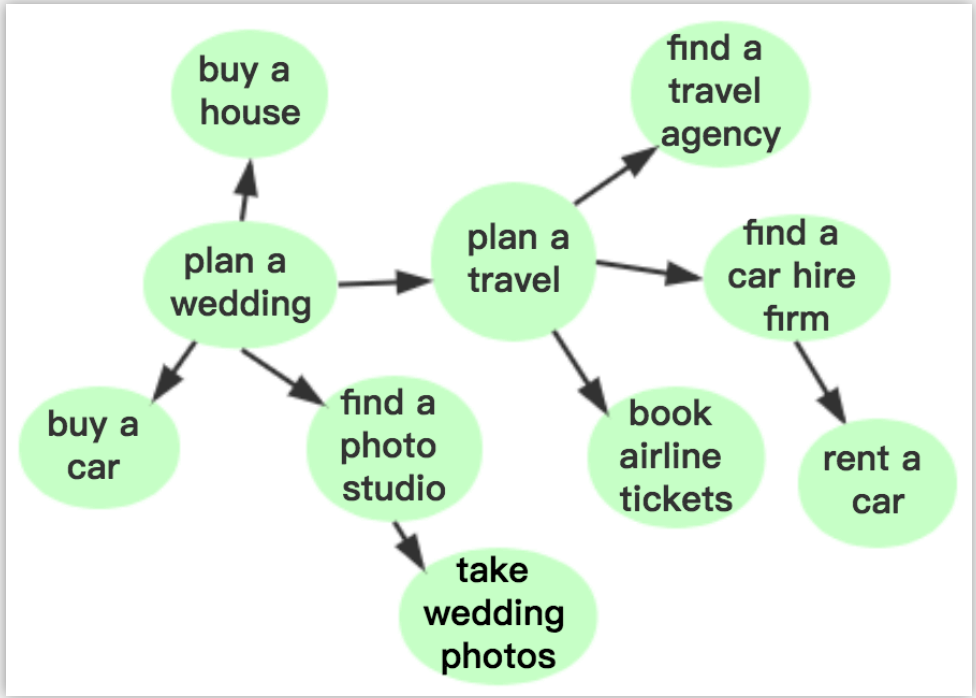


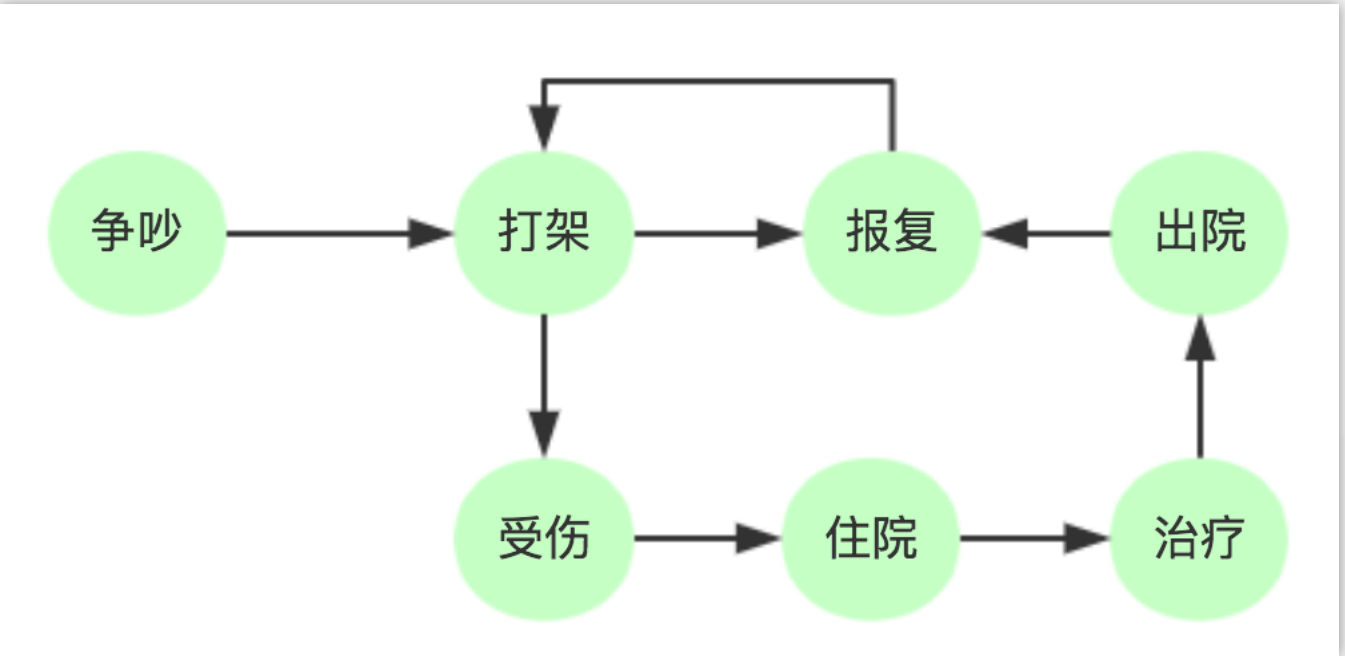
Tree structured EEG under the scenario of "plan a wedding".

Three Topology Structures of EEG



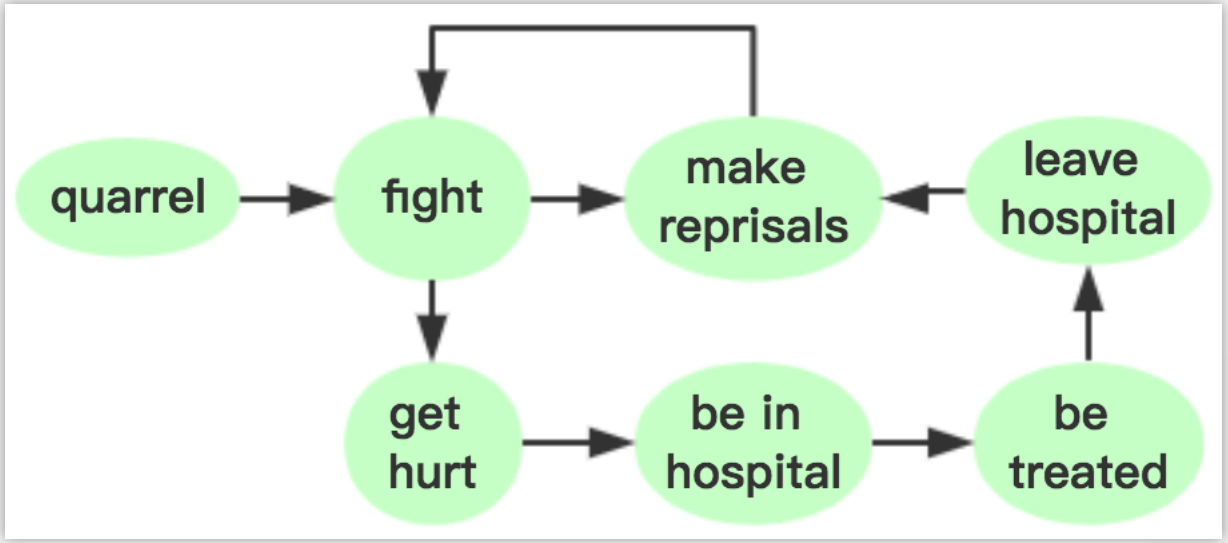
Tree structured EEG under the scenario of "plan a wedding".

Three Topology Structures of EEG



Cyclic structured EEG under the scenario of “fight”.

Three Topology Structures of EEG



Cyclic structured EEG under the scenario of "fight".

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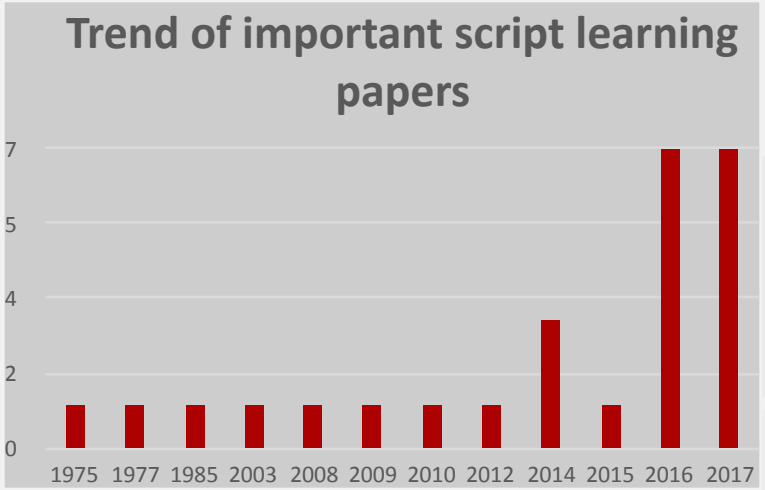
Two Relevant Research Fields

- Statistical Script Learning
- Event Relation Recognition
  - Temporal relation recognition
  - Causal relation recognition

Statistical Script Learning

- A very relevant research field to EEG
- Development Stage
  - In 1975, American researcher Schank proposed the concept of *Script*
  - 2003： Japanese researchers proposed automatic acquisition of script knowledge
  - 2008-2013： Pioneering work
  - 2014~now： Recovery and development stage



Statistical Script Learning (1)

- [IJCAI 1975] Scripts, plans, and knowledge. Roger C. Schank, and Robert P. Abelson, Yale University

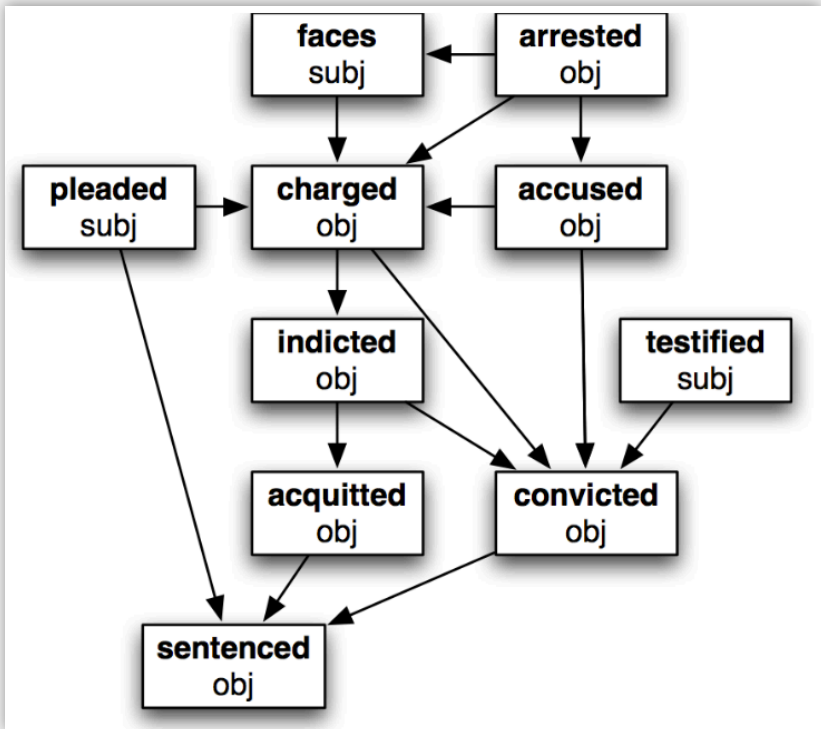
- Scripts [Schank & Abelson 1975] are an influential early encoding of situation-specific world event

```
script:  restaurant
roles:   customer, waitress, chef, cashier
reason:  to get food so as to go up in pleasure
            and down in hunger

scene 1: entering
         PTRANS self into restaurant
         ATTEND eyes to where empty tables are
         MBUILD where to sit
         PTRANS self to table
         MOVE sit down

scene 2: ordering
         ATRANS receive menu
         MTRANS read menu
         MBUILD decide what self wants
         MTRANS order to waitress

scene 3: eating
         ATRANS receive food
         INGEST food

scene 4: exiting
         MTRANS ask for check
         ATRANS receive check
         ATRANS tip to waitress
         PTRANS self to cashier
         ATRANS money to cashier
         PTRANS self out of restaurant
```

(From [Schank & Abelson 1975])

Statistical Script Learning (2)

- [ACL 2008] Unsupervised learning of narrative event chains, Chambers, Jurafsky, Stanford University



Statistical Script Learning (3)

- [AAAI 2014] Learning scripts as Hidden Markov Models, J. Walker Orr et al, Oregon State Univserity

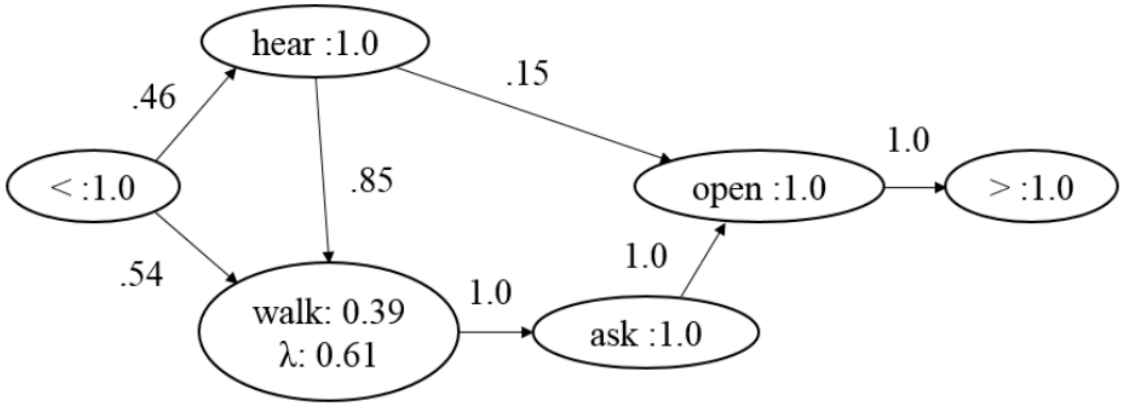


Figure 1: A portion of a learned "Answer the Doorbell" script

Statistical Script Learning (4)

- [ACL 2016] Using sentence-level LSTM language models for script inference, Pichotta and Mooney, University of Texas at Austin

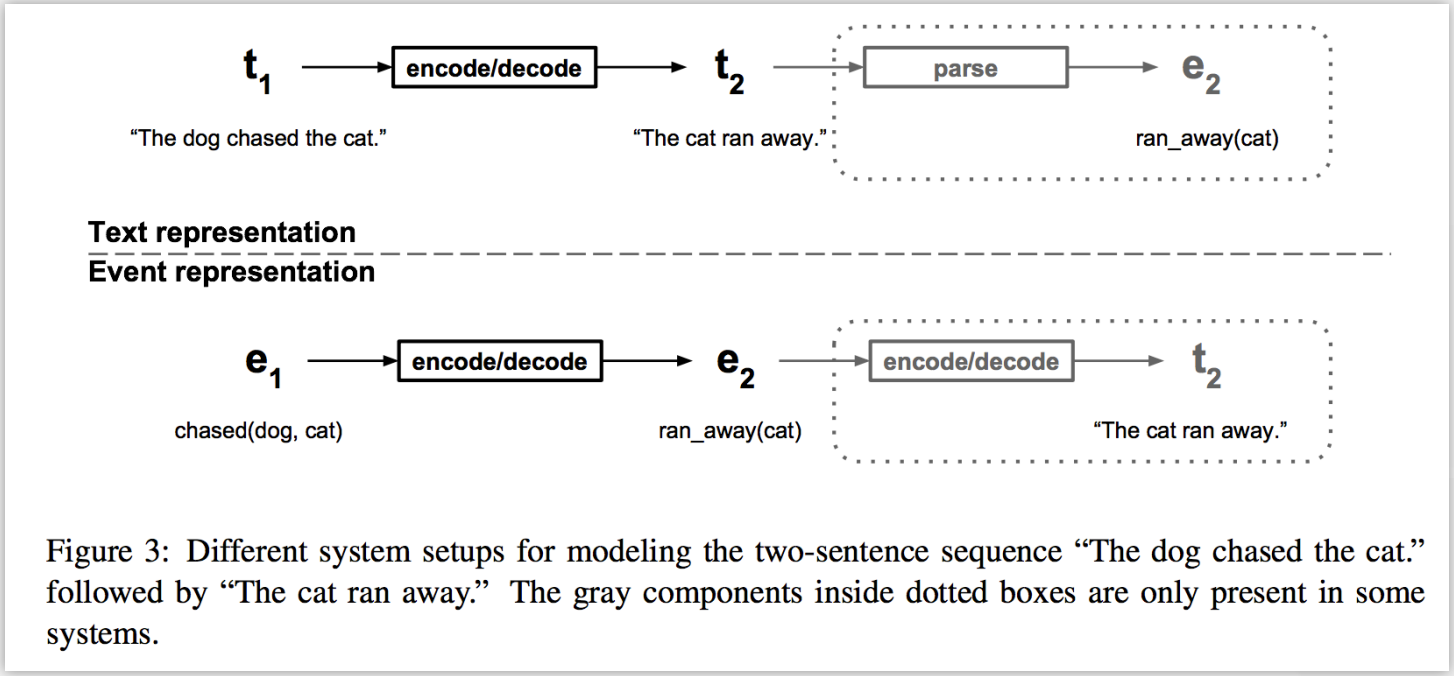


Figure 3: Different system setups for modeling the two-sentence sequence "The dog chased the cat." followed by "The cat ran away." The gray components inside dotted boxes are only present in some systems.

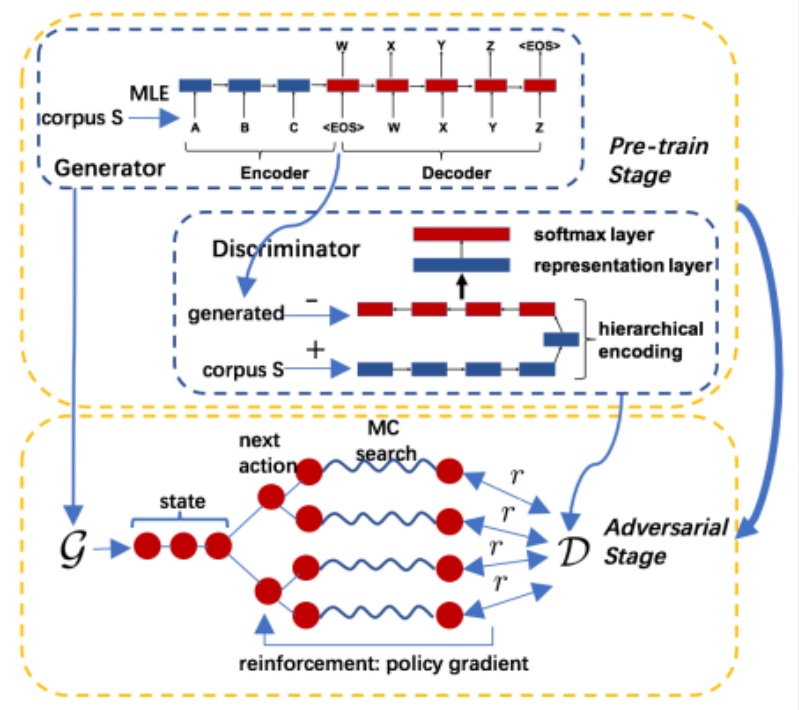
Statistical Script Learning (5)

- Inferring the correct story ending according to story contexts
  - [NAACL 2016]A corpus and cloze evaluation for deeper understanding of commonsense stories, Mostafazadeh et al.
  - [EMNLP 2017]Story Comprehension for Predicting What Happens Next, Snigdha Chaturvedi, Haoruo Peng, Dan Roth, UIUC

Context: One day Wesley's auntie came over to visit. He was happy to see her, because he liked to play with her. When she started to give his little sister attention, he got jealous. He got angry at his auntie and bit her hand when she wasn't looking.

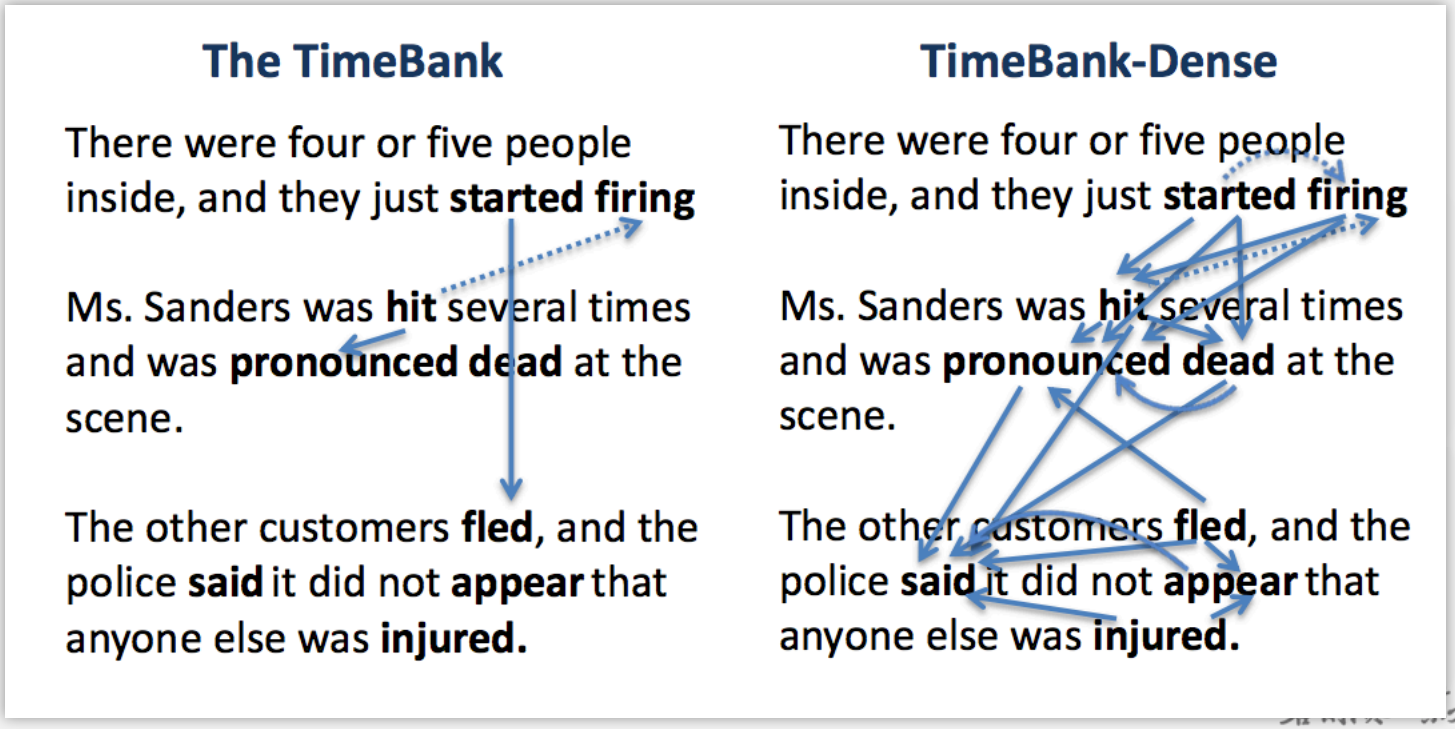
Incorrect Ending: She gave him a cookie for being so nice.

Correct Ending: He was scolded.



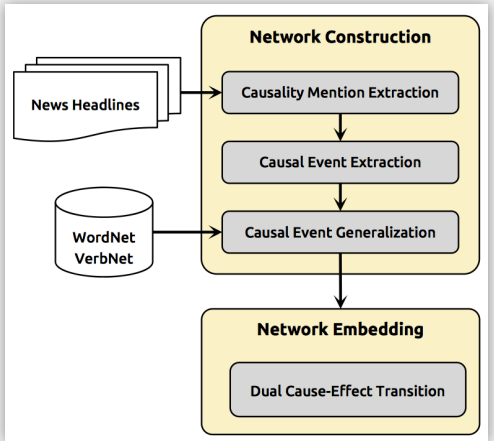
Temporal Relation Classification

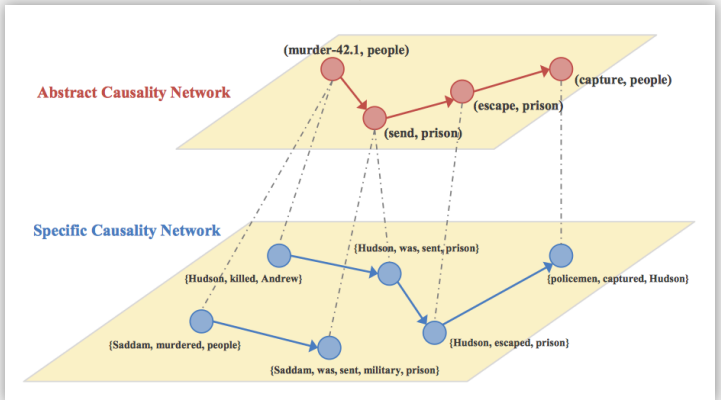
- [TACL 2014] Dense event ordering with a multi-pass Architecture, Chambers et al, United States Naval Academy



Event-Causality-Driven Stock Prediction

- [WSDM 2017] Constructing and embedding abstract event causality networks from text snippets, Sendong Zhao et al., HIT-SCIR





Experiments are carried out on long-term (one month) stock price movements using 12,482 events during this period.

Focus on predicting the increase or decrease of Standard & Poor's 500 stock (S&P) index.

	Accuracy
ET+SVM (Ding [10])	53.72
$\text{EoC}_{\textbf{Causal-TransE}}$+SVM	55.41
$\text{EoC}_{\textbf{Dual-CET}}$+SVM	**56.76**
ET+DNN (Ding [10])	56.08
$\text{EoC}_{\textbf{Causal-TransE}}$+DNN	57.77
$\text{EoC}_{\textbf{Dual-CET}}$+DNN	**59.80**

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HIT-SCIR: Our Exploration on EEG

Construction and Application of Travel Domain EEG

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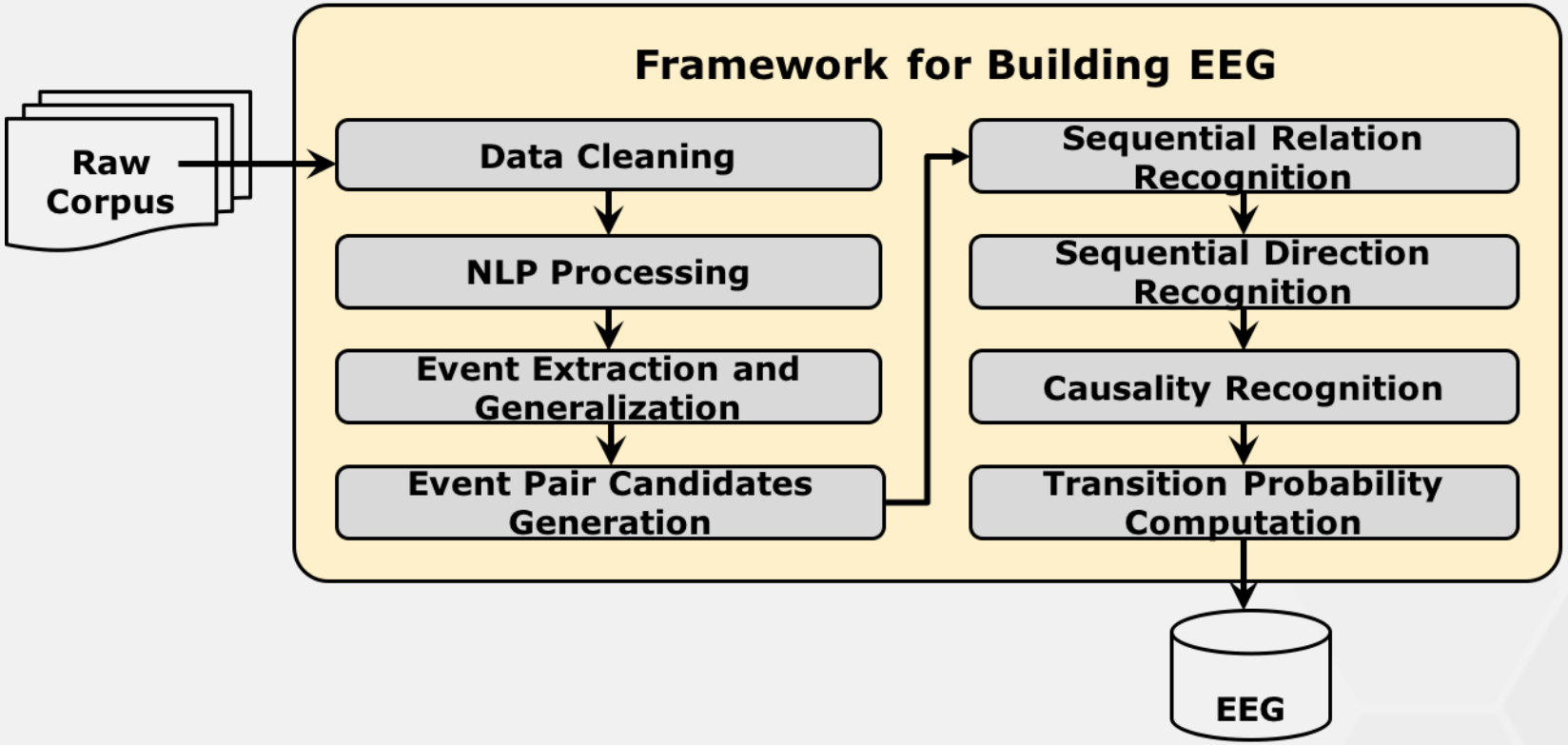
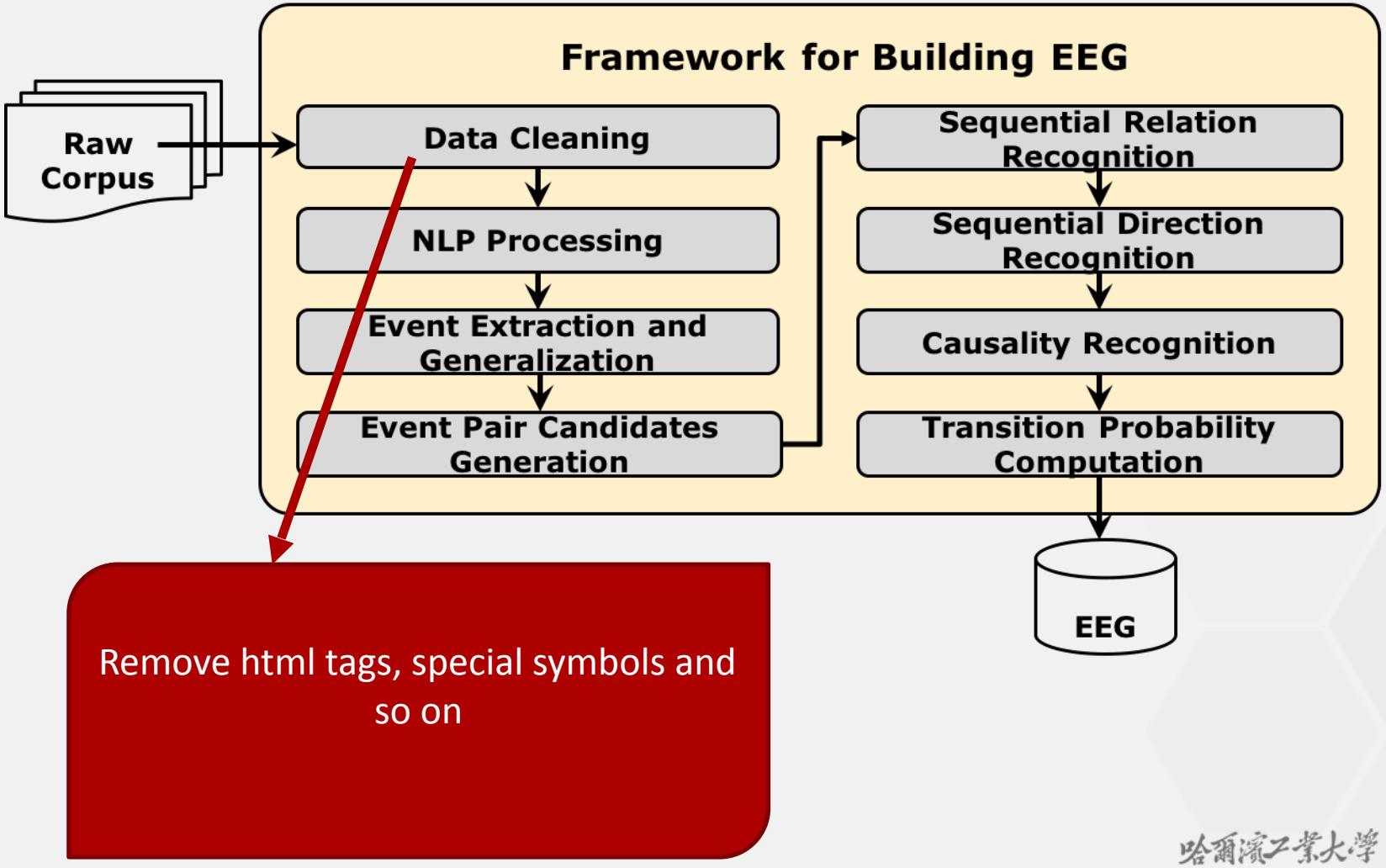
社会计算与信息检索研究中心

Travel Domain EEG Construction



Travel Domain EEG Construction



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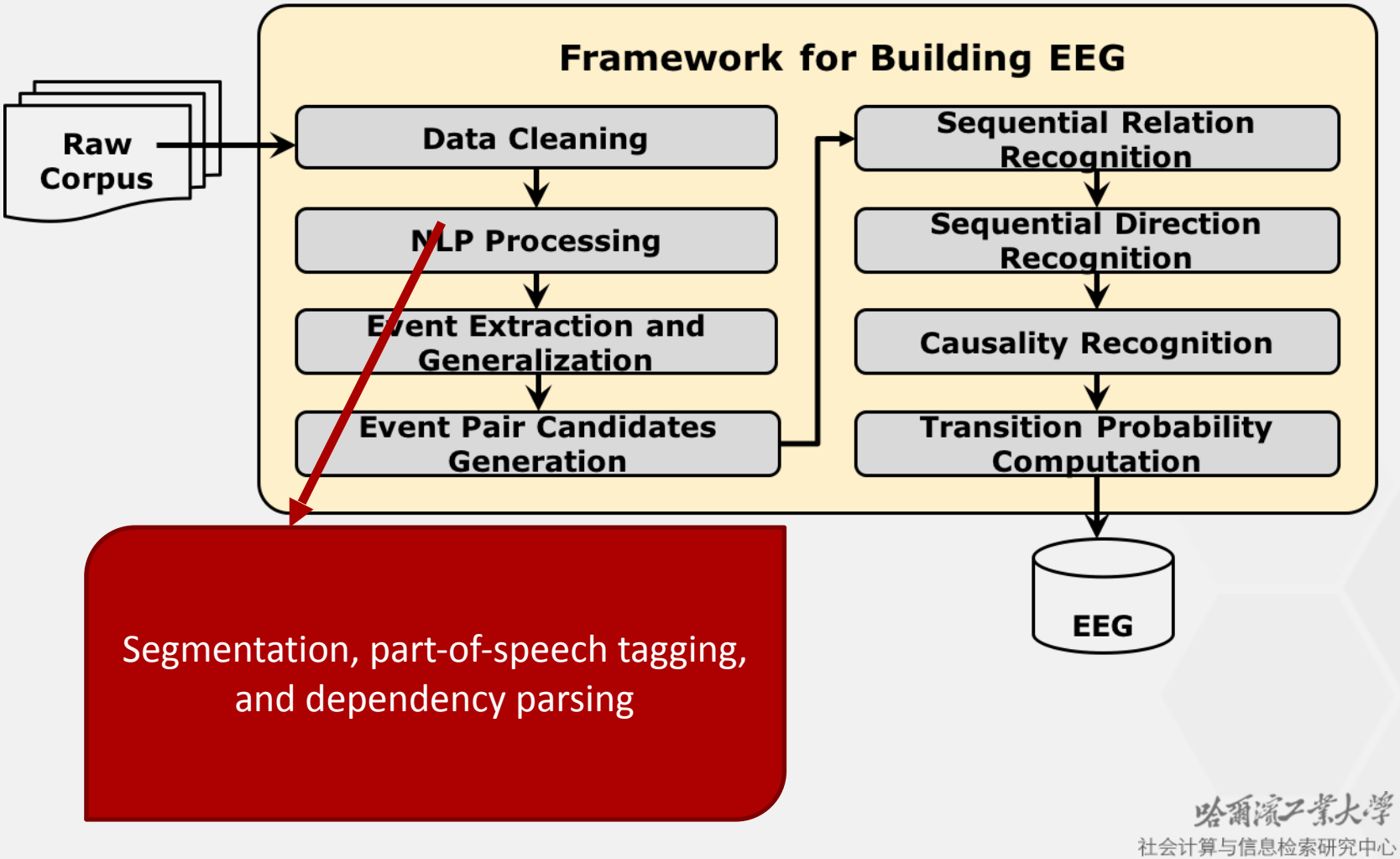
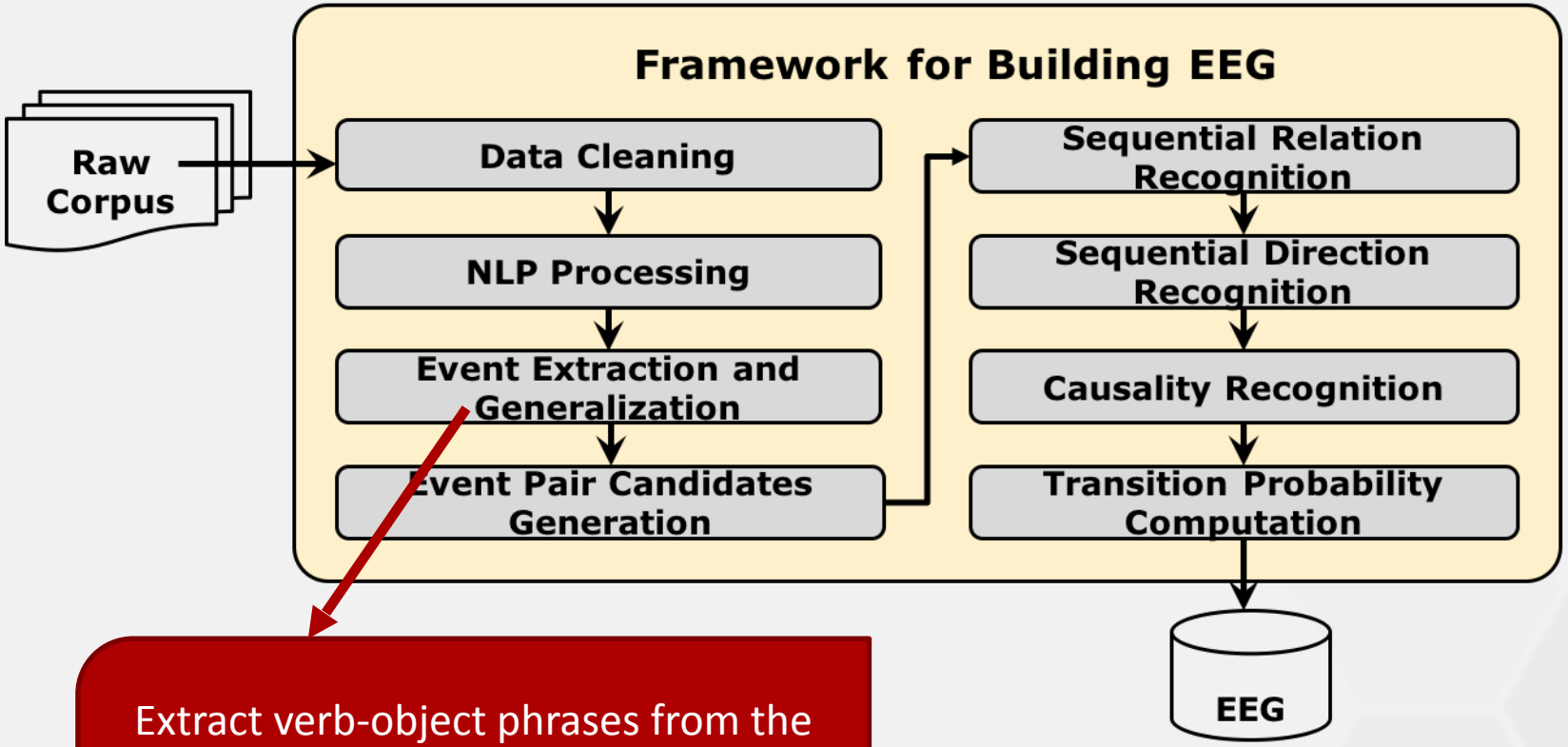
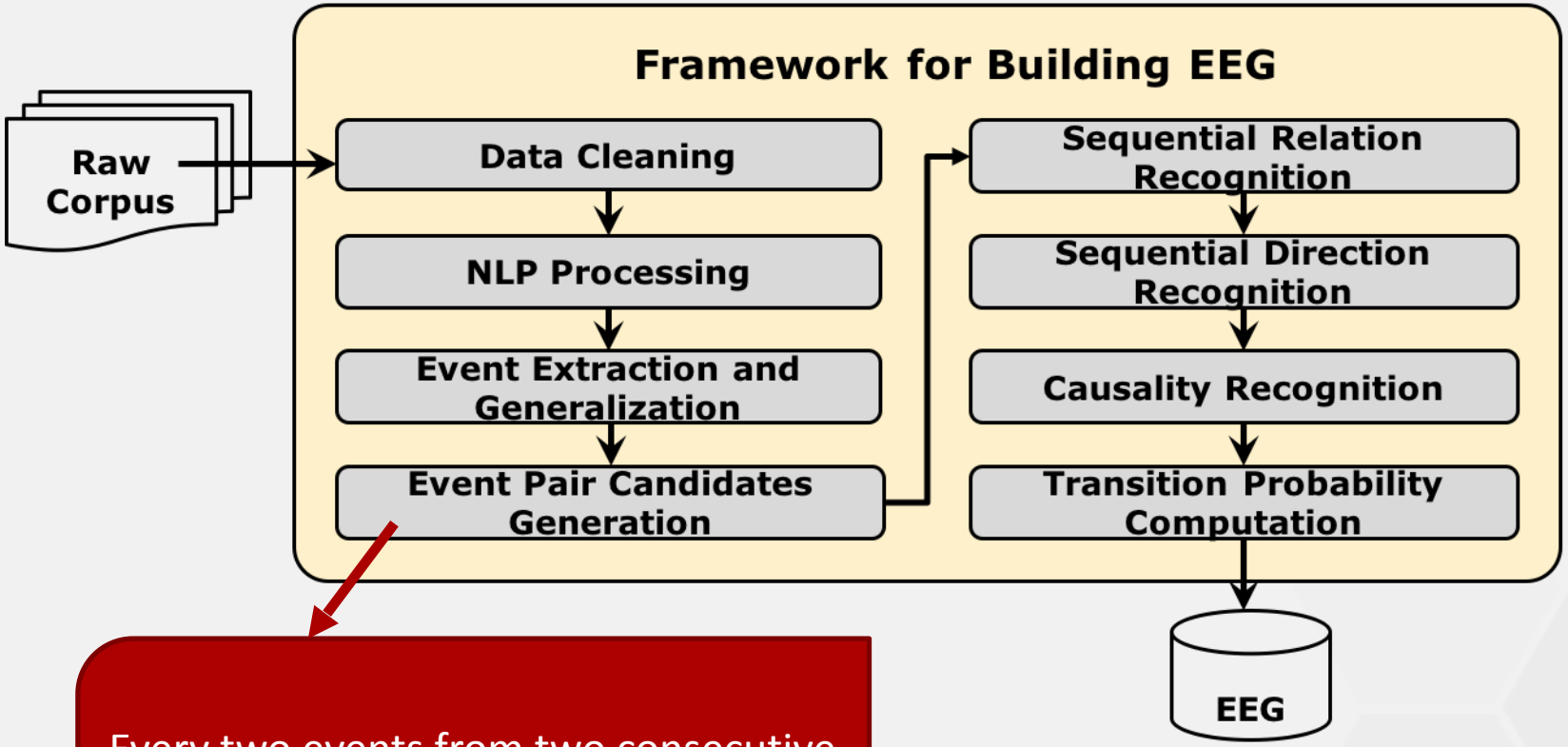


Travel Domain EEG Construction



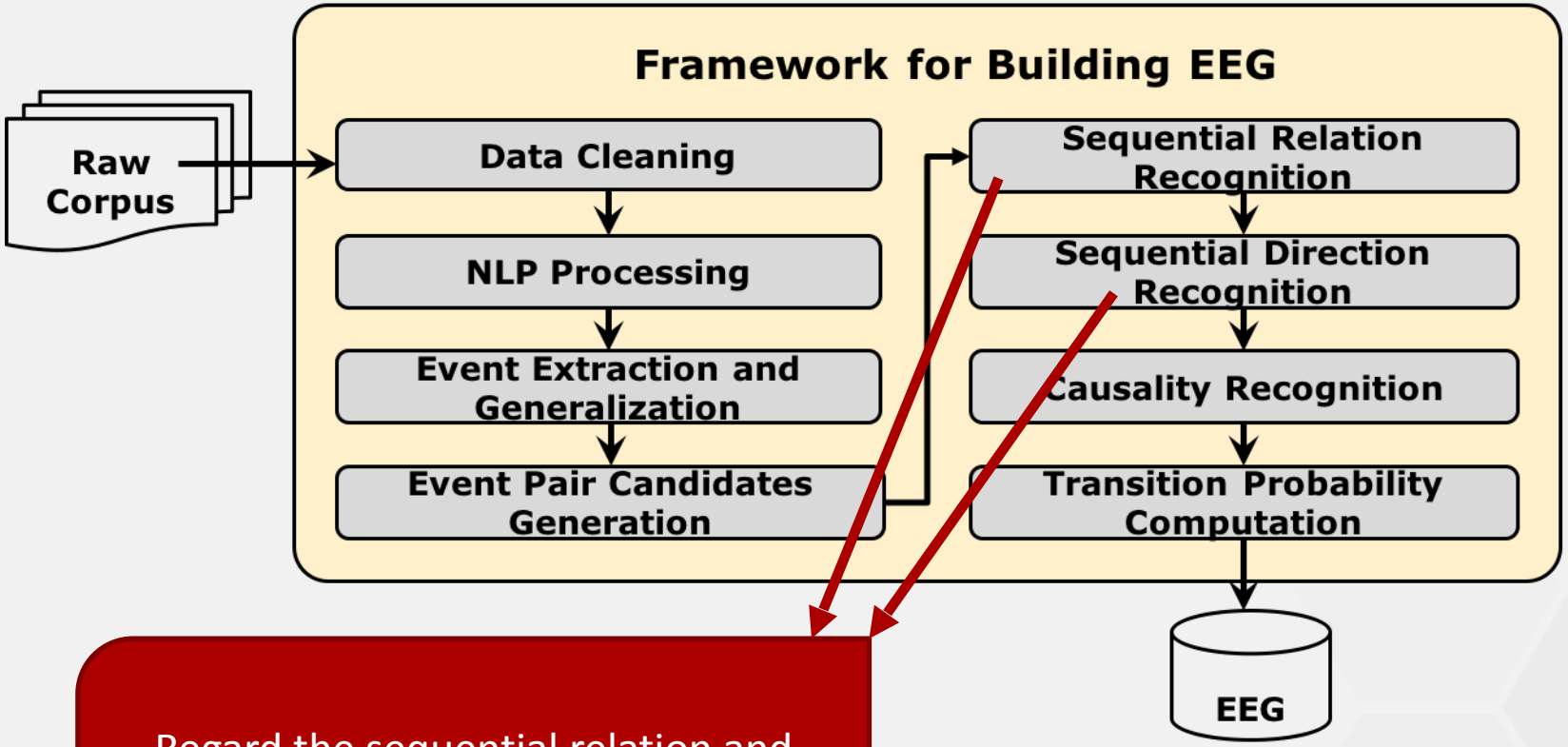
Extract verb-object phrases from the dependency-parsed tree, filter the low-frequency phrases by a proper threshold

Travel Domain EEG Construction



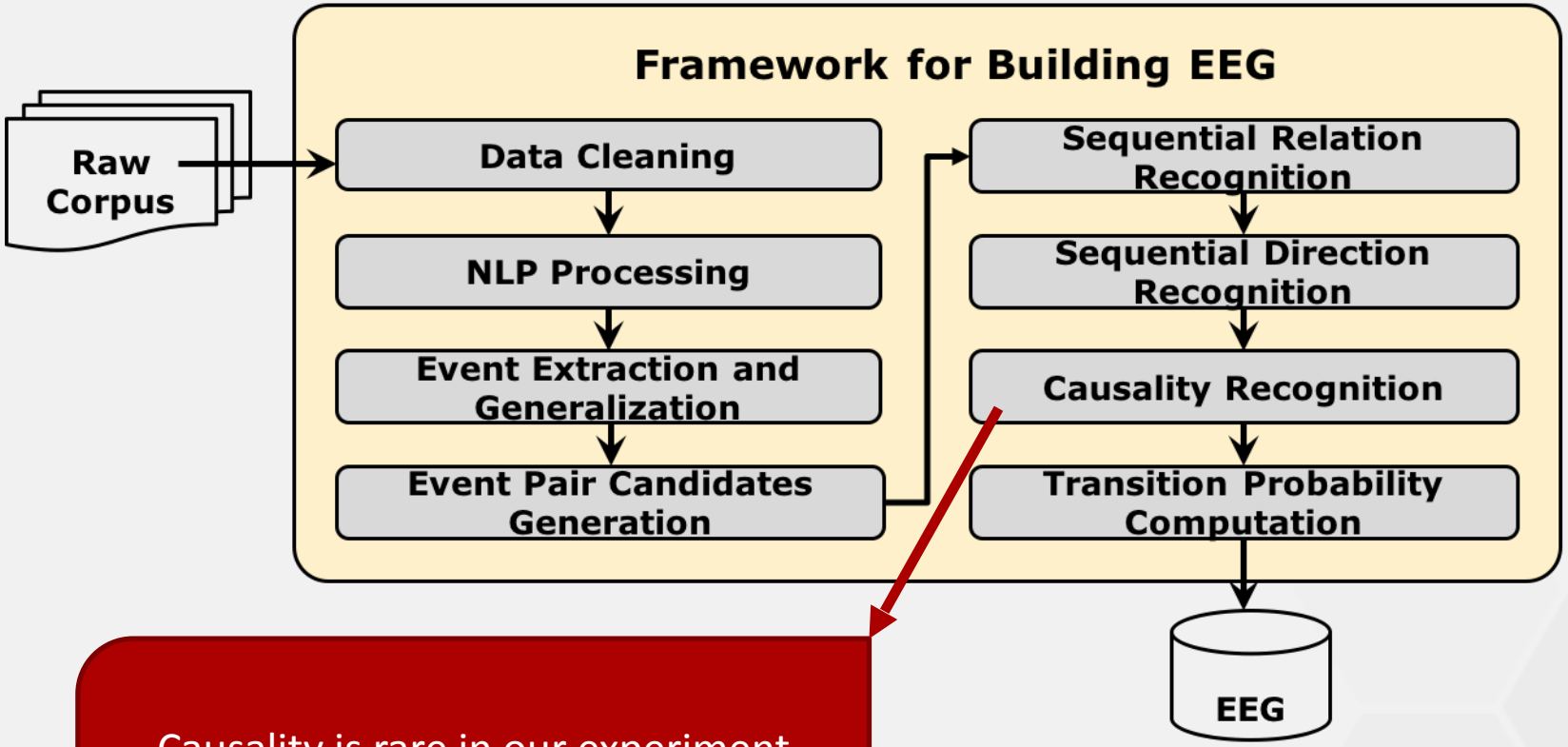
Every two events from two consecutive sentences are considered as an event pair candidate

Travel Domain EEG Construction



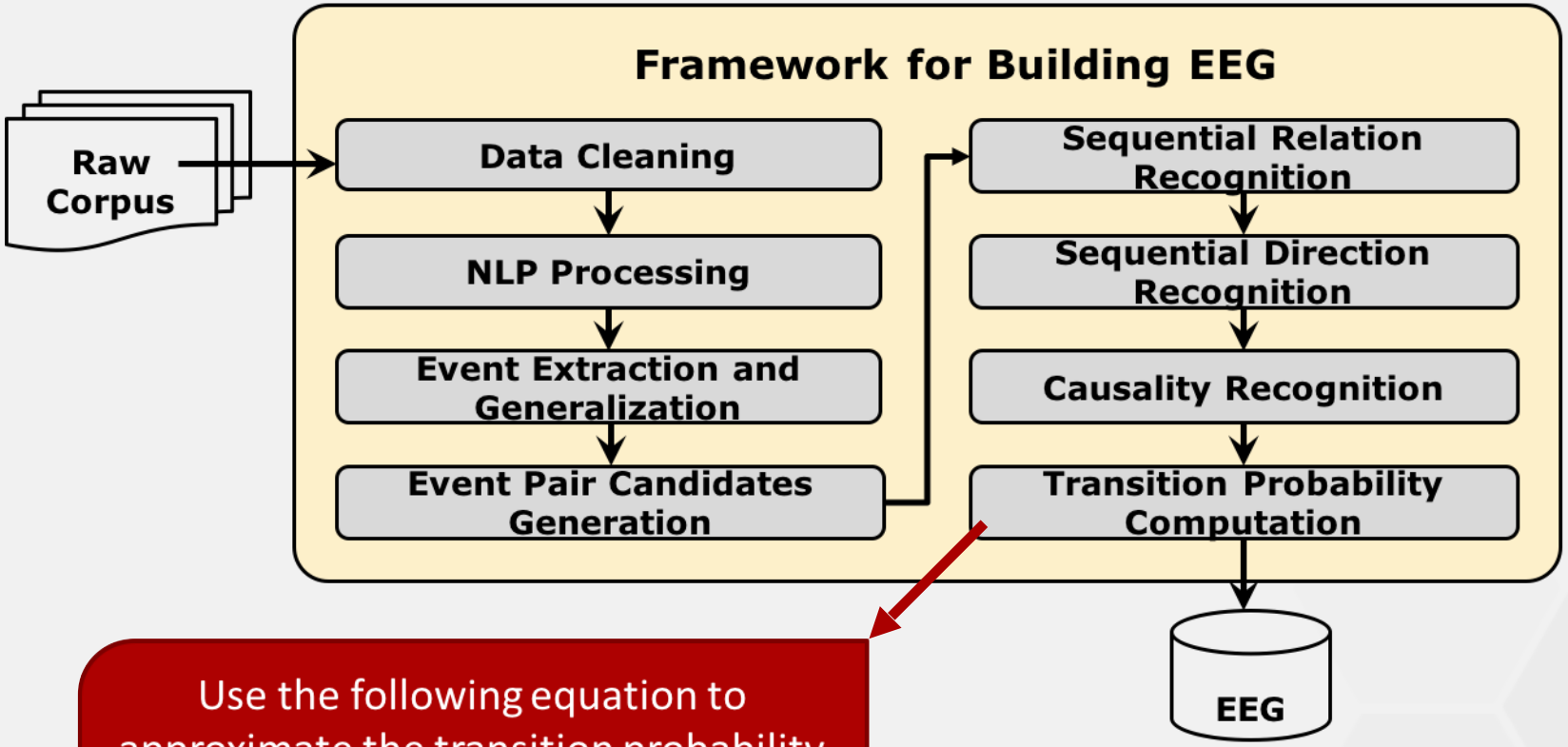
Regard the sequential relation and direction recognition as two separate supervised binary classification tasks

Travel Domain EEG Construction



Causality is rare in our experiment corpus, so causality recognition is not covered in this paper.

Travel Domain EEG Construction



Use the following equation to approximate the transition probability from event A to event B:

$$P(B|A) = \frac{count(A,B)}{count(A)}$$

Data Sets and Experiments Results

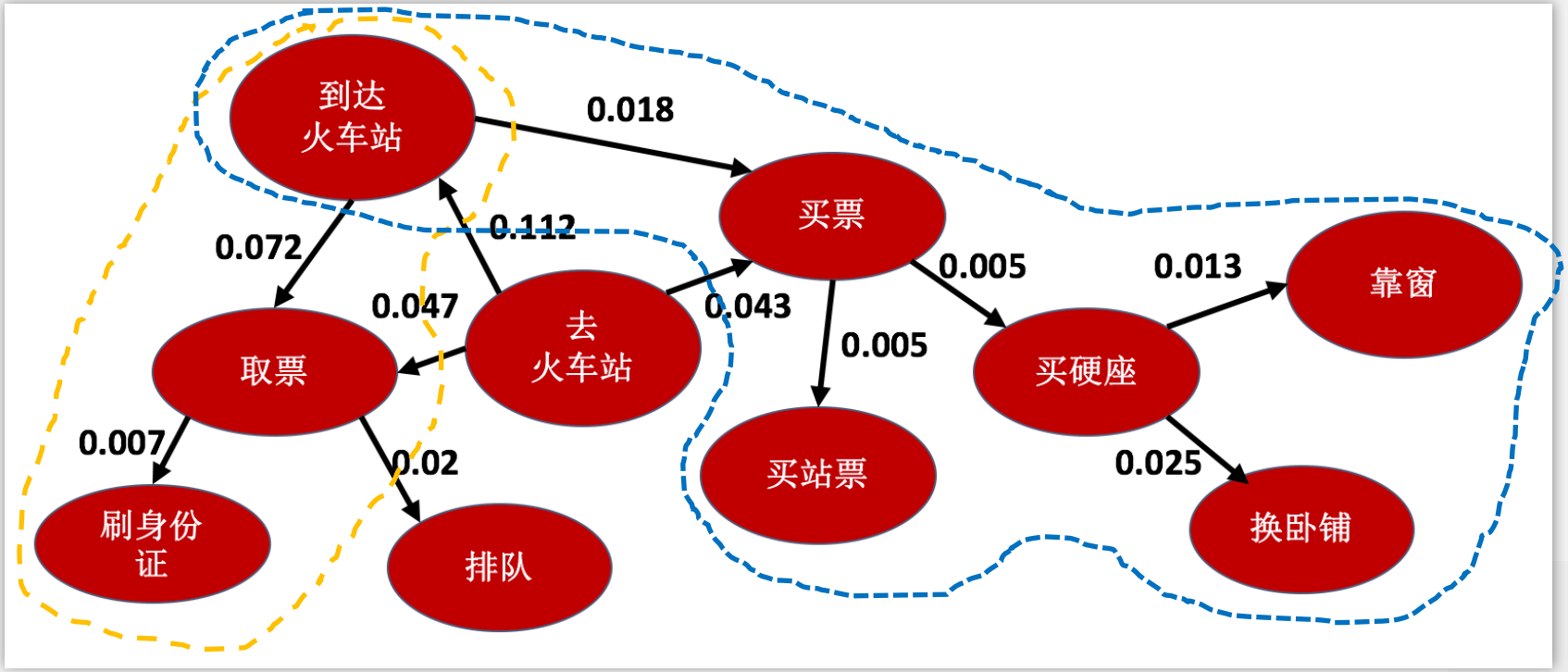
- Experiment corpus
  - 320,702 question-answering pairs crawled from travel topic on“Zhihu”
- Suprevised classification of sequential relation and direction

	Total	Positive	Negative
Sequential Relation	2,173	1,563	610
Sequential Direction	1,563	1,349	214

F1 value of sequential relation classification： 85.7%

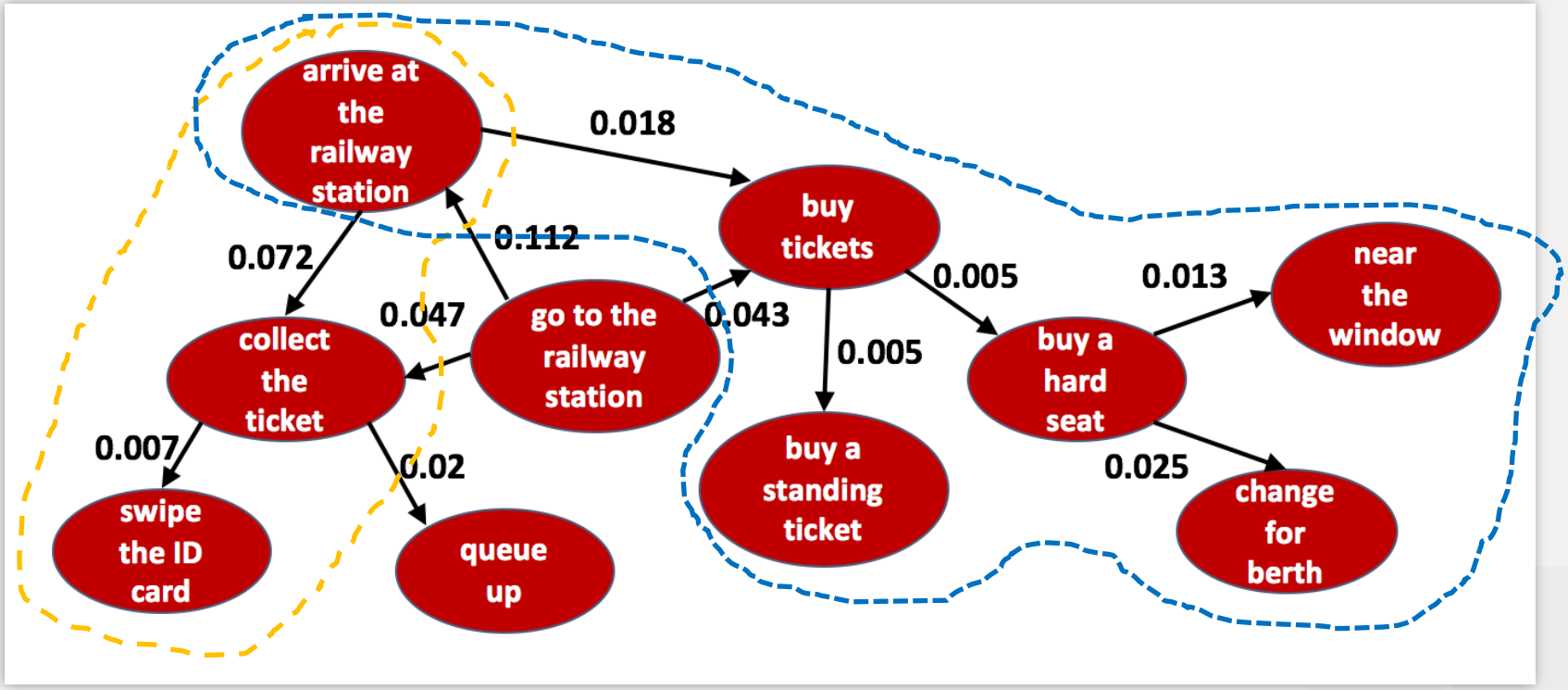
F1 value of sequential direction classification： 92.9%

Case Study



Subgraph in our automatically constructed travel domain EEG under the scenario of “buy train tickets”.

Case Study



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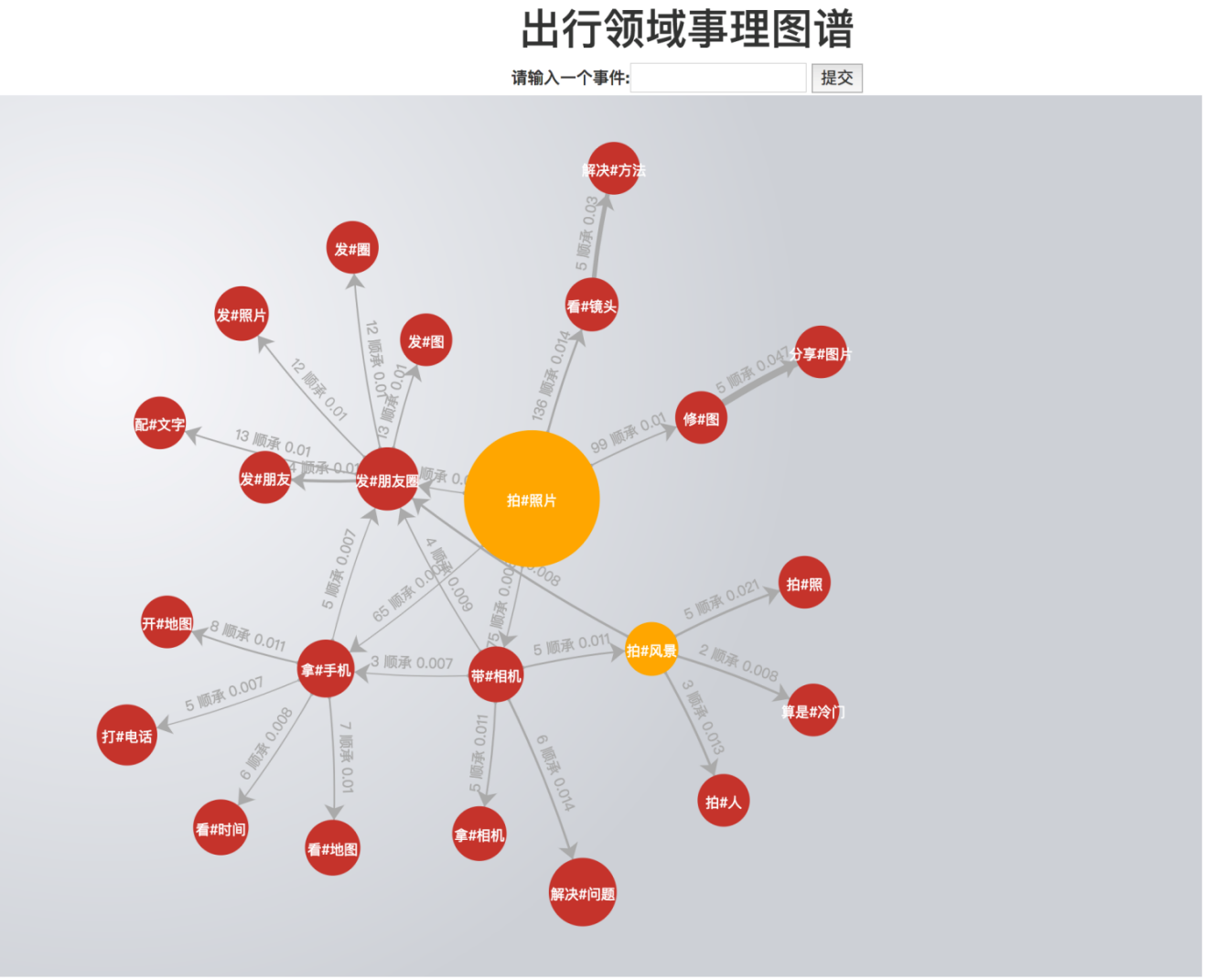
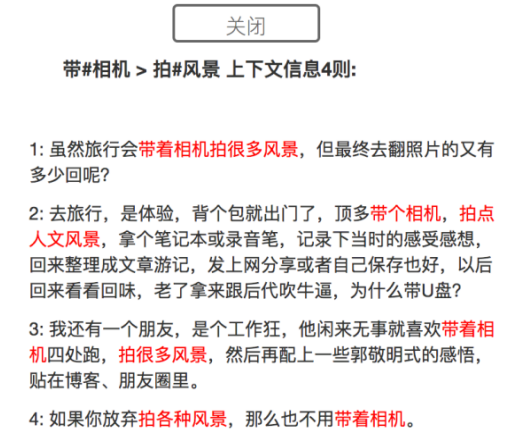
Demonstration： Travel Domain EEG





Scale of travel domain EEG：

29,825 event nodes,

234,547 directed edges.

Travel Domain EEG: Potential Applications

- Consumption Intention Mining and Recommendation
  - Most events can join with ‘want to’, ‘plan to’, ‘will’ and become intention events
    - want to go to Beijing, want to watch movies, plan to clime Mountain Tai, will have hot pot
  - Certain events have notably consumption intention, and they can lead to following consumption events; it is of great value to find these events
    - watch movies, go on a tourist

Travel Domain EEG: Potential Applications

- Dialogue Generation
  - go to Beijing→buy tickets
    - A: I plan to go to Beijing. B: Have you buy the tickets?
  - go to Taian→climb Mountain Tai
    - A: I want to climb Mountain Tai. B: Then you need to go to Taian first.
- Question Answering System
  - Q: Is there any dos and don'ts if I want to climb Mountain Tai ?
  - A: Remember to rent a coat, take some water and a flashlight.

HIT-SCIR: Our Exploration on EEG

Construction and Application of Financial Domain EEG

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Sample Analysis

- Financial news contain lots of event-event **causal relations**
  - Explicit causality (with connectives)： “Plasticizer incident led to liquor stocks plummeted.”
    - “塑化剂事件导致白酒股大跌。”
  - Implicit causality (no connectives)： “Baidu Q2 earnings report： net profit increased by 82.9%, stock price rose by 7%.“
    - “百度Q2财报：净利同比增82.9%，股价盘后上涨7%”
- Except for causal relations, it also contains large quantities of **sequential relations**
  - “After nearly half a month’ suspension, IFLYTEK’ stock resumed trading limit.”
    - “停牌了近半个月的科大讯飞（002230.SZ）复牌，股价开盘即涨停。”

Target for Financial Domain EEG

- Target
  - Mine economic changes related (especially stock price movements) sequential and causal event relations from financial news articles, to construct the financial domain EEG
- Method
  - Causal and sequential event relation extraction
  - Transforming ‘cause-effect pairs’ into graph

Extraction Methods for Cause-Effect Pairs

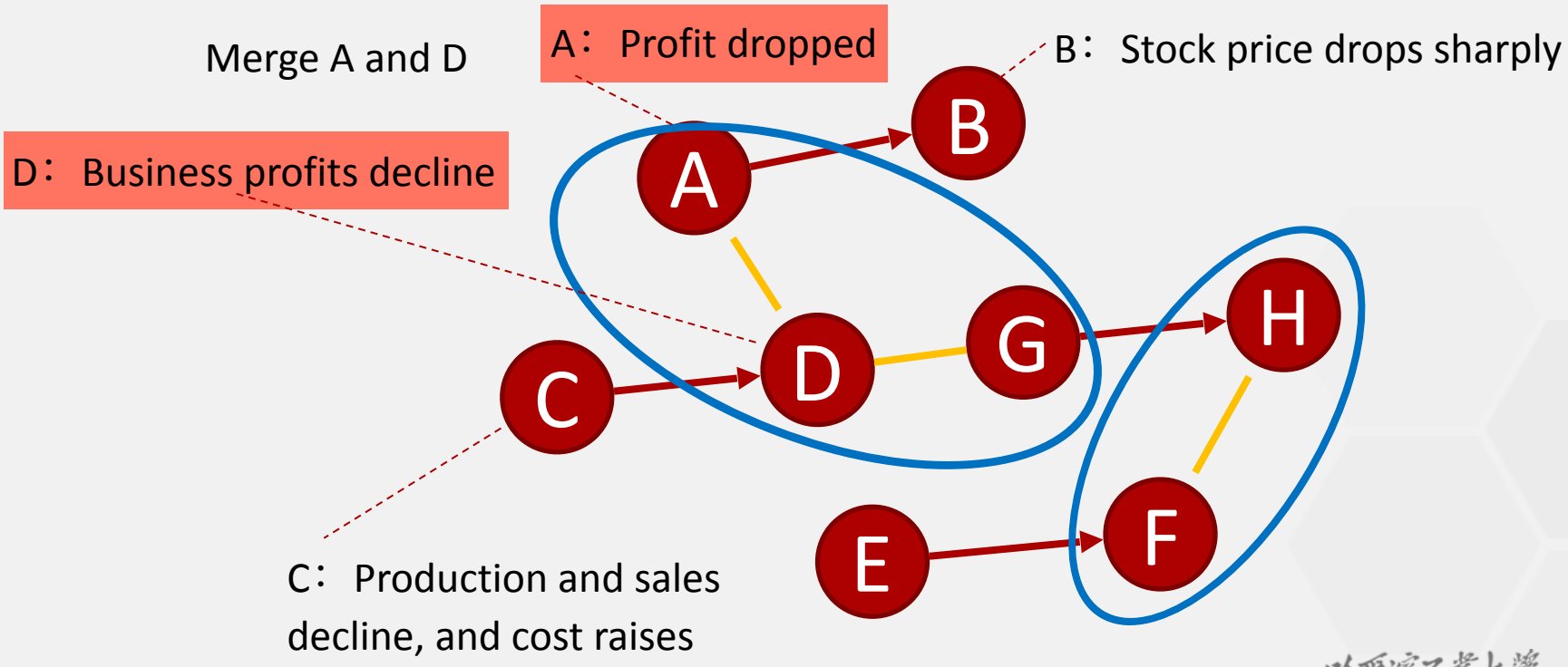
- Exploit causal triggers to construct templates and match with regular expressions, to obtain the cause and effect mentions
  - For example：(.+)(result in|lead to|cause)(.+)(drop|rise)
    - (.+)(导致|引起|造成)(.+)(下跌|上涨)
- Carry out segmentation and POS tagging on the cause and effect mentions
- Finally, the sequence of verbs, nouns, and adjectives is regared as the cause and effect after filtering with POS tags

Representative Extracted Cause-Effect Pairs

- Profits decline of ZTE lead to its stock price dropping sharply.
  - “中兴通讯利润下滑引发股价大跌”
- Astronomical compensation rumors of ZTE resulted in its stock dropping sharply.
  - “中兴通讯天价赔偿传闻导致股票大跌”
- The news of Shuanghui’ acquisition of Smith Field made Shuanghui development stock price rise.
  - “双汇并购史密斯菲尔德消息使得双汇发展股价大涨”
- Meat products production and sales decline, and cost raises caused the bussiness profits to drop.
  - “肉制品产、销量下降，成本上升造成肉制品业务利润下降”
- Related competitors’ entering resulted in the market share of gross profit margin declined.
  - “相关竞争对手进入导致产品毛利率市场份额下降”

Financial Domain EEG

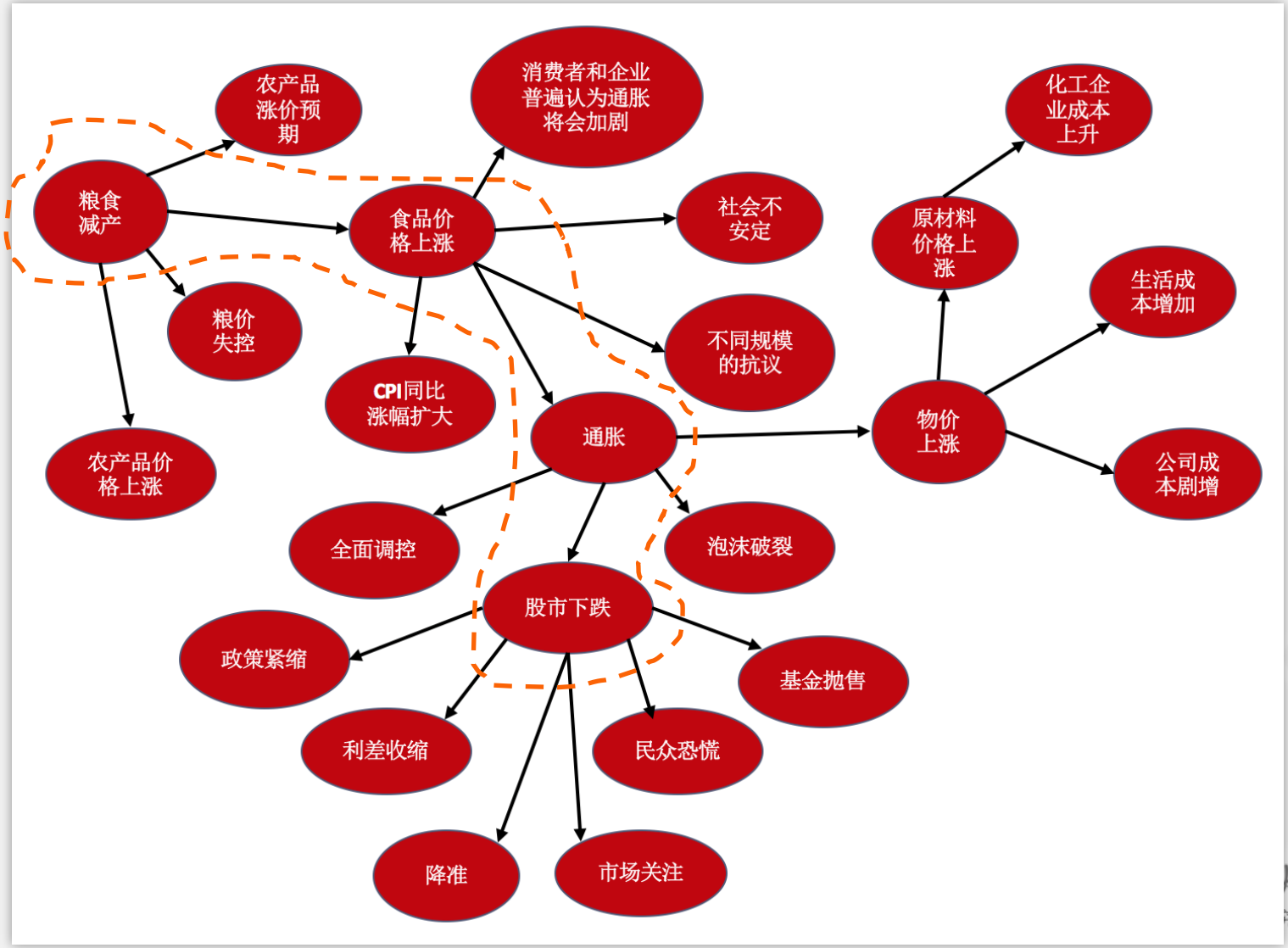
- Transforming ‘cause-effect event pairs’ into graph by merging certain events.



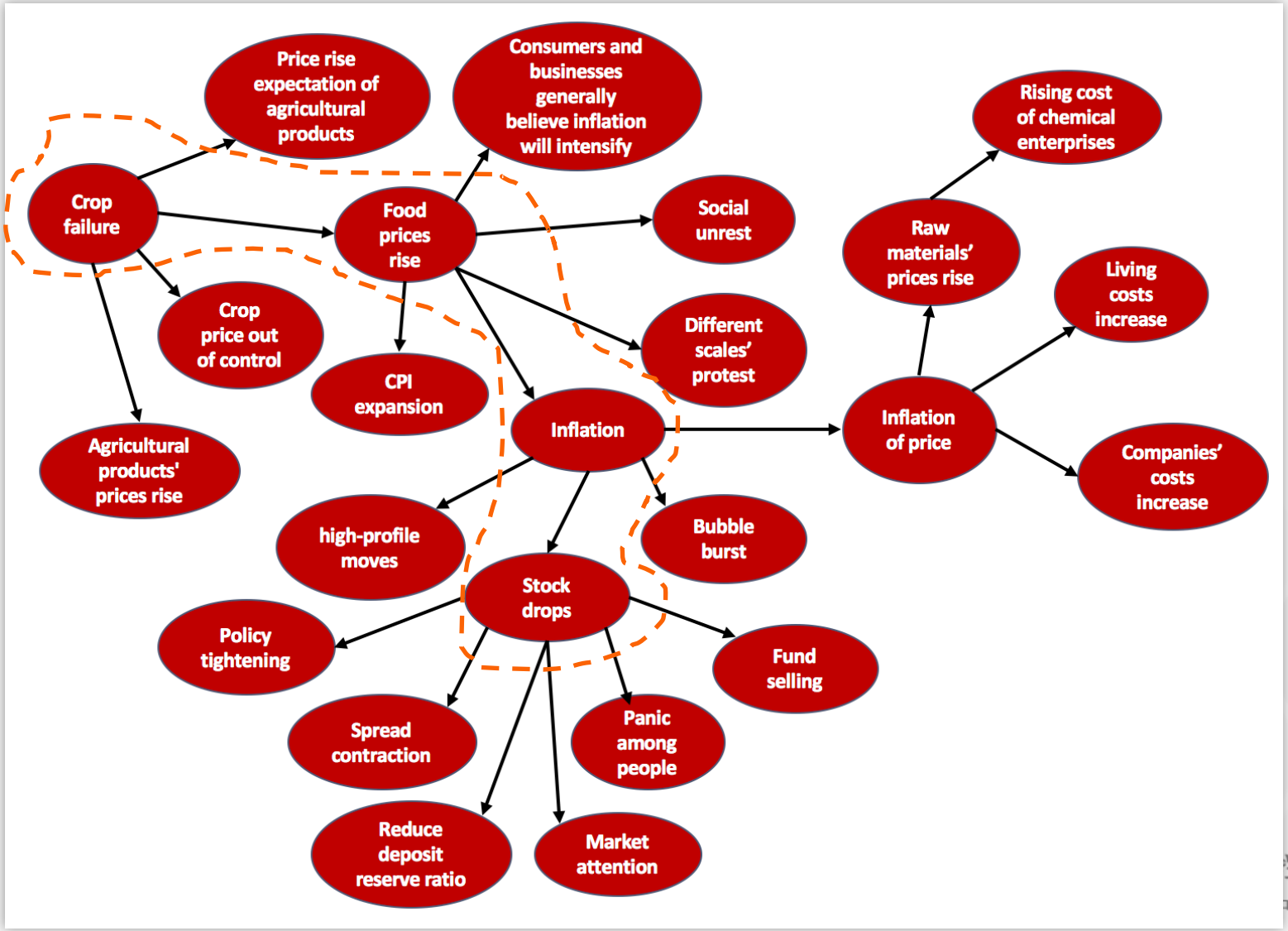
Merge Events by Similarity Computation

- Event representation
  - Bags of verbs and nouns
  - Bags of verbs, nouns and adjectives
  - Average word embedding of all words
  - Average word embedding of verbs, nouns and adjectives
- Similarity measure
  - Jaccard similarity
  - Cosine similarity

Case Study


农产品涨价预期
消费者和企业普遍认为通胀将会加剧
化工企业成本上升
粮食减产
食品价格上涨
社会不安定
原材料价格上涨
生活成本增加
粮价失控
不同规模的抗议
CPI同比涨幅扩大
通胀
物价上涨
公司成本剧增
农产品价格上涨
全面调控
泡沫破裂
股市下跌
政策紧缩
基金抛售
利差收缩
民众恐慌
降准
市场关注

Case Study


Price rise expectation of agricultural products
Consumers and businesses generally believe inflation will intensify
Crop failure
Food prices rise
Social unrest
Rising cost of chemical enterprises
Raw materials' prices rise
Living costs increase
Crop price out of control
Different scales' protest
CPI expansion
Inflation
Inflation of price
Companies' costs increase
Agricultural products' prices rise
high-profile moves
Bubble burst
Stock drops
Policy tightening
Fund selling
Spread contraction
Panic among people
Reduce deposit reserve ratio
Market attention

Data Sources and Scale of Financial EEG

- **Data sourses： 1,362,345 financial news articles**
  - 716,391 individual stocks news articles from Tencent and Netease
  - 246,499 plate news articles from Netease
  - 399,455 articles filtered from 10 years' newspaper articles
- **Scale of financial domain EEG:**
  - 247,926 event nodes
  - 154,233 cause-effect pairs/directed edges
  - 3,111,720 similar pairs/undirected edges

Outline

- Motivation of Event Evolutionary Graph
- Related Work
- Our Efforts on Event Evolutionary Graph
- **Conclusion**

Conclusion

- By farming in various domains for a long time, Knowledge Graph gradually shows its great value.
  - 知识图谱在各个领域精耕细作，逐渐显露价值
- Knowledge representation still needs breakthrough, and its inference ability needs to be improved.
  - 知识表示形式有待突破，推理能力有待提高
- Statistical script learning and event relation recognition attracted more and more research attentions.
  - 统计脚本学习和事件关系识别等事理图谱相关研究越来越吸引研究者关注

Conclusion

- Event evolutionary graph, whose nodes are predicate phrases and edges are event evolutionary logics, is in the ascendant.
  - 以“谓词性短语”为节点，以事件演化（顺承、因果）为边的事理图谱方兴未艾

- Event evolutionary graph will play an important role in event prediction and dialogue generation research fields, and improve the interpretability of artificial intelligence systems.
  - 事理图谱必将在预测、对话等领域发挥重要作用，有力地提升人工智能系统的可解释性

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Thanks !