Syntactic vs. Semantic Knowledge for Supervised Learning of Textual Entailment Recognition

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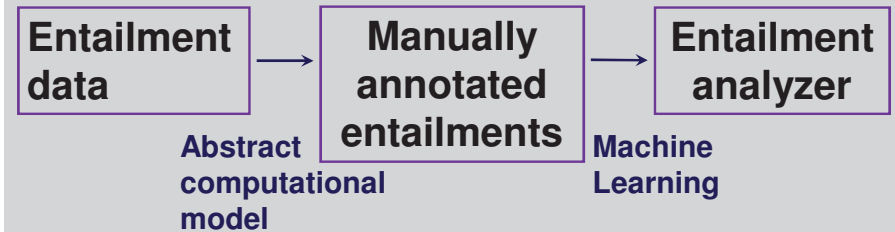
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Entailment

Partial order on well-formed sentences

Translation and Paraphrasing = ~ bi-entailment

General question:

Can entailment be automatically acquired using methodologies familiar from acquisition of stochastic parsers?

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Desired situation

Entailment data → Manually annotated entailments → Entailment analyzer

Abstract computational model

Machine Learning

In the absence of general model:

- **Not much annotated data**

- **Little understanding of modularity in entailment systems**

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Simplified Models?

Grammaticality

- **Constituency**

- **Dependency**
  agreement, extraction, subcategorization etc.

Entailment
**No simplified semantic model.
In full generality, perhaps close to Turing test.**

➔ **Rely on simplified models, simplified data, or both.**

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Two general approaches

Restricted Model and Annotation	(and/or)	Selecting Special Entailments

For phenomena that are:
- **Useful for many RTE systems**
- **Surface level**

For sparser and non-surface phenomena that reveal limitations of current engines

Aim: improving evaluation, modularity, and ultimately learnability

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Analyzing entailments

Question:
How can current entailment data be best analyzed to improve system evaluation and modularity?

Suggested approach:
Analyze those phenomena that are:
- Common in RTE data
- Commonly used (w or w/o analysis) by current engines
- Easiest to analyze on the surface

Joint work with:
Utrecht: Sophia Katrenko, Assaf Toledo, Stavroula Alexandropulou, Heidi Klockmann
Bar Ilan: Ido Dagan, Ahser Stern, Amnon Lotan

Two general approaches

Restricted Model and Annotation	(and/or)	Selecting Special Entailments

Focus of this talk

Work in progress with Danilo Giampiccollo, Emanuele Pianta a.o. (CELCT, Trento)

Entailment analysis

Entailment is analyzed as made up of small pieces of local **semantic relations**.

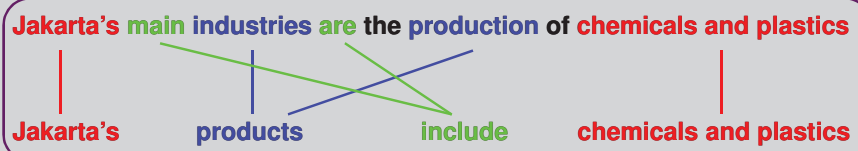Analyzing entailments consists of aligning and classifying elements of these relations in text and hypothesis.

Distinguish between:
Lexical relations
Structural relations

Lexical relations - example

Jakarta's main industries are the production of chemicals and plastics

Jakarta's   **products**   **include**   **chemicals and plastics**

- identity

  Lexical relations:
- X's main Y's are Z ➔ X's Y's include Z
- X's industries are the production of Y ➔ X's products are Y

> Common in RTE, but data are **sparse.**
> ➔ Concentrate on **structural relations.**

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Structural relations – example

Senator Hill and Foreign Affairs Minister Alexander Downer will host the 20th annual AUSMIN (Australia-United States ministerial consultations) conference at the Adelaide Town Hall
➔ **Alexander Downer will host a conference**

- **Conjunction:**
  Senator Hill and Foreign Affairs Minister Alexander Downer
  ➔ Foreign Affairs Minister Alexander Downer
- **Apposition/Restrictive adjunct:**
  Foreign Affairs Minister Alexander Downer
  ➔ Alexander Downer
- **Definite/indefinite entailment:**
  the [20th annual AUSMIN (Australia-United States ministerial consultations) conference at the Adelaide Town Hall]
  ➔ **a** [20th annual AUSMIN (Australia-United States ministerial consultations) conference at the Adelaide Town Hall]
- **Restrictive adjuncts:**
  [[20th annual AUSMIN (Australia-United States ministerial consultations)] conference **[at the Adelaide Town Hall]**]
  ➔ **[20th annual AUSMIN (Australia-United States ministerial consultations)]** conference
  ➔ conference

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Semantics of adjuncts: Restriction vs. Apposition

ADJ X:

Restriction: ADJ X is subsumed by X

Apposition: ADJ is predicated over X

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Restriction – Semantics

Restrictive adjunct:

An adjunct ADJ is *restricitive* iff for every grammatical constituent ADJ X:
$$\text{ADJ } X \leq X.$$

Intersective adjunct:

An restrictive adjunct ADJ is furthermore *intersective* iff ADJ is based on Y, s.t for every grammatical constituent ADJ X:
$$\text{ADJ } X = Y \wedge X.$$

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Restriction – Examples

Restriction supports adjunct omission in MON↑ environments:

John is a **tall** man ➜ John is a man

John ran **quickly** ➜ John ran

John is a man **who runs** ➜ John is a man

John is tall **and thin** ➜ John is tall

Intersection – Examples

Intersection – modifee omission in MON↑ environments <u>plus adjunct change</u>:

John is a **tall** man ➜ John is **tall**

John ran **quickly** ➜ There was a **quick running** (by John)

John is a man **who runs** ➜ John **runs**

John is tall **and thin** ➜ John is **thin**

This kind of omission appears in RTE data, but not often:
**Iran will soon release eight British servicemen detained along with three vessels
➜ British servicemen** (were) **detained**

Apposition – Semantics

Appositive adjunct:

An adjunct ADJ is **appositive** iff for every grammatical constituent ADJ X:
ADJ is predicated of X.

Apposition – Examples (1)

Adjunct omission (in all environments):

Prof. Smith ran ➜ Smith ran

Nobody likes **Prof.** Smith ➜ Nobody likes Smith

John, **who is a/the teacher,** ran ➜ John ran

John, **a/the teacher,** ran ➜ John ran

Apposition – Examples (2)

Predication:

Prof. Smith ran ➔ Smith is a Prof.

Nobody likes **Prof.** Smith ➔ Smith is a Prof.

John, **who is a/the teacher,** ran ➔ John is a/the teacher

John, **a/the teacher,** ran ➔ John is a/the teacher

Set F and its annotation

- **Appositions**
- **Titles**
- **Conjunctions**
- **Relatives**
- **Other adjuncts**

> **early** a restrictive modifier of **Thursday**, but this does not contribute to entailment

When to annotate? Only when phenomenon contributes to entailment.

Only a week after it had no comment on upping the storage capacity of its Hotmail e-mail service, Microsoft **early Thursday** announced it was boosting the allowance to 250MB to follow similar moves by rivals such as Google, Yahoo, and Lycos.
➔ Microsoft's Hotmail has raised its storage capacity to 250MB.

Structural annotation guidelines

1. **Read the Hypothesis**
2. **Read the Text and verify the entailment**
3. **Describe informally (in text) why the entailment holds**
4. **Annotate each phenomenon occurrence _f_ from _set F such that f_ is used in inference**

The two surface-level phenomena

Omission of adjunct

ADJ X ➔ X',
where X➔X'
(X' may or may not equal X)

Restrictive adjuncts
Appositives
Conjunctions
(inc. Relatives)

Predication using modifier

ADJ X ➔ X' is ADJ,
where X⬅➔X'
(X' may or may not equal X)

Intersective adjuncts
Appositives
(inc. Relatives)

Restrictive adjunct omission – modifiers

ADJ X ➔ Y, where X➔Y (X may or may not equal Y)

These <u>early</u> men learned to make fire. They traveled over land bridges from Africa, and began to populate the world, about 1 million years ago.
➔ **Humans existed 10,000 years ago.**

Tropical Storm Debby is blamed for several deaths <u>across the Caribbean</u>.
➔ A tropical storm has caused loss of life.

A joint venture led by Australia's Global Petroleum Ltd. said, yesterday, it had won the right to explore for oil and gas <u>in the inhospitable waters south and east of the Falkland Islands.</u>
➔ Petroleum will be explored in the South Atlantic.

Guggenheim Museum, officially Solomon R. Guggenheim Museum, was founded in 1939 <u>as the Museum of Non-Objective Art</u>.
➔ The Solomon R. Guggenheim Museum was opened in 1939.

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Restrictive adjunct omission – conjuncts

ADJ X ➔ Y, where X➔Y (X may or may not equal Y)

Some plants grow really well in a hydroponic environment, **<u>but others do not</u>**.
➔ Plants are grown in water or in substances other than soil.

The ivory ban has been successful. **<u>Demand for ivory has dropped and</u>** elephant populations expanded dramatically in areas where they were virtually extinct.
➔ The ban on ivory trade has been effective in protecting the elephant from extinction.

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Appositive adjunct omission

ADJ X ➔ Y, where X➔Y (X may or may not equal Y)

Brought under Ottoman rule in the 16th century, Jordan has been led only since the 1920s by <u>Hashemite rulers</u>, **a family whose roots are in present-day Saudi Arabia**.
➔ <u>**The Hashemite dynasty**</u> rules Jordan.

German automaker, <u>Volkswagen AG,</u> launched a special collector's edition of its original Beetle, on Thursday, to mark the end of the line for the most popular car in history.
➔ <u>**Volkswagen AG**</u> produces the 'Beetle'.

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Appositive adjunct – predication

ADJ X ➔ X' is ADJ, where X⬅➔X'
(X' may or may not equal X)

Muslim fundamentalists such as <u>**the Islamic Resistance Movement, also known as Hamas**</u>, and the smaller Islamic Jihad are determined to torpedo the peace process.
➔ <u>**The Islamic Resistance Movement is also known as Hamas**</u>.

<u>**The two young leaders of the coup, Pibul Songgram and Pridi Phanomyang**</u>, both educated in Europe and influenced by Western ideas, came to dominate Thai politics in the ensuing years.
➔ <u>**Pibul was a young leader.**</u> (*also Conjunction and Adjunct Omission*)

In a move reminiscent for some of another actor, <u>**Ronald Reagan, who was twice elected governor of California**</u>, Schwarzenegger said he would be putting his movie career on hold so he can devote his time to running for governor.
➔ <u>**Ronald Regan was elected governor of California.**</u> (*also Adjunct Omission*)

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Annotation so far

Development sets RTE1 and RTE2:

- **683** positive examples of entailments

- **524 (76.7%)** of which were annotated with the following phenomena:
  - Appositions: 195   (17.5%)
  - Conjunctions: 141   (12.5%)
  - Relatives: 290   (26%)
  - Other adjuncts: 487   (44%)

- **Total:**   **1113** annotations

Test cross-annotator agreement

50 positive entailments:
- **2 disagreements** on whether to annotate or not

93 annotations:
  - 62 identical
  - 31 no full agreement:
    - 9 ambiguities
    - **2 major mistakes**
    - 10 minor mistakes
    - 10 problems in scheme

Annotation next step

More fine-grained indication of inferential steps with restrictive and appositive adjuncts.

Further work in progress

Evaluating application of entailment rules in BIU entailment system using annotated corpus.

Learning entailment analysis automatically from annotation.

Extending annotation scheme.

Corpus of special temporal and numerical entailments.