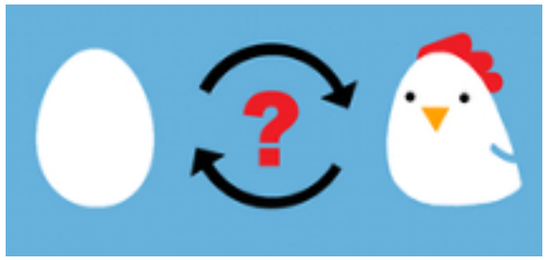
Reasoning Causality Between Short Texts

Luo Zhiyi
Email: jessherlock@sjtu.edu.cn

Causality

- Intuitively
  - Causality represents the causal relationship.
  - One thing(event) causes another



Causality

- In NLP context
  - We use text to describe the event.
  - We focus on the causality between *short texts*.
    - i.e. word, phrase and sentence.

egg -> **chicken**
chicken -> **egg**

- Typically modeling causality as a *(cause, effect)* pair
  - (egg, chicken)
  - (chicken, egg)

Causality Reasoning

- Ability to *recognize* and *measure* the causality between short texts.

- What is the strength of causality existing between **A** and **B**?

- Thus, it is nature to specialize the causality reasoning problem to the following task.

I knocked on my neighbor's door.

What happened as an *effect*?

Alternative 1: **My neighbor invited me in.**

Alternative 2: My neighbor left her house.

Observations of Causality in Text

- **Causality is a directional relation.**
- **There are two tendencies of causality encoded in text.** (A *causes* B)
  - Necessity causality
    - The effect **B** would not have occurred if its cause **A** did not occur, which means **A** is necessary for **B**.
  - Sufficiency causality
    - If **A** occurred then its effect **B** would follow which means **A** is sufficient for **B** or **A** implies **B**.

Observations of Causality in Text

- **Causality is a directional relation.**
- **There are two tendencies of causality encoded in text.** (A *causes* B)
  - Necessity causality
    - The effect **B** would not have occurred if its cause **A** did not occur, which means **A** is necessary for **B**.
  - Sufficiency causality
    - If **A** occurred then its effect **B** would follow which means **A** is sufficient for **B** or **A** implies **B**.
- **Causality pair is stronger when encoding both sufficiency and necessity causality.**

Causality Computation

Question 1:
What pairs will be extracted?

- Extract causality knowledge from text corpus.

The <e1>burst</e1> **has been caused by** water hammer <e2>pressure</e2>.

(pressure,burst)

(hammer,burst)

(water,burst)

- Pros and Cons
  - Fast for Huge corpus
  - Sparsity and Bias

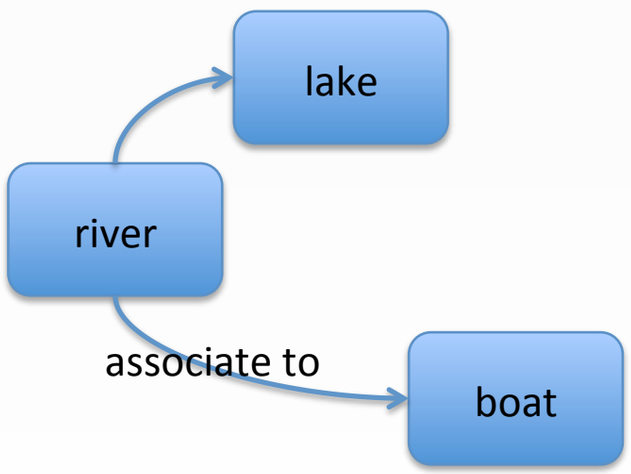
Causality Computation

- Necessity and sufficiency causality makes the cause/effect terms co-occur in text.
- Use statistical metric to captures *necessity causality* and *sufficiency causality*
- Necessity causality pair (A,B)
  - Every time B occurs, A is necessarily occurred. We should penalize on frequent cause.
    - (A, B), (A, X)
- Sufficiency causality pair (A,B)
  - Every time A occurs, B always follow to occur. We should penalize on frequent effect.
    - (A, B), (X, B)

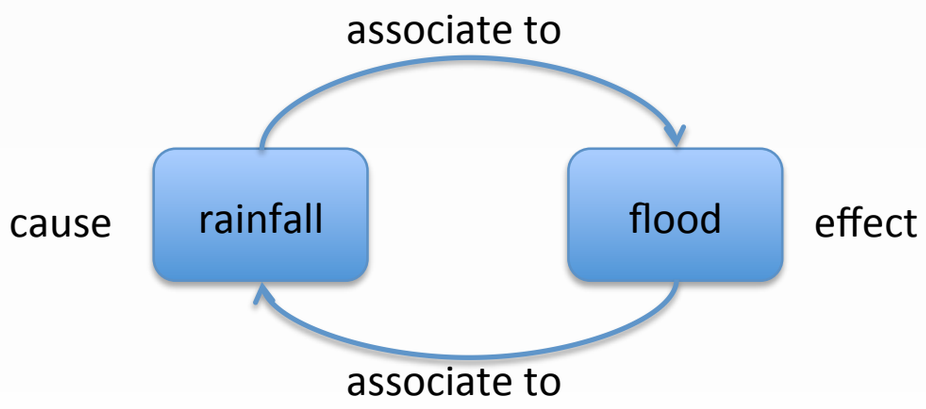
Causality Computation

- For causality pair (i_c, j_e)
  - the strength of i_c associate to j_e $\frac{p(j_e|i_c)}{p^{\alpha}(j_e)}$
  - the strength of j_e associate to i_c $\frac{p(i_c|j_e)}{p^{\alpha}(i_c)}$
- **Question 2: Which one should model necessity causality?**

sufficiency causality



necessity causality



Causality Computation

- Necessity and Sufficiency Causality

$$CS_{nec}(i_c, j_e) = \frac{p(i_c, j_e)}{p^{\alpha}(i_c)p(j_e)}$$

$$CS_{suf}(i_c, j_e) = \frac{p(i_c, j_e)}{p^{\alpha}(j_e)p(i_c)}$$

- Causality

$$CS(i_c, j_e) = CS_{nec}(i_c, j_e)^{\lambda} CS_{suf}(i_c, j_e)^{1-\lambda}$$

- Parameter Tuning
  - We need to tune lambda to fit our corpus.

Causality Reasoning Tasks

- Choice of Plausible Alternatives (COPA)
- Self-construction task for phrases
- Causality Detection task

COPA Evaluation

I knocked on my neighbor's door.

What happened as an *effect*?

Alternative 1: **My neighbor invited me in.**

Alternative 2: My neighbor left her house.

Data Source	Methods	Accuracy(%)
Web corpus	PMI (W=5)	61.6%
	PMI (W=10)	61.0%
	PMI (W=15)	60.4%
	PMI (W=25)	61.2%
	$CS_{\lambda=0.5}$	**64.8%**
Gutenberg	PMI (W=5)	58.8%
	PMI (W=25)	58.6%
LDC Gigaword	UTDHLT Bigram PMI	61.8%
	UTDHLT SVM	63.4%
ConceptNet	Fuzzy match	51.3%
1-Million Stories	PMI (W=25)	65.2%
10-Million Stories	PMI (W=25)	**65.4%**
CausaNet	$CS_{\lambda=1.0}$	**70.2 %**

Data Source	Methods	Accuracy(%)
Web corpus	$p(j_e\|i_c)$	58.2%
	$p(i_c\|j_e)$	62.8%
	$CS_{\lambda=0.5}$	**64.8%**
	$CS_{\lambda=0.7}$	63.4%
	$CS_{\lambda=0.9}$	63.0%
	$CS_{\lambda=1.0}$	63.0%
CausalNet	$p(j_e\|i_c)$	56.2%
	$p(i_c\|j_e)$	60.2%
	$CS_{\lambda=0.5}$	68.8%
	$CS_{\lambda=0.7}$	69.4%
	$CS_{\lambda=0.9}$	**70.2%**
	$CS_{\lambda=1.0}$	**70.2%**

Self-construction Evaluation

(exercise,sweat)

(dog,sweat)

Question 2:
Which choice is more plausible?

(destroy your enemy,victory)

(destroy your enemy,cunning and planning)

These term and phrase pairs are selected from ConceptNet, which is a handcrafted commonsense knowledge base.

Methods	Accuracy(%)
$CS_{\lambda=0.5}$	78.4%
$CS_{\lambda=0.9}$	78.6%
$CS_{\lambda=1.0}$	78.6%

Causality Detection

- To qualify our causality computation model
- We select 100 causality pairs and 100 non-causality pairs from ConceptNet.

(meet a friend, happiness)

(listen to music, furniture)

- **Question 3: Which one is positive pair? Which one is negative pair?**

positive pair

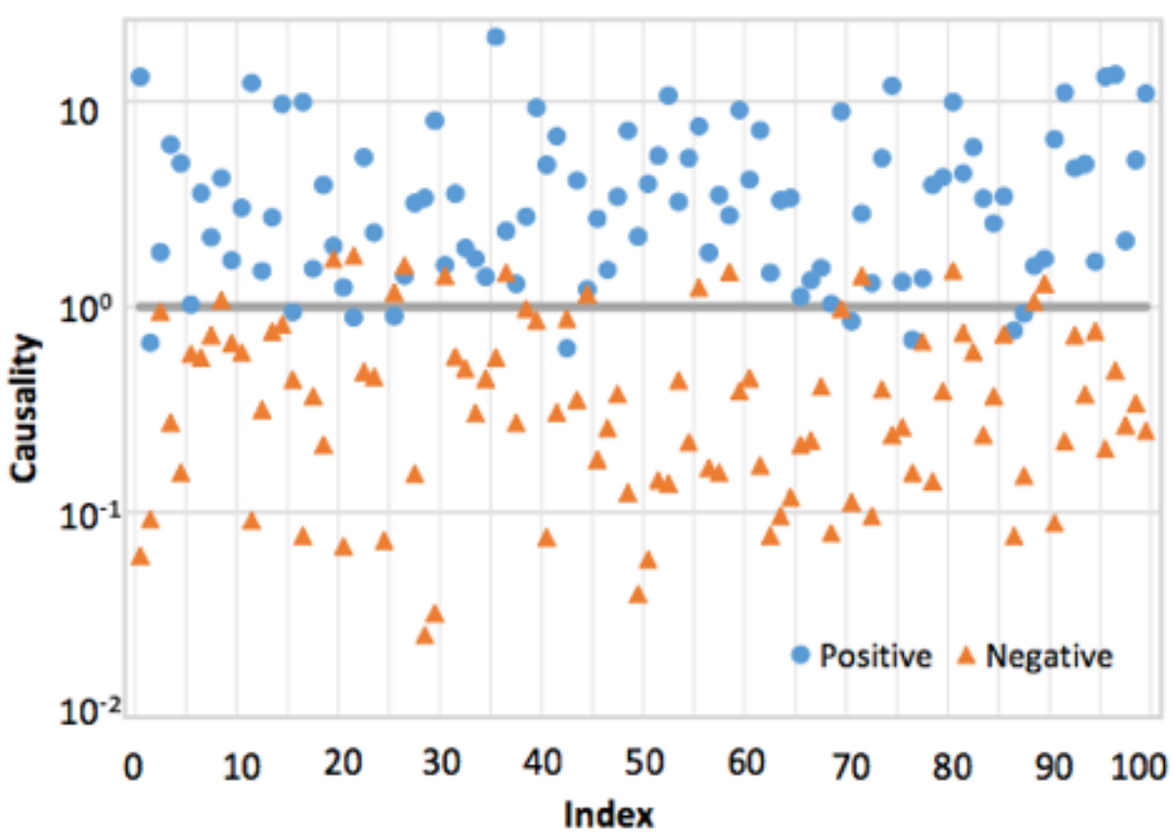
negative pair

Causality Detection

- To qualify our causality computation model
- We select 100 causality pairs and 100 non-causality pairs from ConceptNet.

(meet a friend, happiness) — positive pair

(listen to music, furniture) — negative pair



Thanks for listening!