## Resolving Direct and Indirect Anaphora for Japanese Definite Noun Phrases

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#### Anaphora resolution

Identifying the referent of a referring expression

<u>A new minivan</u> was released. <u>The vehicle</u> has a yellow body.

- Important process in NLP applications such as Information Retrieval and Machine Translation
- We deal with an anaphor which is definite NP:
  - kono (this) + NP, sono (the) + NP, ano (that) + NP

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![](_page_3_Figure_2.jpeg)

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- We deal with an anaphor which is definite NP:
  - kono (this) + NP, sono (the) + NP, ano (that) + NP

#### Three anaphora types

![](_page_4_Figure_1.jpeg)

• In anaphora resolution, it is necessary to classify anaphora type as well as identifying an antecedent

![](_page_5_Figure_0.jpeg)

![](_page_5_Figure_1.jpeg)

A

B

C

- <u>A new CD</u> was released. He purchased <u>the CD</u>.
- The artist announced <u>her new song</u>. He purchased <u>the CD</u>.

#### I fell in love on that day.

- Anaphora type depends on the preceding context
- In anaphora resolution, it is necessary to classify anaphora type as well as identifying an antecedent

![](_page_6_Figure_0.jpeg)

![](_page_6_Figure_1.jpeg)

#### I fell in love on that day.

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#### Three anaphora types

![](_page_7_Figure_1.jpeg)

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- Antecedent Selection (AS)
  - Identify an antecedent for given anaphor
- Anaphora Type Classification (ATC)
  - Classify given anaphor into direct anaphora, indirect anaphora or exophora

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![](_page_9_Figure_5.jpeg)

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![](_page_10_Figure_5.jpeg)

#### Related Work

- Antecedent selection (direct anaphora)
  - NP coreference resolution has been studied intensively though the evaluation-oriented tasks (Soon et al., 2001; Ng, 2002; Yang et al., 2003; Bean et al. 2004)
- Antecedent selection (indirect anaphora)
  - Bridging Reference (Clark, 1977)
  - Resolving Mereological BDs (Poesio et al, 2004)
- Anaphora type classification
  - Definite Description Classification (Vieira, 2000)

#### Our research

In a learning-based anaphora resolution model, how can the two subtasks, antecedent selection and anaphora type classification, be best configured? (e.g. which task should be carried out before)

• Bridging Reference (Clark, 1977)

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mun eet anapi

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![](_page_13_Figure_2.jpeg)

## Two approaches for antecedent selection

- Single Common Model Approach
  - Construct a single model which uses the information to identify an antecedent of both types
- Separate Model Approach
  - Construct two models; direct antecedent selection model (ASM) which uses the information to identify a direct-anaphoric antecedent, and indirect ASM which uses the information to identify an indirect-anaphoric antecedent

#### Single model and separate model

![](_page_15_Picture_1.jpeg)

of direct anaphora

![](_page_15_Figure_3.jpeg)

#### Single model and separate model

Training data of direct anaphora

![](_page_16_Picture_2.jpeg)

Training data of indirect anaphora

#### Single model and separate model

![](_page_17_Figure_1.jpeg)

![](_page_18_Figure_0.jpeg)

# Basic framework for AS: the tournament model

• Select the most likely antecedent by conducting one-on-one games in a step-ladder tournament (lida et al., 2004)

<u>Mariah Carey</u> came to <u>Japan</u>. <u>Her</u> <u>voice</u> attracted <u>many people</u> in <u>Japan</u>. <u>I</u> want to see <u>her</u>.

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![](_page_20_Figure_3.jpeg)

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![](_page_21_Figure_3.jpeg)

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![](_page_22_Figure_3.jpeg)

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  - Classify given anaphor into direct anaphora, indirect anaphora or exophora

![](_page_23_Figure_5.jpeg)

• Antecedent Selection (AS)

Identify an anteced Second, going with ... hor

• Anaphora Type Classification (ATC)

• Classify given anaphor into direct anaphora, indirect anaphora or exophora

![](_page_24_Figure_5.jpeg)

![](_page_25_Figure_0.jpeg)

## Possible five models in anaphora type classification Order of ATC

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Before

After

Order of ATC

Contextual Information Contextual Information

Classify-then-Select

Select-then-Classify

![](_page_28_Figure_0.jpeg)

**Classify-then-Select** 

Select-then-Classify

![](_page_29_Figure_0.jpeg)

Classify-then-Select model I. anaphor-Classify-then-Select (aC/S)

Anaphor

#### 2. candidate-Classify-then-Select (cC/S)

![](_page_31_Figure_0.jpeg)

2. candidate-Classify-then-Select (cC/S)

![](_page_32_Figure_0.jpeg)

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![](_page_33_Figure_0.jpeg)

![](_page_33_Figure_1.jpeg)

![](_page_34_Figure_0.jpeg)

![](_page_35_Figure_0.jpeg)

![](_page_36_Figure_0.jpeg)

![](_page_37_Picture_1.jpeg)

![](_page_38_Picture_1.jpeg)

![](_page_39_Figure_1.jpeg)

![](_page_40_Figure_1.jpeg)

![](_page_41_Figure_0.jpeg)

2. indrect-Select-then-Classify (iS/C)

Anaphor

3. parallel-Select-then-Classify (pS/C)

![](_page_41_Picture_4.jpeg)

![](_page_42_Figure_0.jpeg)

3. parallel-Select-then-Classify (pS/C)

![](_page_42_Picture_2.jpeg)

![](_page_43_Figure_0.jpeg)

	Anaphor	All candidates	Candidate selected by direct ASM	Candidate selected by indirect ASM
I.aC/S				
2. cC/S				
3. dS/C				
4. iS/C				
5. pS/C				

	Anaphor	All candidates	Candidate selected by direct ASM	Candidate selected by indirect ASM
I.aC/S	$\checkmark$			
2. cC/S				
3. dS/C				
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2. cC/S	$\checkmark$	$\checkmark$		
3. dS/C	$\checkmark$		$\checkmark$	
4. iS/C	$\checkmark$			$\checkmark$
5. pS/C				

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2. cC/S	$\checkmark$	$\checkmark$		
3. dS/C	$\checkmark$		$\checkmark$	
4. iS/C	$\checkmark$			$\checkmark$
5. pS/C	$\checkmark$		$\checkmark$	$\checkmark$

#### Review of the issues

- Issue I: The distinction of information in AS
  - Should separate models with different information be used for each anaphora type or can a single model effectively apply all available information?
- Issue 2: Encoding contextual information in ATC
  - How should the contextual information be encoded for anaphora type classification?

#### Experiments

- Annotated 1,698 instances in 869 broadcast articles of the NAIST Text Corpus (lida et al., 2007)
  - direct: 572 / indirect: 878 / exophora: 248
  - I0-fold cross-validation
  - Including verbal-predicate antecedents
- Three-way classification: one-versus-rest
- Binary classification: SVMs (Vapnik, 1995)
  - SVM<sup>light</sup> with a polynomial kernel of degree 2

#### Feature set for antecedent selection

- Lexical, syntactic, positional features
  - Head word, POS proper noun type, etc.
  - Case particle, Distance between an anaphor and its candidate, etc.
- Semantic relation features (for an anaphor and antecedent)
  - String match, Distributional similarity (direct ASM)
  - Dictionary-based synonym, hyponym detection (direct ASM)
  - Co-occurrence measure PMI, based on phrase patterns "A of B" or (NP (PRED X) Y) (indirect ASM)

#### Feature set

for anaphora type classification

- Classify-then-Select
  - Lexical, syntactic features of Anaphor
  - Existence of candidates of each anaphora type (Following Vieira et al. 2000's work)
    - String-matched candidate exists or not, etc.
- Select-then-Classify
  - Lexical, syntactic features of Anaphor
  - Information of selected antecedent
    - Use the same feature set as used ASM

#### Results of antecedent selection

	Single Model	Separate Model
Direct anaphora	63.3% (362/572)	65.4% (374/572)
Indirect anaphora	50.5% (443/878)	53.2% (467/878)
Overall	55.2% (801/1,450)	58.0% (841/1,450)

Separate Model achieved the best accuracy

 The information of direct and indirect-selection should be distinguished for each anaphora type (Answer to the issue I)

Madal	Classify-then-Select		Sele	Select-then-Cla		
Inodel	aC/S	cC/S	dS/C	iS/C	pS/C	
Accuracy	75.4%	73.6%	78.7%	74.6%	78.4%	

- The S/C model achieved the best accuracy
  - Selected candidate provides useful contextual information for ATC (Answer to the issue 2)
- The accuracy of the cC/S model is lower
  - The candidate information used in the previous literature (Vieira et al. 2000; etc) is not informative

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![](_page_55_Picture_4.jpeg)

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![](_page_57_Figure_2.jpeg)

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#### Results of overall anaphora resolution

Madal	Classify-then-Select		Select-then-Classify		
	aC/S	cC/S	dS/C	iS/C	pS/C
Accuracy	47.3%	46.3%	50.6%	46.3%	50.4%

• The dS/C model also outperformed the other models in overall anaphora resolution task

#### Error analysis of antecedent selection for direct anaphora Selected by our model

I don't know good knowledge of <u>movies</u>, but still know of <u>Frankenstein</u>. I think <u>this movie</u> is a great masterpiece.

- Confusion of semantic category (60%) Correct antecedent
  - A wrong candidate which belongs to the same semantic category as correct antecedent is likely to be chosen
  - It is necessary to recognize saliency and/or concept-instance use in addition to the semantic similarity

## Error analysis of antecedent selection for indirect anaphora

Mariah Carey came to Japan. Her

voice attracted many people in

- Japan. I want to hear the voice.
- Most of wrongly selected antecedents are not associated with the anaphor
- Additional evaluation with the feature of association measure disabled shows that 51.4 % of accuracy (No statistical difference from the original model)
- More useful linguistic knowledge is required to improve the performance

Selected by our model

![](_page_62_Figure_0.jpeg)

# Results of anaphora type classification for each type (F-measures)

	Direct anaphora	Indirect anaphora	Exophora
aC/S	70.9	83.7	48.9
cC/S	71.4	80.7	39.4
dS/C	77.1	84.4	55.7
iS/C	71.1	82.9	42.9
pS/C	76.1	84.3	57.2

• The identification of exophoric instances is more difficult than the others

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![](_page_65_Picture_0.jpeg)

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![](_page_67_Picture_0.jpeg)

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  - It's potentially difficult to judge the anaphora type of a temporal expression (often occurred as direct or indirect)

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  - Resolving the anaphor of a temporal expression is hard; the selection error provided wrong contextual information
  - It's potentially difficult to judge the anaphora type of a temporal expression (often occurred as *direct* or *indirect*)
  - It is required to recognize event-event relations specified by temporal expressions precisely

#### Conclusion

- Investigated the following two issues by decomposing anaphora resolution into antecedent selection (AS) and anaphora type classification (ATC)
- Issue I. The distinction of information in AS
  - The information effective for identifying an antecedent of each anaphora type should be incorporated separately
- Issue 2. Encoding contextual information in ATC
  - Selected candidate provides contextual information useful for classifying anaphora type

#### Future work

- Precise recognition of temporal expressions
  - Integrating temporal relation identification system
- Capturing saliency of discourse entity and/or recognizing concept-instance use
- Knowledge acquisition for indirect anaphora resolution