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What Kinds and Amounts of Causal Knowledge Can Be Acquired from Text by Using Connective Markers as Clues?

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Background & Research goal (1/2)

- To achieve intelligent machines, we require large amounts of several types knowledge.

- In previous research (e.g. [Lenat1995][Stork1999]), much of the knowledge is constructed manually. It is costly due to the scale of required knowledge.

- Automatic knowledge acquisition from document collections

Document collections **Knowledge base**

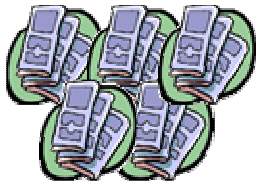
Background & Research goal (2/2)

- Knowledge acquisition of causal relations
  - Refer to an event that causes another event

Someone is thirsty → Someone Drinks water

It rains hard → Flooding occurs

- Key idea : use connective markers as clues



The laundry dried well because it was sunny.

It is sunny → The laundry dries well → KB

Outline of presentation

First part : introduction

- Example
- Typology of causal relations

Second part : technical issues

- Key idea & its problem
- Analyses & Experiments

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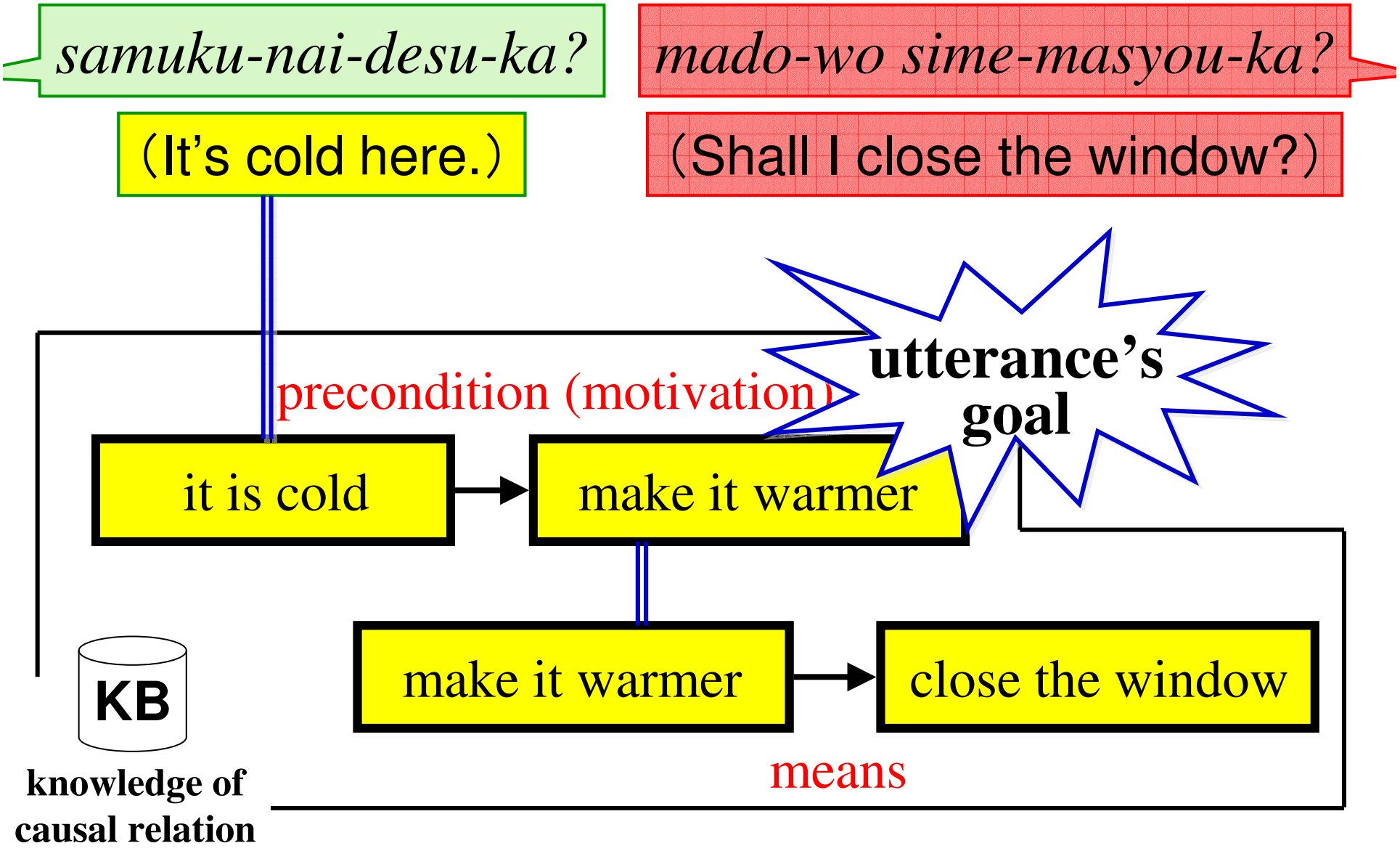
Example of utterance understanding



Typology of causal relations (1/5)

- Acquire 4 types of causal relations between 2 events following [Allen 1995]

cause effect precond(ition) means

Typology of causal relations (2/5)

- *cause* relation -

non-volitional state of affairs

non-volitional state of affairs

cause ({it is sunny}, {laundry dries well})

Typology of causal relations (3/5)

- *effect* relation -

agent's volitional action

effect ({someone destroys mangrove swamps}, {flooding occurs})

non-volitional state of affairs

Typology of causal relations (4/5)

non-volitional state of affairs

precond ({someone has a driving license},
{someone drives a car})

agent's volitional action

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agent's volitional action

means ({someone goes to the ticket office},
{someone buys a ticket})

agent's volitional action

Typology of causal relations (5/5)

Act : agent's volitional action

SOA : non-volitional state of affairs

Causal_rel(arg1, arg2)	example
cause (SOA, SOA)	***cause*** ({it is sunny}, {laundry dries well})
effect (Act, SOA)	***effect*** ({someone destroys mangrove swamps}, {flooding occurs})
precond (SOA, Act)	***precond*** ({someone has a driving license}, {someone drives a car})
means (Act, Act)	***means*** ({someone goes to the ticket office}, {someone buys a ticket})

necessary condition

sufficient conditions described later

Outline of presentation

First part : introduction

- Example
- Typology of causal relations

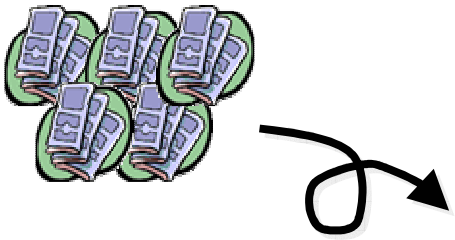
Second part : technical issues

- Key idea & its problem
- Analyses & Experiments

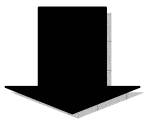
Note: this research was conducted using Japanese newspaper articles

Key idea

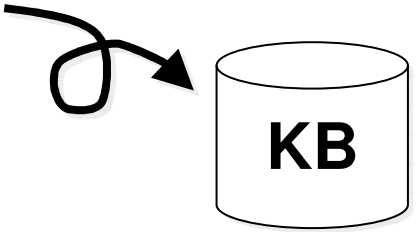
- Use connective markers as clues



The laundry dried well today because it was sunny.



cause ({it is sunny}, {laundry dries well})



Problem

- Different types of causal relations are expressed with the same marker.

The laundry dried well today because it was sunny.

➡ ***cause*** ({it is sunny}, {laundry dries well})

We need to create a computational model to identify which type of causal relation can be acquired from a given sentence.

➡ ***means*** ({Mary uses a tumble dryer}, {she dries the laundry quickly})

Procedure

Step 1 Select markers.

Step 2 Evaluate marker's effectiveness.

Step 3 Identify the causal relations automatically.

Procedure

Step 1 Select markers.

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Step 3 Identify the causal relations automatically.

Step 1

Step 1

- Selected ***tame*** as our target
  - Used frequently and
  - Typically used to express causal relations

marker		freq.
ga	(but)	131 164
tame	**(because)**	**76 087**
to	(when/if)	56 549
reba	(if)	48 606
nagara	(while)	13 796

kara	(because)	10 209
node	(because)	9 994
nara	(if)	7 598
tara	(if)	6 027
noni	(but)	2 917

From Nihon Keizai Shimbun issued 1990

Example sentences

Step 1

【Ex.1】

manguroubu-wo *hakaisi-ta-**tame***

mangr ACC destroy-PAST-***tame***

subordinate clause

matrix clause

suigai-ga *hasseisi-ta*

flooding-NOM occur-PAST

【Ex.2】

kippu-wo	*kau-**tame***	*kippu-uriba-ni*	*i-tta*
ticket-ACC	buy-***tame***	to ticket office	go-PAST

Example sentences

Step 1

【Ex.1】

manguroubu-wo *hakaisi-ta-**tame***

mangrove-ACC destroy-PAST-***tame***

suigai-ga *hasseisi-ta*

flooding-NOM occur-PAST

【Ex.2】

kippu-wo *kau-**tame*** *kippu-uriba-ni* *i-tta*

ticket-ACC buy-***tame*** to ticket office go-PAST

Procedure

Step 1 Select markers.

We used "tame"

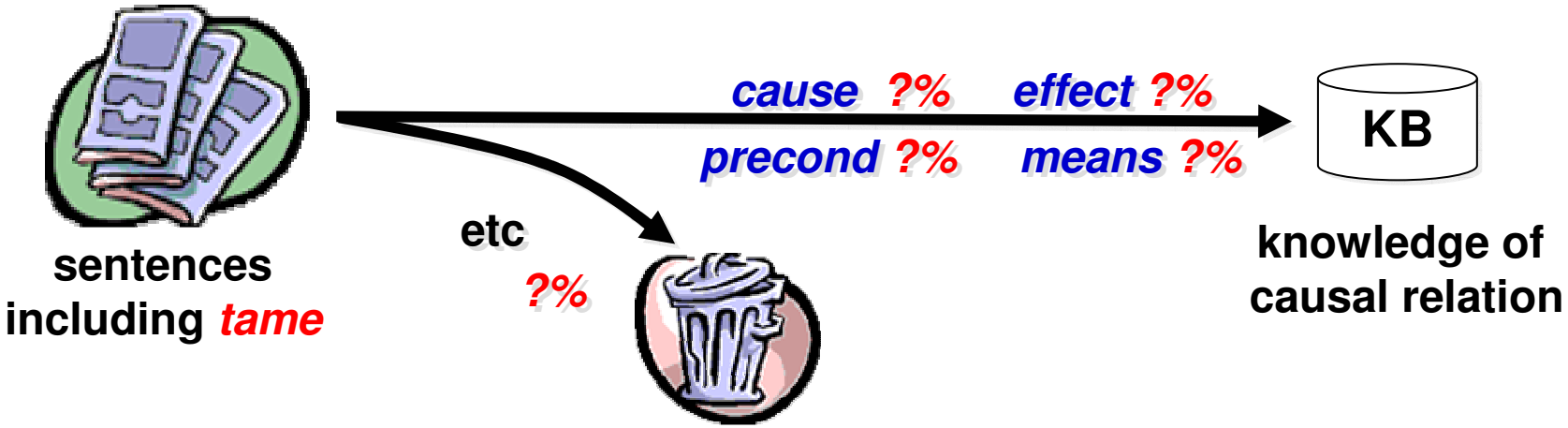
Step 2 Evaluate marker's effectiveness.

Step 3 Identify the causal relations automatically.

Step 2

Step 2

- Evaluate effectiveness of *tame*
  - How many causal relation instances are expressed by sentences including *tame*?



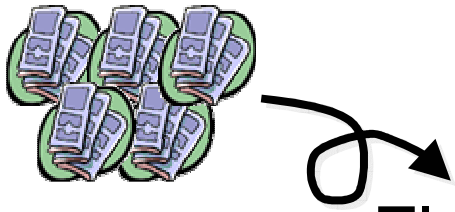
- Manually classified samples
  - Sample: about 1000 sentences including *tame*
  - Using linguistic tests

Linguistic tests (1/3)

Step 2

1. Translate sentence to two base-form items.

- Some modal information (tense, passive voice, etc.) is deleted.



Flooding occurred because mangrove swamps were destroyed.

past

passive voice

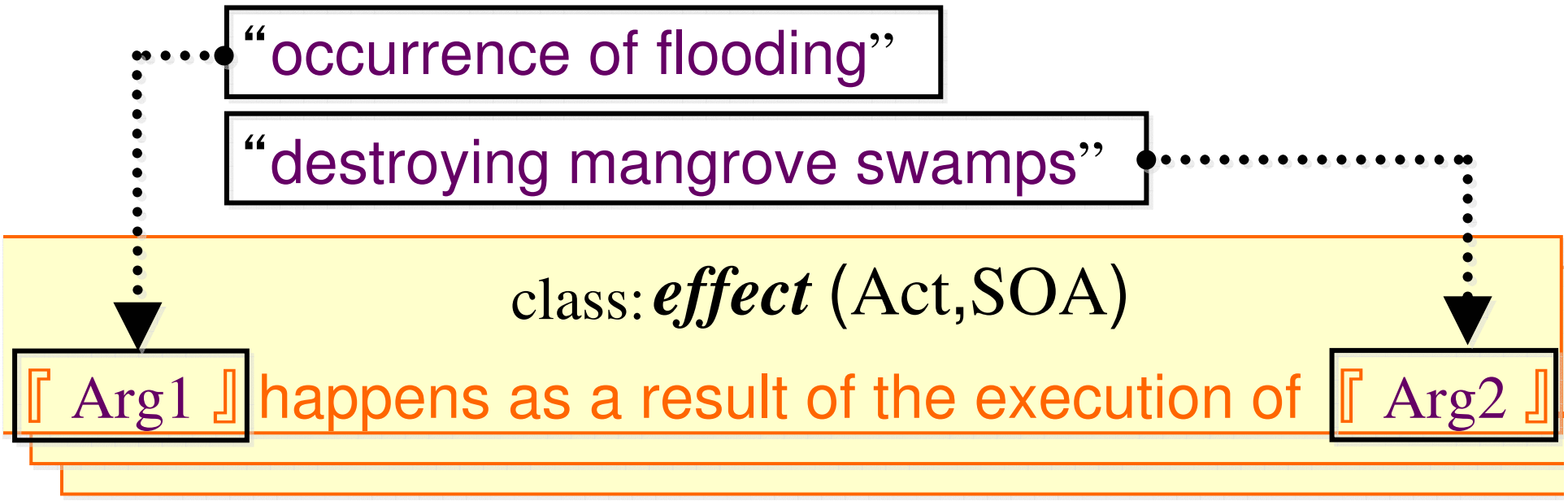
“occurrence of flooding”

“destroying mangrove swamps”

Linguistic tests (2/3)

Step 2

2. Embed items in the slot of the template to form a candidate sentence

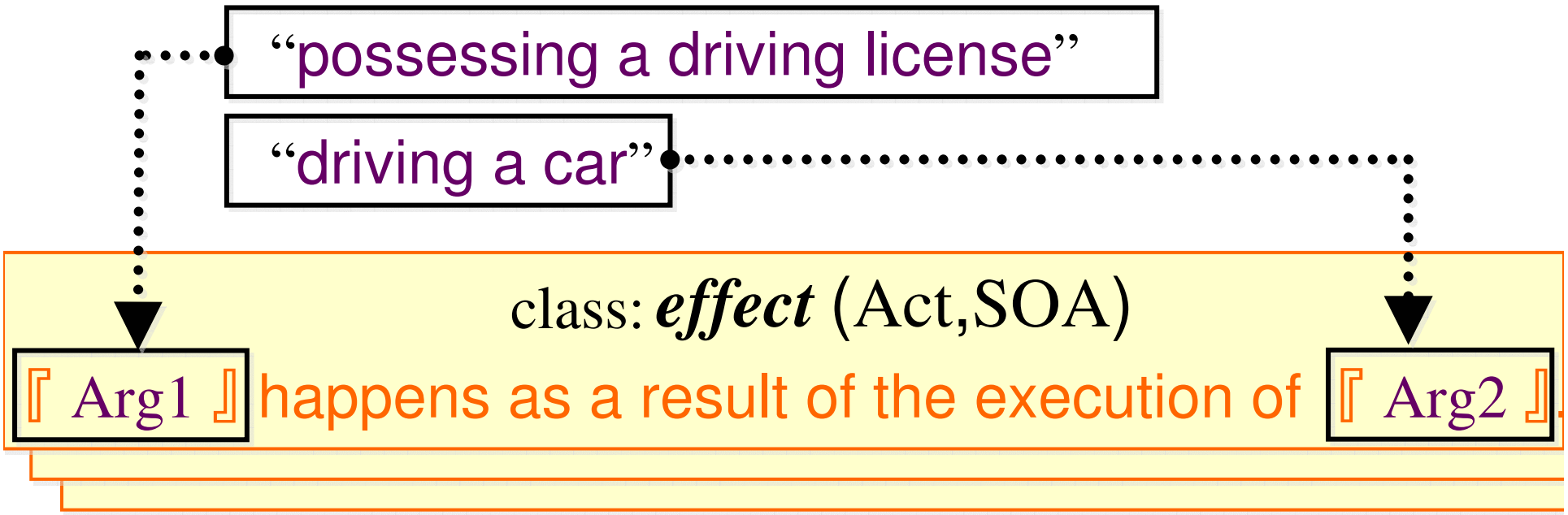


3. If the candidate sentence has the correct meaning, we identify the relation as belonging the class (***effect***)

○

Linguistic tests (3/3)

Step 2



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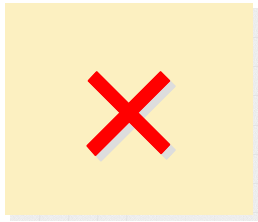
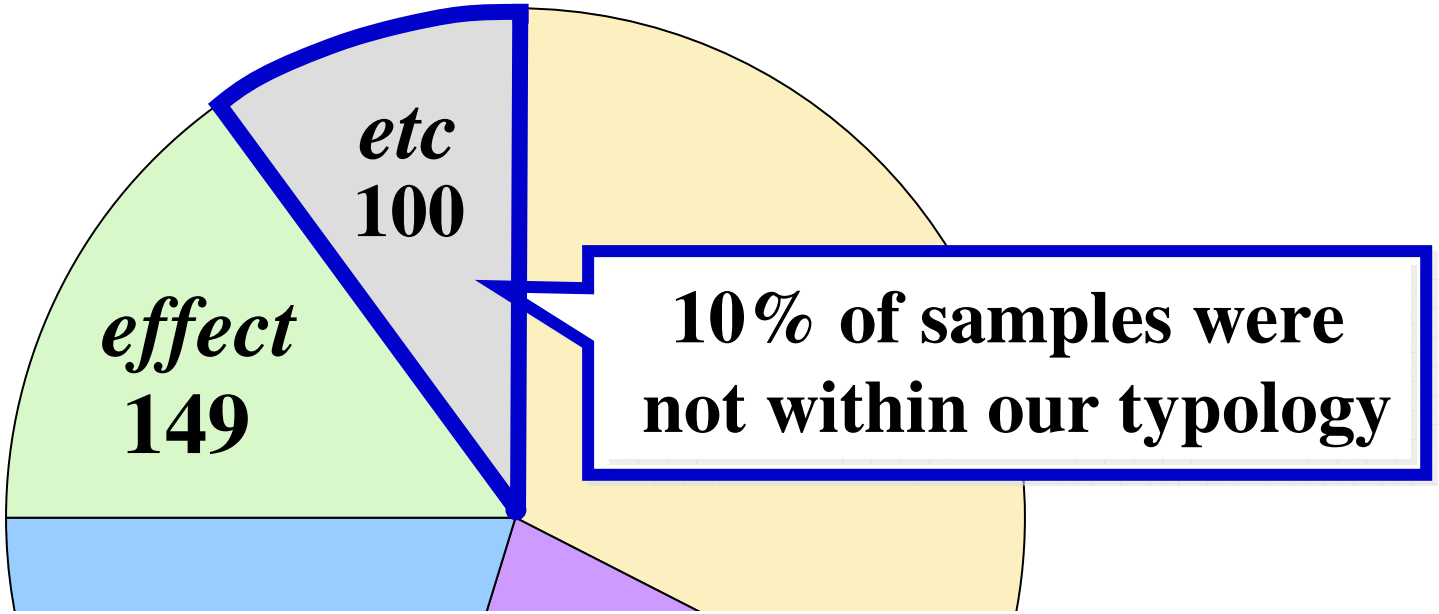


Results

Step 2



【Ex.】

hard disk-wo *kairyousuru-**tame***

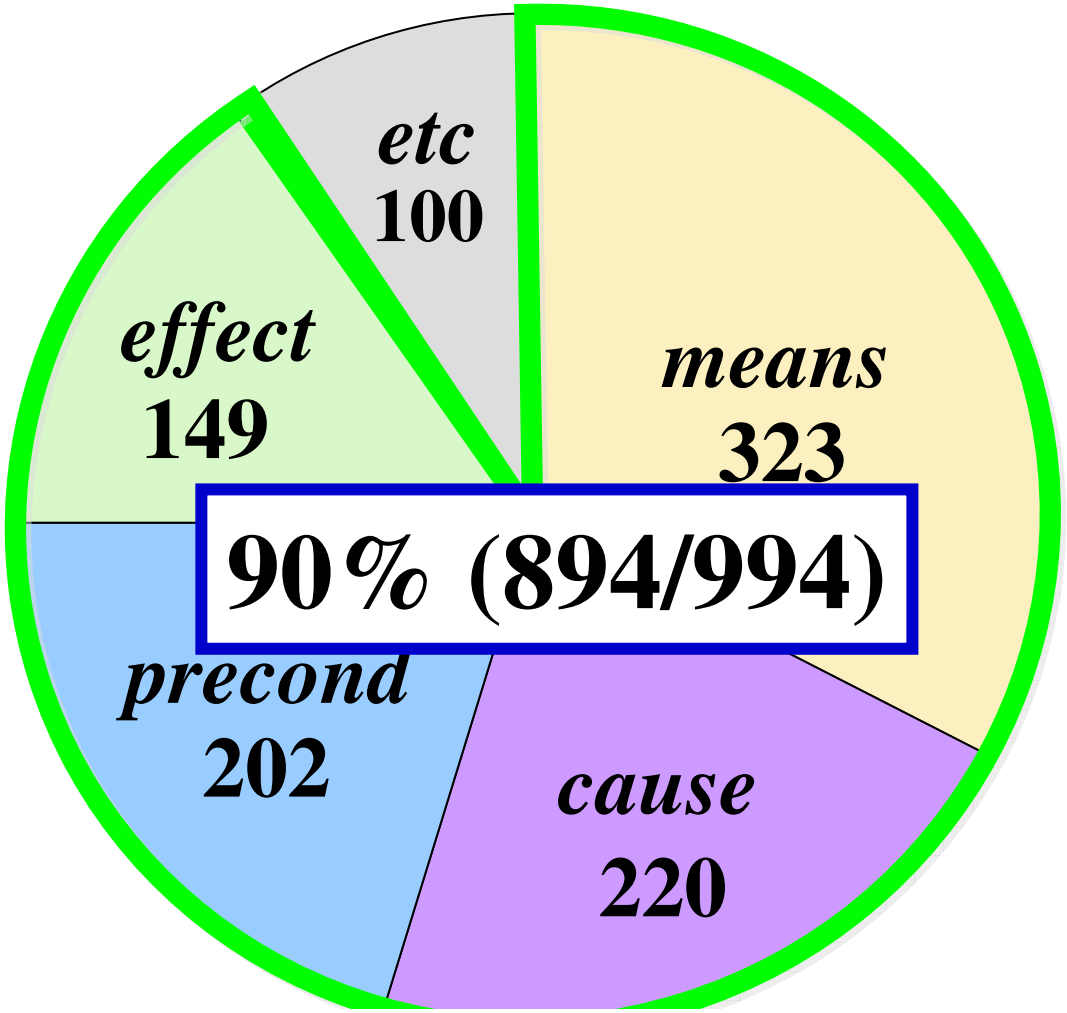
hard disk-ACC improve- ***tame***

kaihatsu kyousou-ga *gekikasuru*

development competition-NOM intensify

Results

Step 2



- Each type of causal relation appeared with relatively similar frequency

Procedure

Step 1 Select markers.

We used "tame"

Step 2 Evaluate marker's effectiveness.

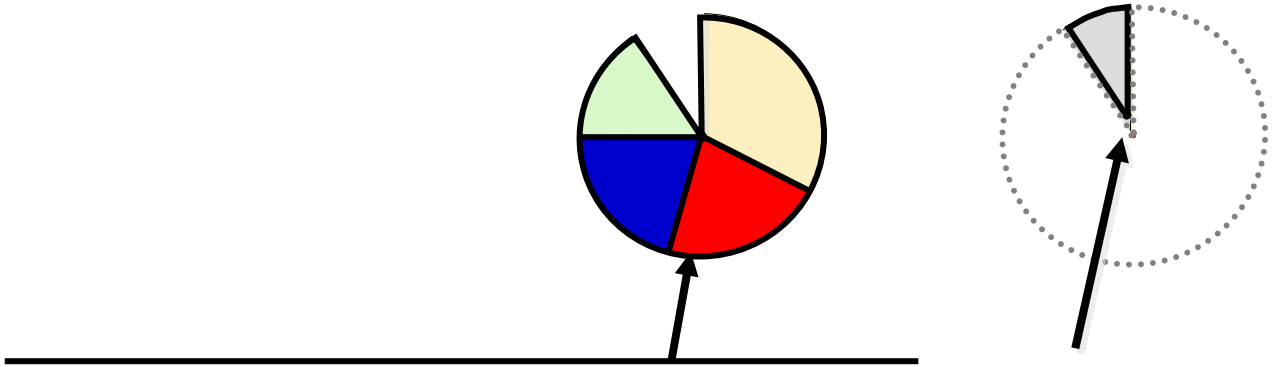
applicable of 90% of samples

Step 3 Identify the causal relations automatically.

Step 3

Step 3

- Identify the causal relations automatically
  - Experiment using a machine learning approach



  - Setting
    - 5 classes: ***cause, effect, precond, means*** and ***etc***
    - SVMs / One vs. Rest method was applied
    - Features

Features

Step 3

class		descriptions
Verb	EDR	Four conc
	ALT-J/E	A se dicti
	Goi-Taikei	Verl
Case	Marker	*"ga*
	Element	The
Modality	**Tense**	*"-ru*
	Aspect	*"-te*
	Voice	*"-re*
	Potential	*"-de*
	Negative	*"-n*
Subject		Whe
Event type		Agent's volitional action or non-volitional state of affairs

Verb = [go: transitive, ・・]

I went to a ticket office.

Tense = [past]

Event type = [Act]

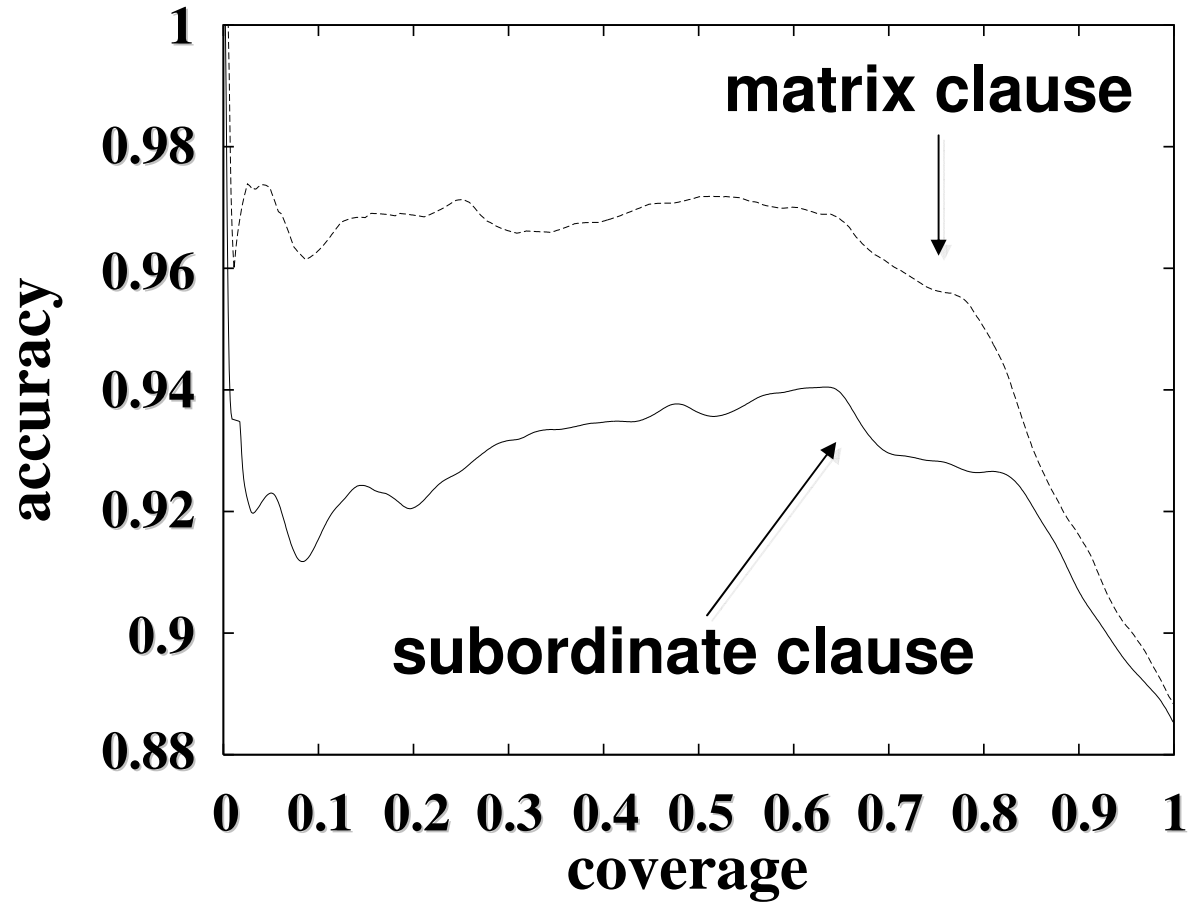
Features: (Event type estimation) Step 3

- Act: agent's volitional action
- SOA: non-volitional state of affairs
- Create

Causal_rel(arg1, arg2)
cause (SOA, SOA)
effect (Act, SOA)
precond (SOA, Act)
means (Act, Act)

necessary condit

Event ty



Step 3

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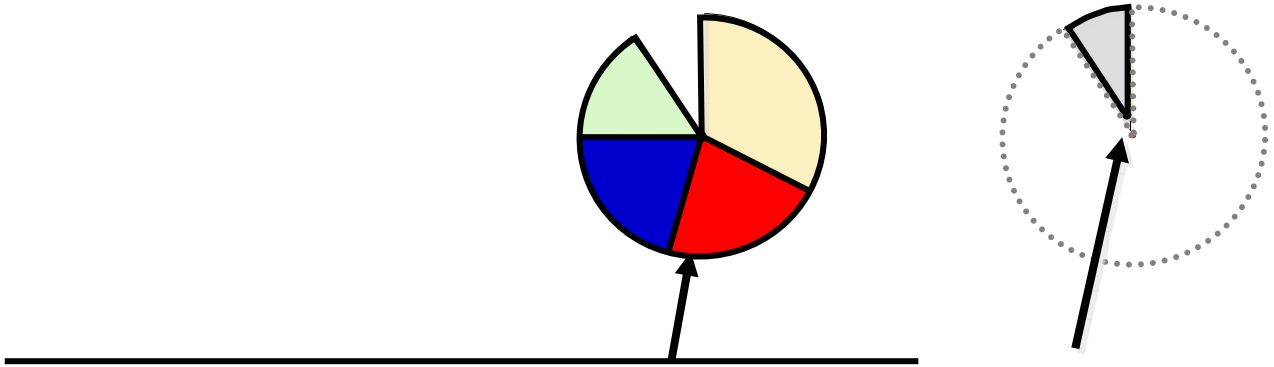
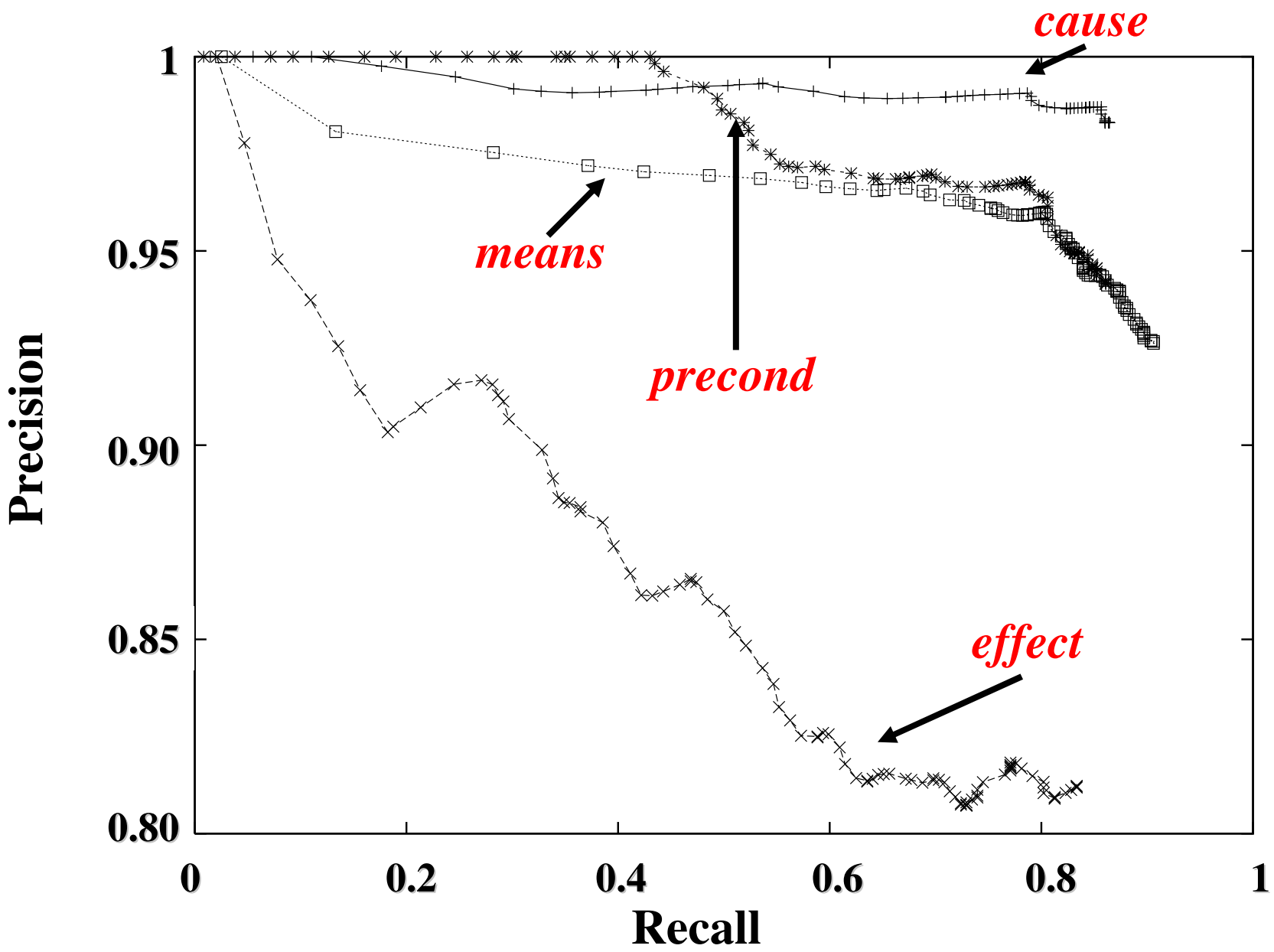


  - Setting
    - 5 classes: ***cause, effect, precond, means*** and ***etc***
    - SVMs / One vs. Rest method was applied
    - Features
    - Training: about 1000 sentences
    - Evaluation: about 1000 new sentences

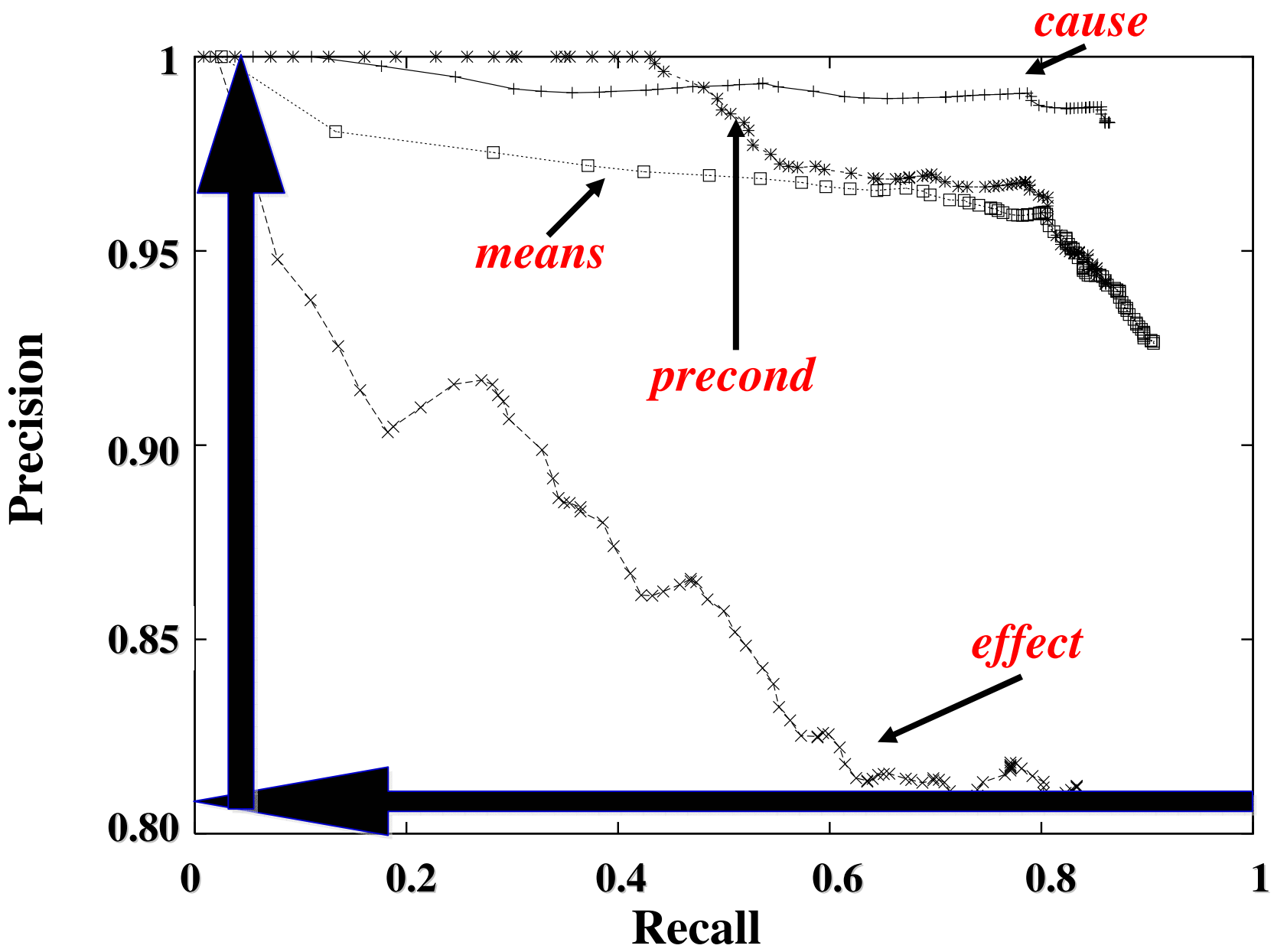
Results

Step 3



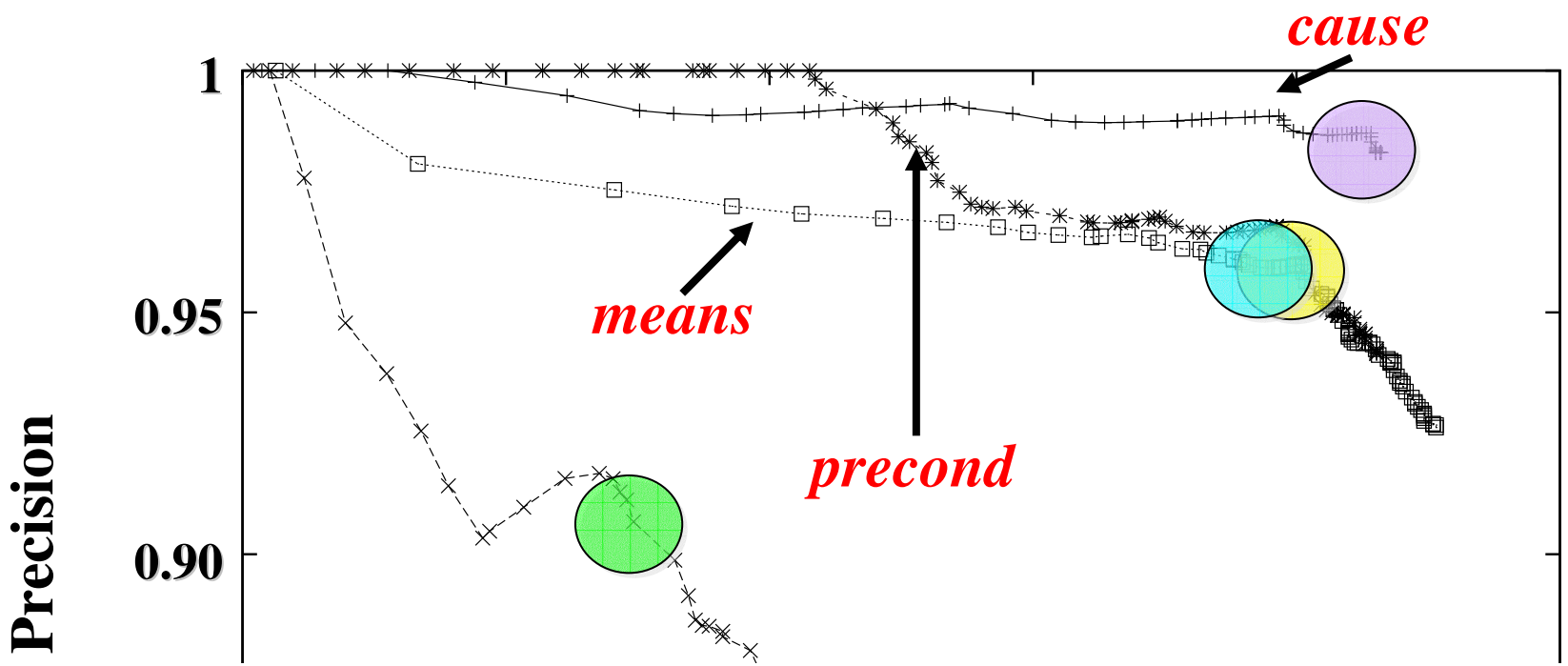
Results

Step 3



Results

Step 3



We expect to be able to acquire over 27,000 causal relation instances from one year of newspaper articles (i.e. 1.8% of all sentences).

Procedure

Step 1 Select markers. ***We used "tame"***

Step 2 Evaluate marker's effectiveness.

applicable to 90% of samples

Step 3 Identify the causal relations automatically.

Accuracy was sufficiently high

Examples of causal relation instances

cause ({temperature stays high},
{coat sales are down})

precond ({house becomes cramped},
{someone moves into a larger house})

means ({someone undertakes intensive highway},
{someone reduces the number of crashes})

Examples of causal relation instances

- Abstraction
- Ellipsis & pronoun resolution

cause ({the weather has been bad recently},
{the plan is 5 days behind schedule})

organization

numerical value

location

precond ({JBM is continuing its move into Asia},
{(ϕ) decides to produce it there})

ellipsis

pronoun

Conclusion

- We study automatic knowledge acquisition of causal relations from document collections.

Findings

Procedure

Step 1 Select markers. *we used "tame"*

Step 2 Evaluate marker's effectiveness.

applicable to 90% of samples

Step 3 Identify the causal relations automatically.

accuracy was sufficiently high

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Future work

Examples of causal relation instances

- Abstraction
- Ellipsis & pronoun resolution

cause ({the weather has been bad recently},
{the plan is 5 days behind schedule})

organization | numerical value | location

precond ({JBM is continuing its move into Asia},
{(ϕ) decides to produce it there})

ellipsis | pronoun

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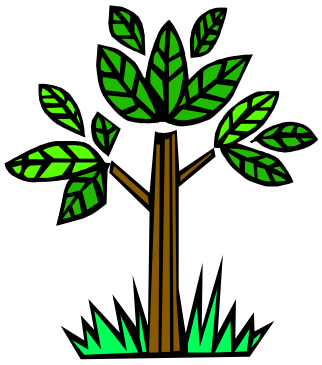
References

- [Allen1995] J. F. Allen. *Natural Language Understanding*. The Benjamin/Cummings Publishing. 1995.

- [Lenat1995] D. Lenat. Cyc: A large-scale investment in knowledge infrastructure. *Communications of the ACM*, 38(11), 1995.

- [Stork1999] D. G. Stork. Character and document research in the open mind initiative. In *Proc. of international conference on Document Analysis and Recognition*, 1999.