

## Class 11: Anaphora and co-reference resolution

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# Things and naming things

# What is co-reference resolution?

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May confessed to Patel that although having secret meetings with the Israelis was a sackable offence, it paled in comparison to her own dire performance but “sadly nobody’s willing to pull the trigger.”

Patel said: “It was so awkward. She said ‘You don’t know how often I’ve dreamt of sitting on your side of the desk, finally being summarily dismissed for my gross incompetence.’

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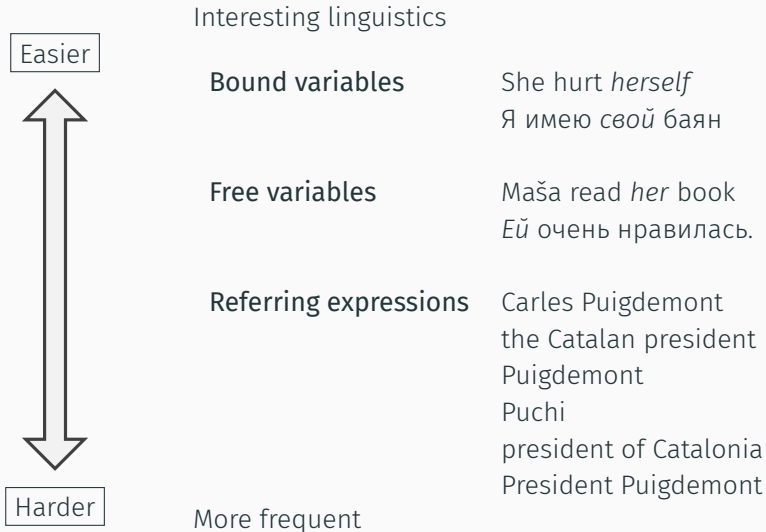
# Noun phrases and reference

- NPs usually refer to entities in the world
- NPs may co-refer, meaning they refer to the same entity
- They may also be nested or discontinuous

Однажды **Пушкин** написал письмо **Рабиндранату Тагору**.  
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толкала, толкала, письмо подсовывала — не видит. **Он**, правда,  
по-русски читать не умел. Так и не познакомились.



# Kinds of reference



# Coreference, anaphora, cataphora

- **Coreference**
  - Two *mentions* (NPs) refer to the same entity
  - May be identical or completely different
- **Anaphora, Cataphora**
  - Interpretation is in some way dependent on an antecedent
  - Traditionally the antecedent came first, but not always the case.

# Cataphora

(Oscar Wilde – The Picture of Dorian Grey)

## Other types of anaphora

- Bridging Anaphora:
- "Other" Anaphora:
- Non-NP Anaphora (e.g. events, propositions)

# Anaphora vs. coreference

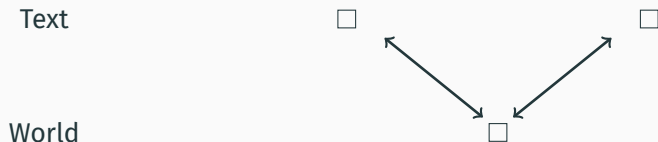
- Not all anaphoric relations are coreferential, e.g. bridging anaphora
- Multiple identical NP matches are often coreferential but not anaphoric

# Two different things

## Anaphora resolution



## Co-reference resolution



## Machine translation:

- Translating pronouns like *себя* — myself, yourself, herself, ...
- Translating from languages with no gender distinction in pronouns *hän* — он, она

## Text summarisation:

- [Maša]<sub>i</sub> read [Wikipedia]<sub>j</sub> with unbridled enthusiasm. [She]<sub>i</sub> spent so long reading [it]<sub>j</sub> that [she]<sub>i</sub> forget about her homework.  
→ Maša read Wikipedia and forgot about her homework.

## Information extraction:

- What did Maša do ?
  - read Wikipedia
  - forgot about her homework

# Pronominal anaphora resolution

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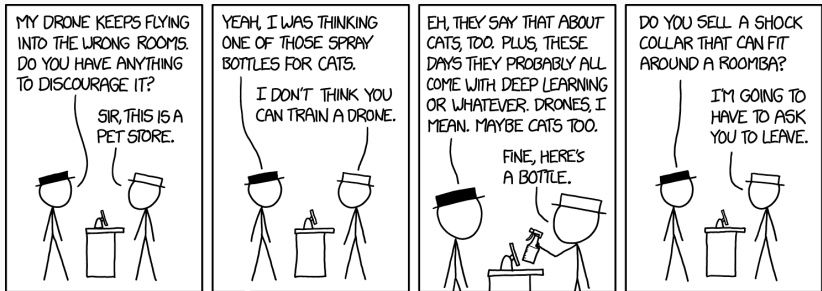


# Hobbs' (1978) algorithm/1

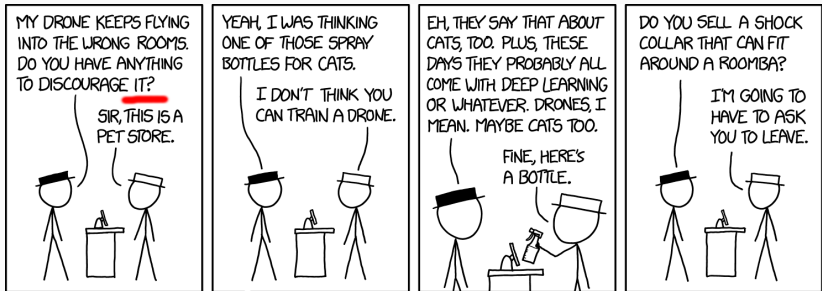
- Simple syntax-based algorithm for 3rd person anaphoric pronouns
- Requires:
  - Constituency parser
  - Gender and number 'checker'
    - Parsers for English rarely include gender information for nouns
- Searches current and preceding sentences in a breadth-first, left-to-right manner, stops when it finds a matching NP

- Right to left search in current sentence
- If not valid antecedent fine, try previous sentence
  - Left to right breadth-first search

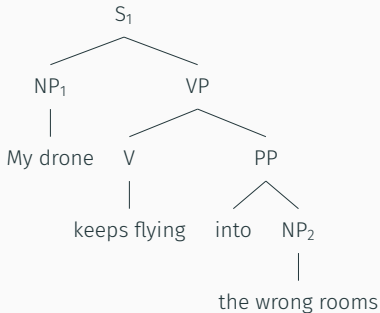
# Hobbs' (1978) algorithm/3



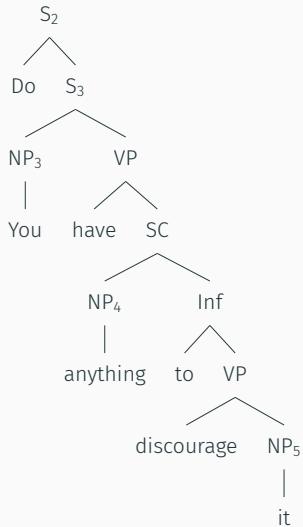
# Hobbs' (1978) algorithm/3



## Hobbs' (1978) algorithm/4



- Start search in NP<sub>5</sub> in S<sub>2</sub>
- Reject NP<sub>4</sub>, no intervening NP
- Reject NP<sub>3</sub>, feature mismatch
- Move to S<sub>1</sub>
- Accept NP<sub>1</sub>



- Supervised machine learning approach
- Requires corpus where each pronoun has been linked with its antecedent
- Extract positive and negative examples
- Train binary classifier
  - True: is co-referent
  - False: is not co-referent

Let's take our previous example:

Positive example:

- (it, my drone)

Negative examples:

- (it, anything)
- (it, you)
- (it, the wrong rooms)



- **strict gender** [true, false]
- **compatible gender** [true, false]
- **strict number** [true, false]
- **compatible number** [true, false]
- **sentence distance** [0, 1, 2, ...]
- **Hobbs distance** [0, 1, 2, ...]
- **grammatical role** [subject, object, ...]
- **linguistic form** [proper, def, indef, pronoun]

Can you think of some other useful features ?

- For each pronoun,
  - For each NP we have seen so far,
    - Classify if NP is an antecedent of the pronoun

# Co-reference resolution

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# Reference models

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Пушкин, он<sub>1</sub>, я<sub>1</sub>, меня<sub>1</sub>

Рабиндранату Тагору, Дорогой далекий друг, Вас<sub>1</sub>, Вы<sub>1</sub>, Тагор, его<sub>1</sub>, Он



## Additional features

Input is a dependency tree.

Constraint-based, rules like:

$C = \langle ANA, ANT, DIST, PROP \rangle$

- ANA, ANT = constraints on the anaphor and antecedent
- DIR = direction (e.g. forward, backwards)
- DIST = how far to look (in sentences)
- PROP = should features (e.g. gender) be propagated?



Example rules:

# Evaluation

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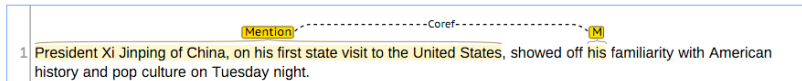
# Model-Theoretic coreference scoring

- B<sup>3</sup> scoring
- CEAF

## Tools and resources

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## Coreference:



<https://stanfordnlp.github.io/CoreNLP/index.html>

- includes coreference for English + Chinese
- rule-based, statistical and neural models
- based on Java
- very “heavy” (> 1G for code + model)



## eXternally configurable REference and Non Named Entity Recogniser

<https://github.com/amir-zeldes/xrenner>

- based on Python
- Rule-based (constraints)
- Functioning model for English
- (relatively) small footprint (< 100M)

## Shared tasks

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Two tracks:

- Pronominal anaphora resolution (8 teams)
  - personal, possessive, relative and reflexive pronouns
  - antecedent should be in the gold-standard coreference chain
- Co-reference resolution (3 teams)

# Practical

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For the practical, select a short paragraph or document and write some coreference rules using Xrenner.

Further instructions:

<https://ftyers.github.io/028-komp-ling/classes/11.html>