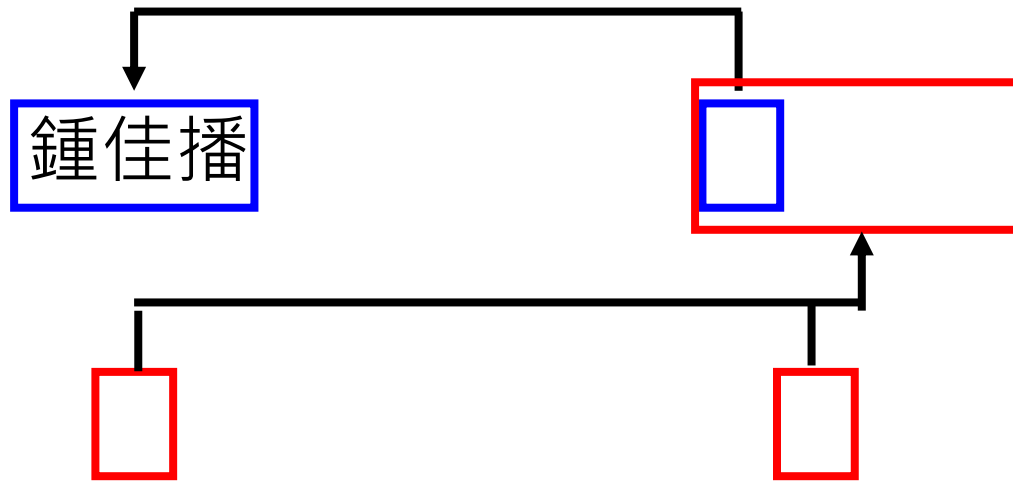


Coreference Resolution

Hung-yi Lee 李宏毅

	One Sequence	Multiple Sequences
One Class	Sentiment Classification Stance Detection Veracity Prediction Intent Classification Dialogue Policy	NLI Search Engine Relation Extraction
Class for each Token	POS tagging Word segmentation Extractive Summarization Slotting Filling NER	
Copy from Input		Extractive QA
General Sequence	Abstractive Summarization Translation Grammar Correction NLG	General QA Chatbot State Tracker Task Oriented Dialogue
Other?	Parsing, Coreference Resolution	

Coreference Resolution



Coreference Resolution

鍾佳播瞪著樂咖舉起他的拳頭說：

「它今天不搥倒高牆，它不放下」

Question: 甚麼東西會搥倒高牆？

Answer: 它

Coreference Resolution

鍾佳播

鍾佳播 瞪著樂咖舉起 的拳頭說：

「 今天不搥倒高牆， 不放下」

鍾佳播的拳頭

鍾佳播的拳頭

Question: 甚麼東西會搥倒高牆？

Answer: 鍾佳播的拳頭

Coreference Resolution

- Winograd Schema Challenge



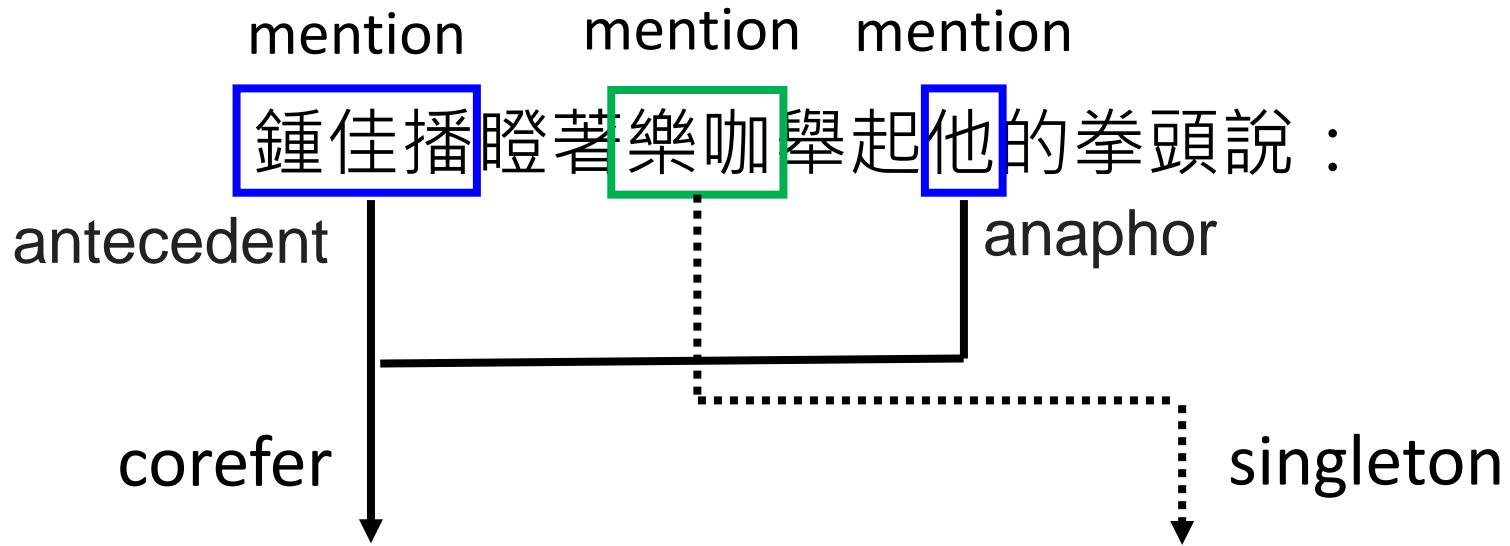
Terry Winograd



The **trophy** would not fit in the brown **suitcase** because **it** was too big. What was too big?

The **trophy** would not fit in the brown **suitcase** because **it** was too small. What was too small?

Coreference Resolution



Task Introduction

鍾佳播瞪著樂咖舉起他的拳頭說：

「它今天不搥倒高牆，它不放下」

Cluster 1: { 鍾佳播, 他 }

Cluster 2: { 他的拳頭, 它, 它 }

- All the mentions are labeled (sometimes singletons are ignored).
- The mentions are grouped into clusters.

Framework

- Step 1: Mention Detection

N tokens in a token sequence

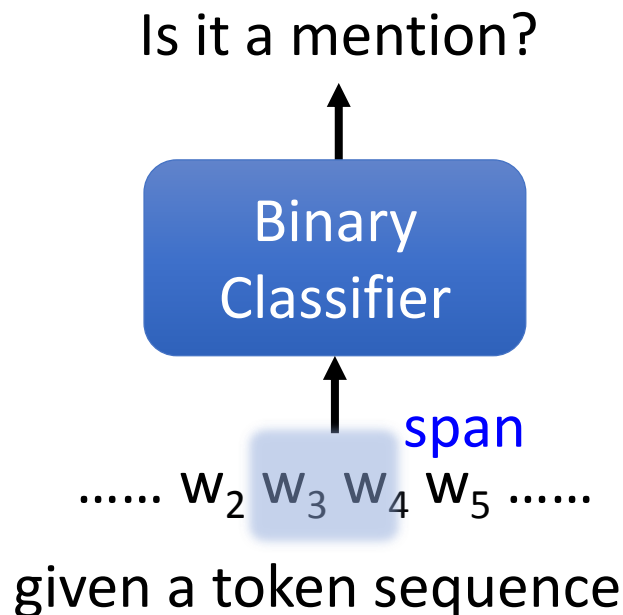
$N(N-1)/2$ possible spans

鍾佳播瞪著樂咖舉起他的拳頭

鍾佳播
樂咖
他
他的拳頭

v.s.

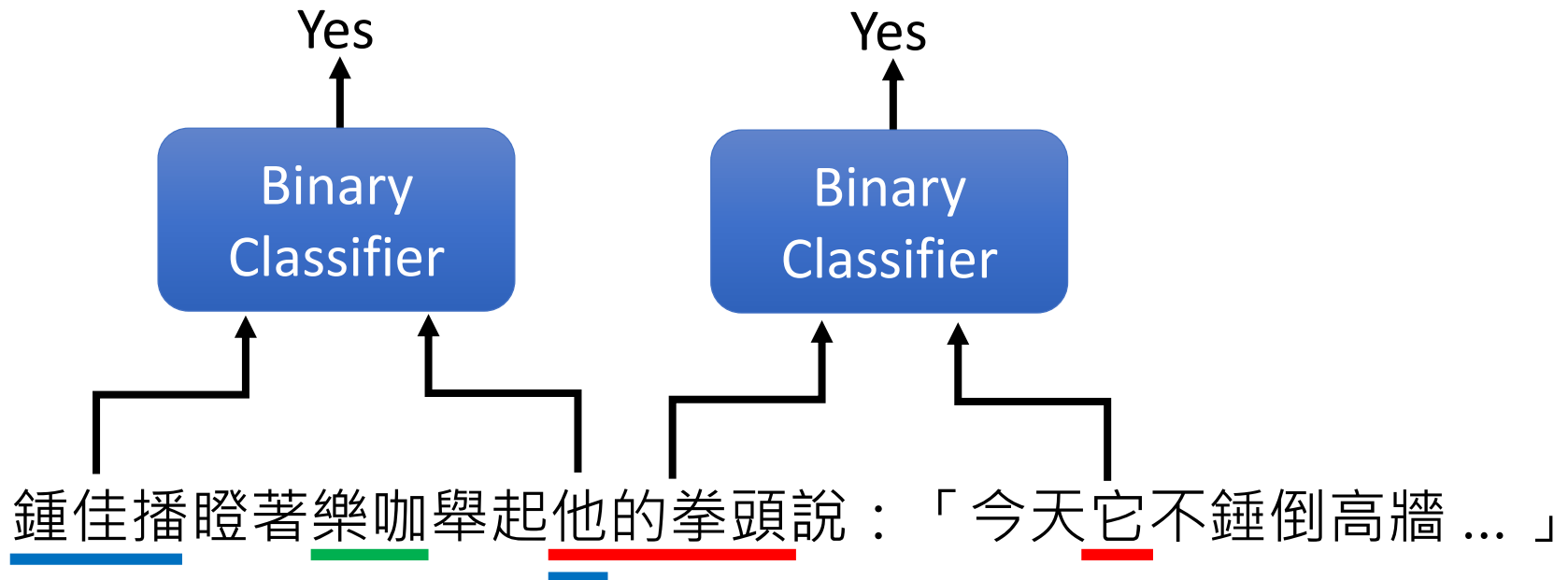
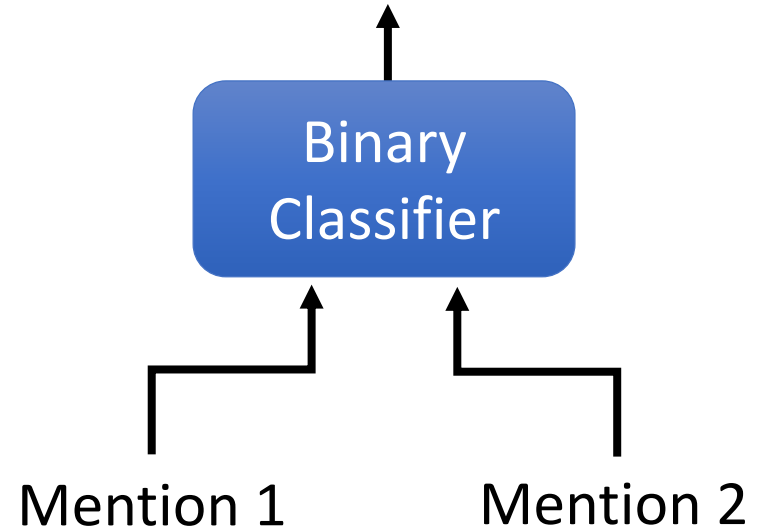
鍾
鍾佳
.....
播瞪著樂
.....
咖舉起他的



Do they refer to the same entity?

Framework

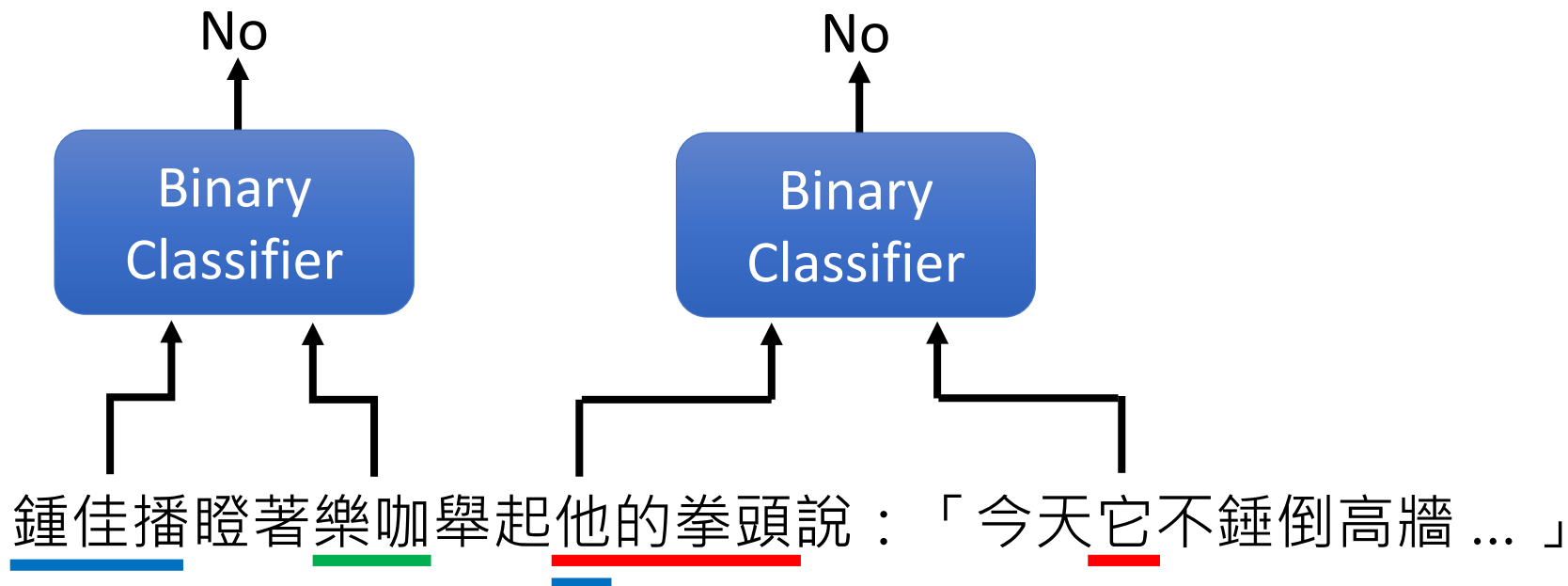
- Step 2: Mention Pair Detection



Framework

- Step 2: Mention Pair Detection

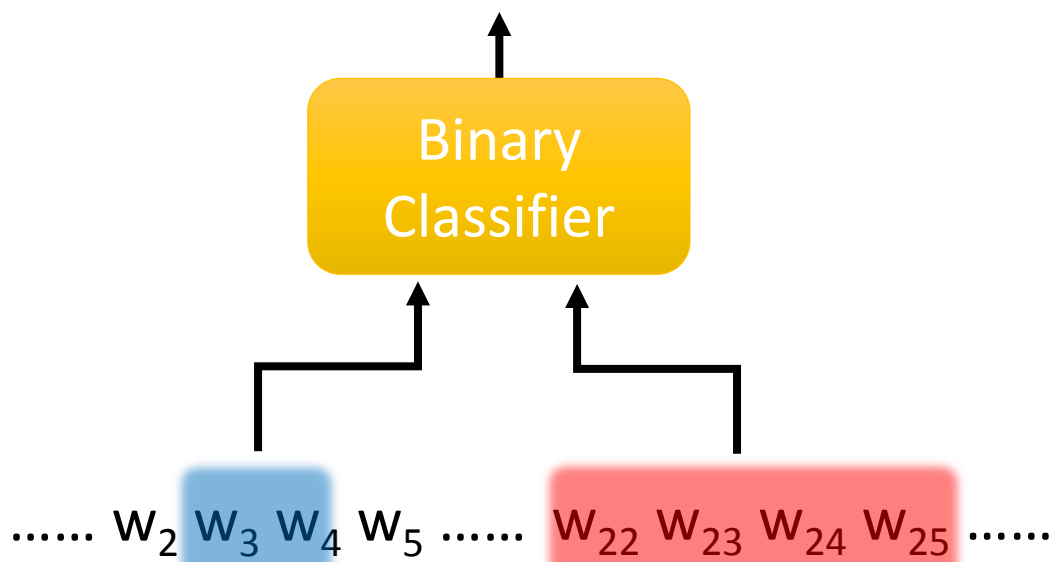
If there are K mentions, run the binary classifier $K(K-1)/2$ times.



End-to-end

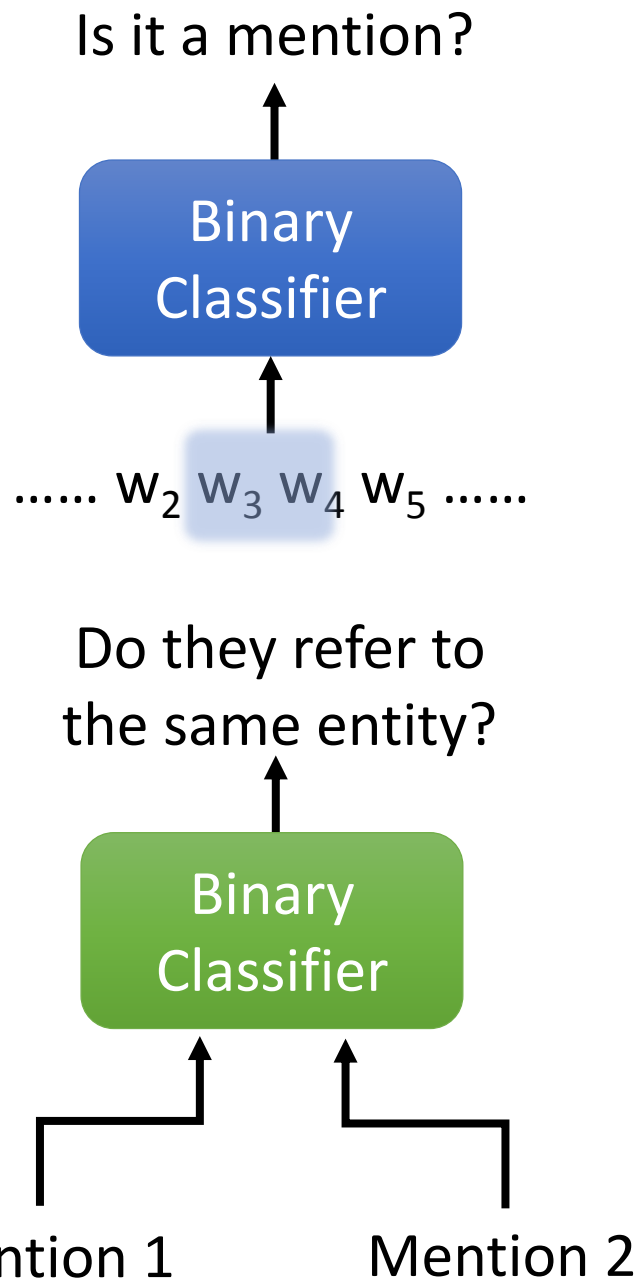
Output “yes” if ...

“Both inputs are mentions” and
“They refer to the same entity”



N tokens $N(N-1)/2$ spans = K

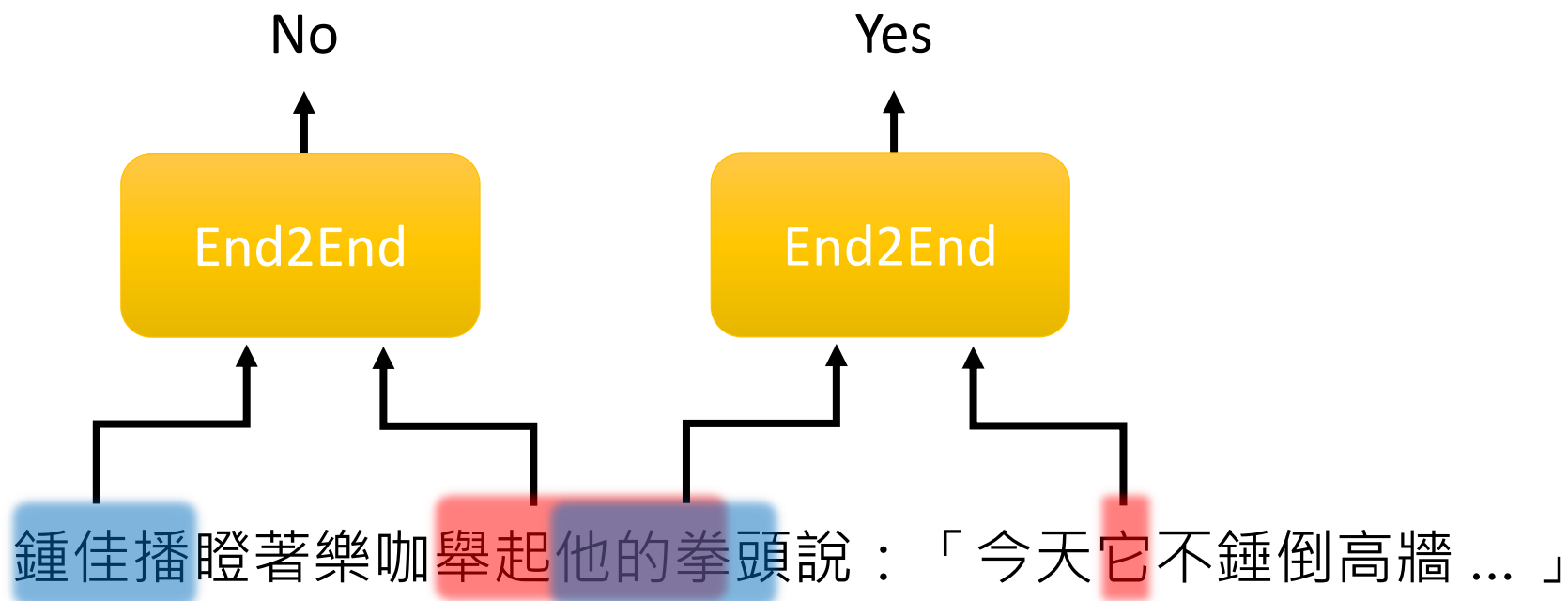
Run $K(K-1)/2$ times

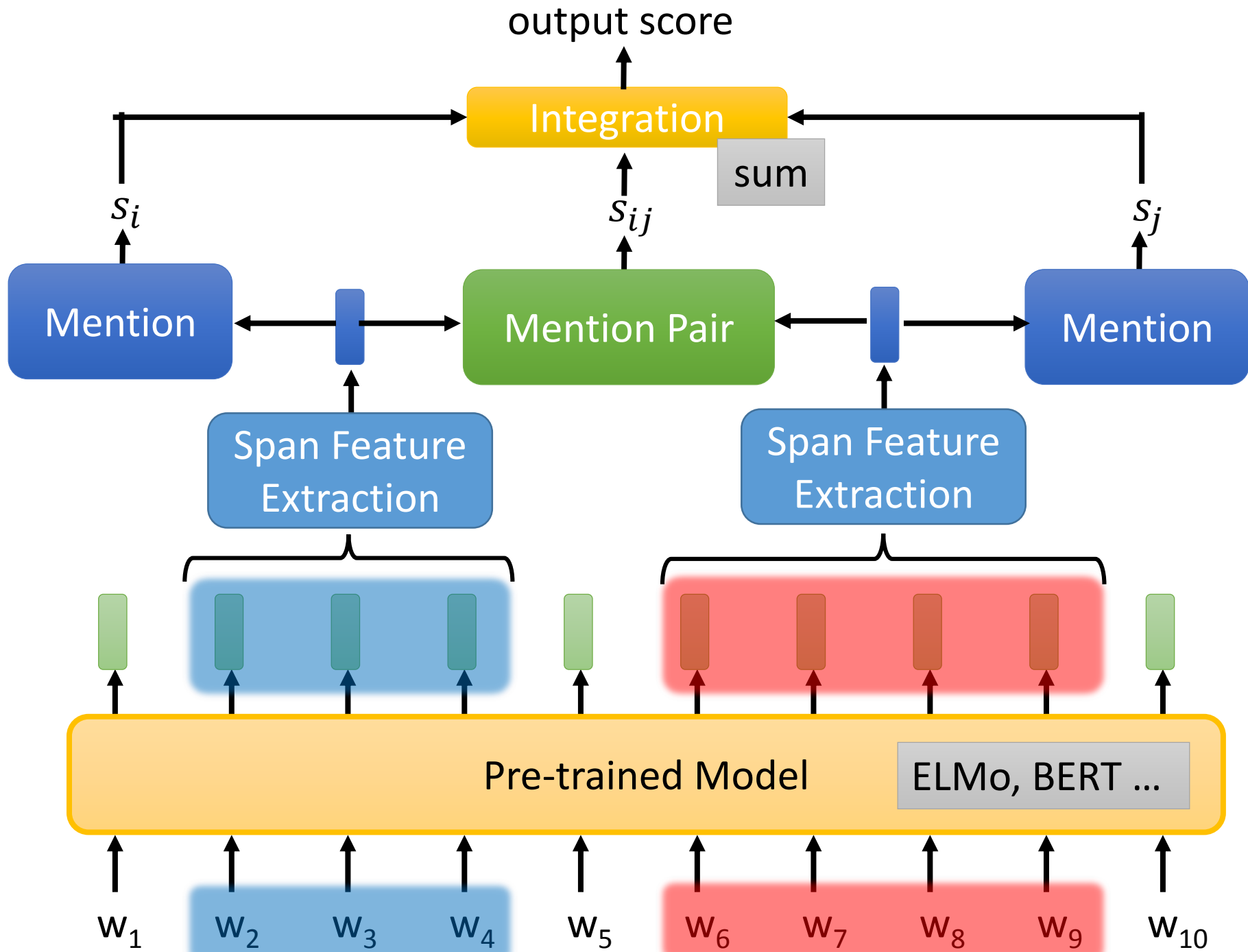


Training – Binary Classification

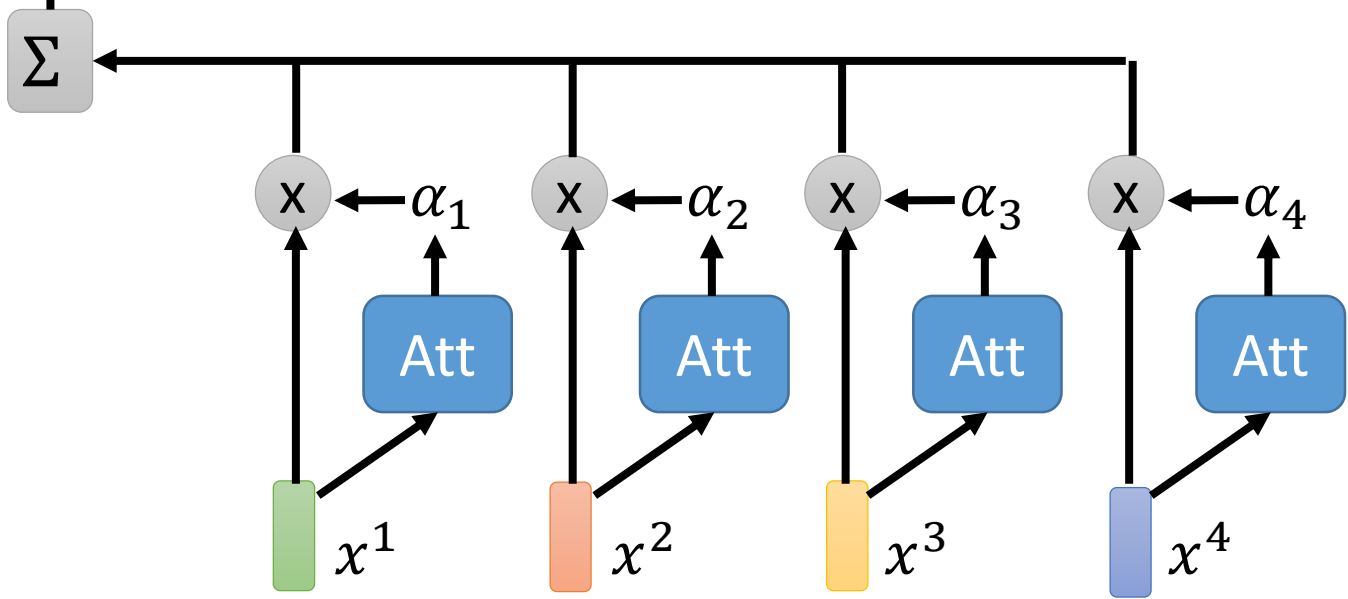
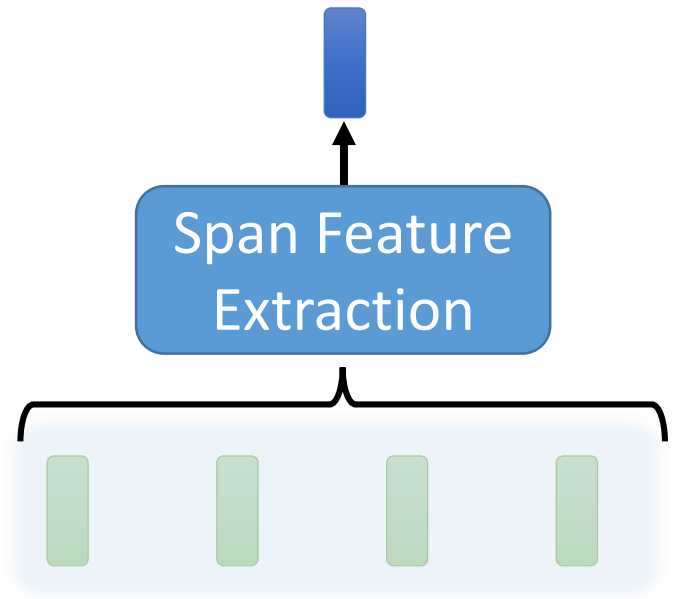
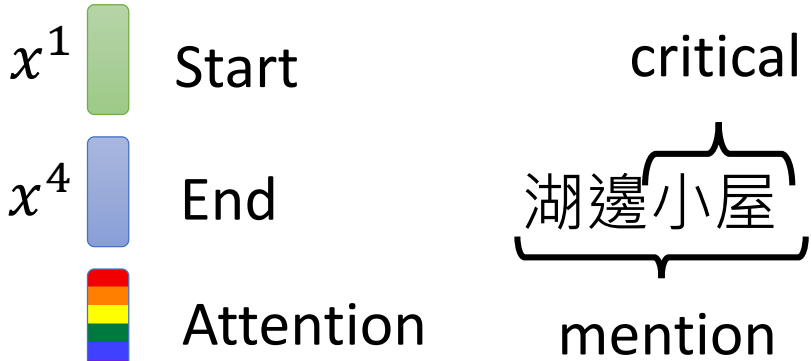
Ignore Mention Ranking Model here

Please refer to chapter 22.4 of “Speech and language processing” (3rd)





Span Representation



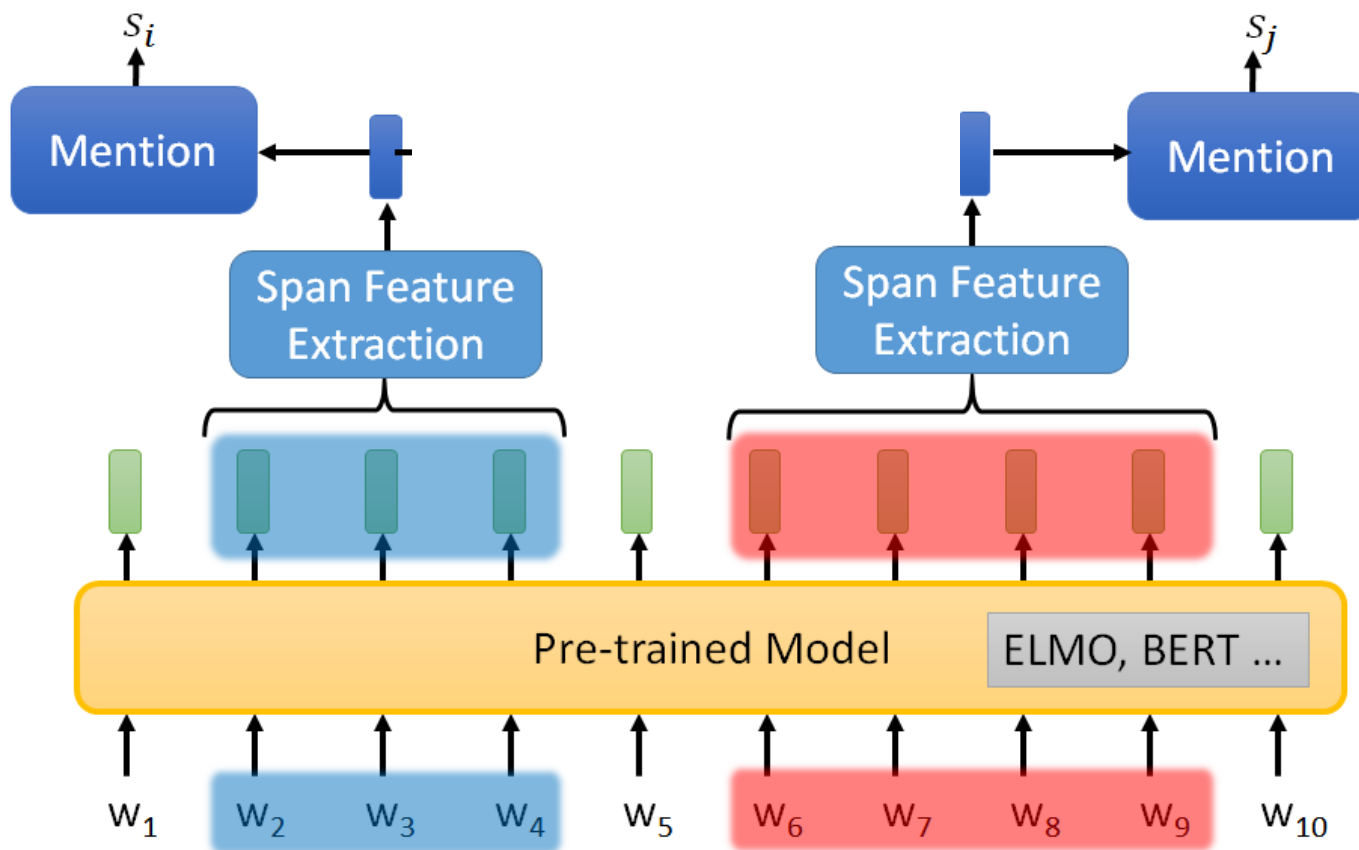
Practical Implementation

Can be reduced by
length constraint

$K \ll N$

Run mention detector $N(N-1)/2$ times to score each span

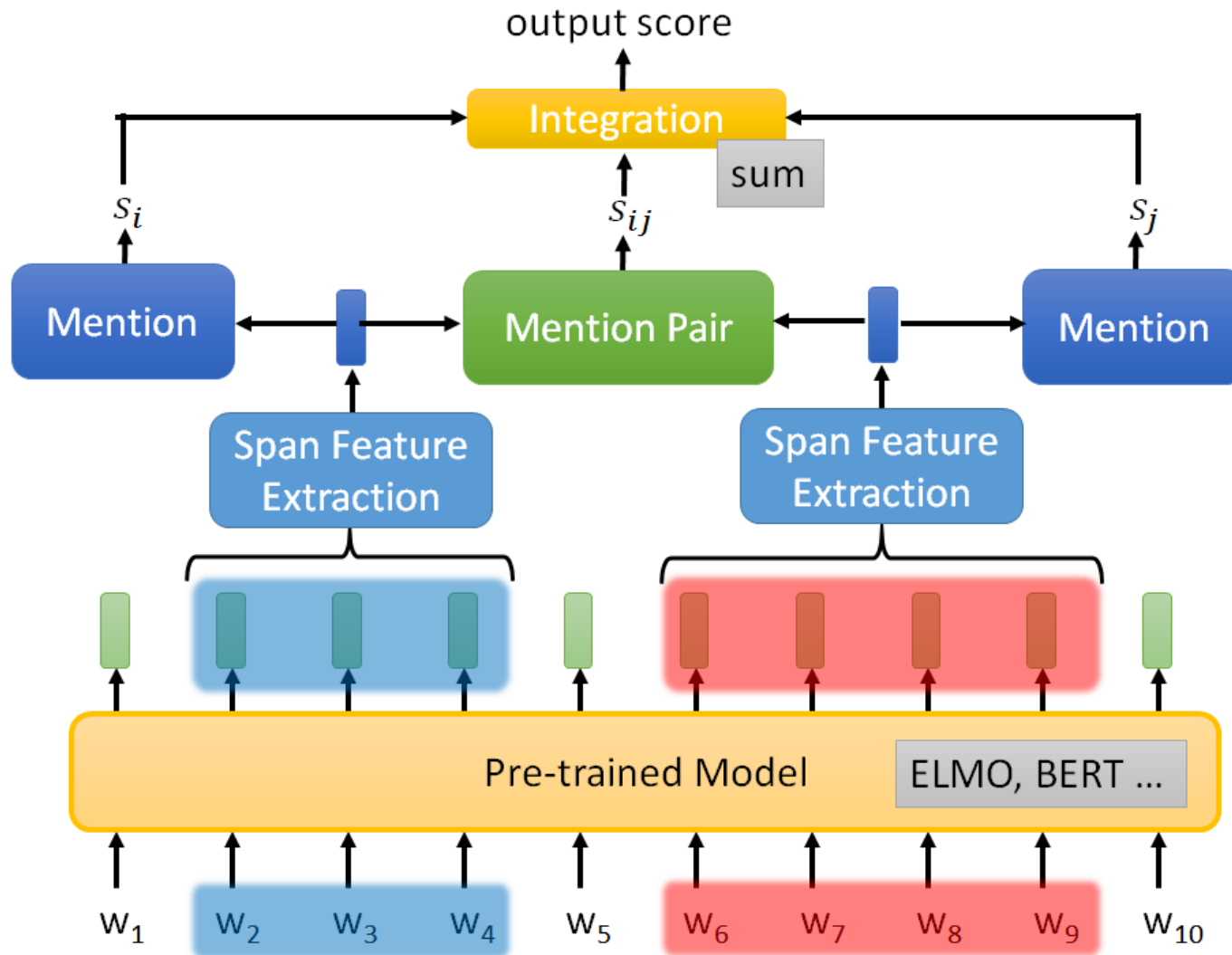
Only select the K mentions with the highest scores



Practical Implementation

$K \ll N$

The whole model is run only $K(K-1)/2$ times.



Results

GLoVe+LSTM [Lee, et al., EMNLP'17]

ELMo [Lee, et al., NAACL'18]

BERT [Joshi, et al., EMNLP'19]

1 (A **fire in a Bangladeshi garment factory**) has left at least 37 people dead and 100 hospitalized. Most of the deceased were killed in the crush as workers tried to flee (**the blaze**) in the four-story building.

A fire in (a **Bangladeshi garment factory**) has left at least 37 people dead and 100 hospitalized. Most of the deceased were killed in the crush as workers tried to flee the blaze in (**the four-story building**).

2 We are looking for (a **region of central Italy bordering the Adriatic Sea**). (**The area**) is mostly mountainous and includes Mt. Corno, the highest peak of the Apennines. (**It**) also includes a lot of sheep, good clean-living, healthy sheep, and an Italian entrepreneur has an idea about how to make a little money of them.

3 (**The flight attendants**) have until 6:00 today to ratify labor concessions. (**The pilots'**) union and ground crew did so yesterday.

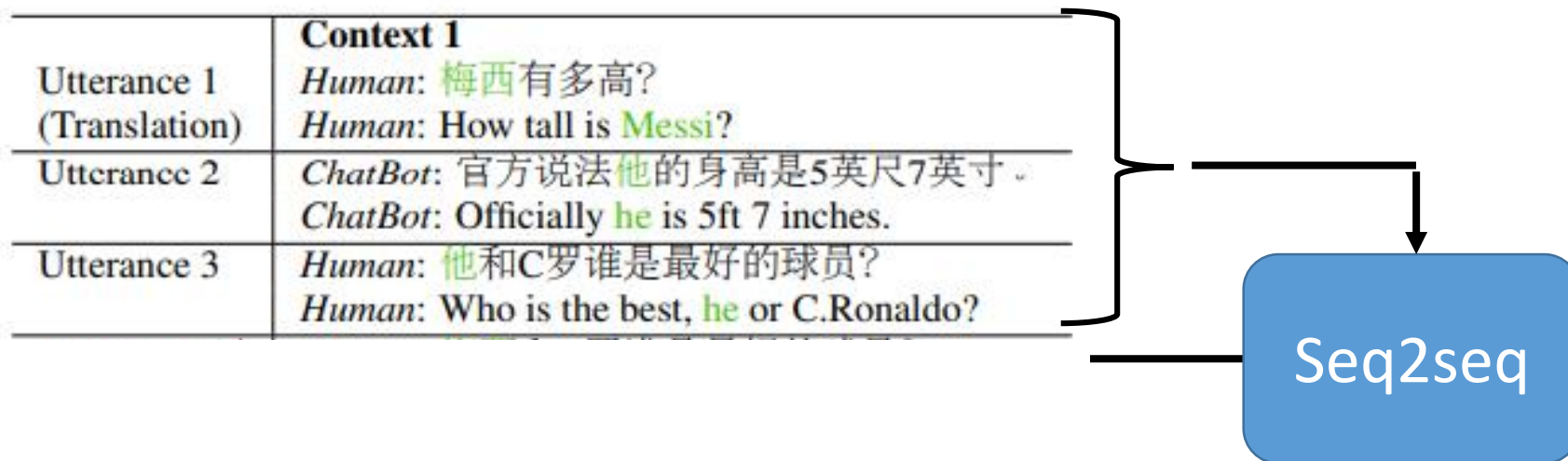
4 (**Prince Charles and his new wife Camilla**) have jumped across the pond and are touring the United States making (**their**) first stop today in New York. It's Charles' first opportunity to showcase his new wife, but few Americans seem to care. Here's Jeanie Mowth. What a difference two decades make. (**Charles and Diana**) visited a JC Penney's on the prince's last official US tour. Twenty years later here's the prince with his new wife.

source of image: <https://arxiv.org/pdf/1707.07045.pdf>

Seq2Seq?

Source of image:

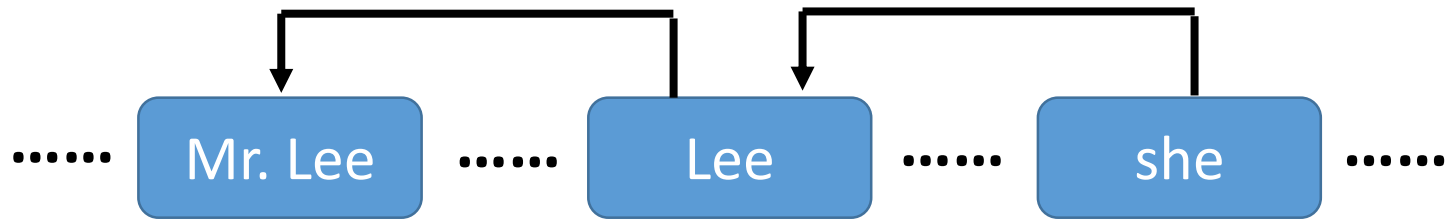
<https://www.aclweb.org/anthology/P19-1003.pdf>



[Su, et al., ACL'19]

Advanced Topics

Global Information



Cluster: {Mr. Lee, Lee, she} Contradiction!

[Lee, et al., NAACL'18] [Kantor, et al., ACL'19]

Unsupervised

[Kocijan, et al., EMNLP'19]

Gina arrives and she is furious with Denise for not protecting Jody from Kingsley, as **MASK** was meant to be the parent.

Using pre-train model to fill-in the blank.

Reference

- [Lee, et al., EMNLP'17] Kenton Lee, Luheng He, Mike Lewis, Luke Zettlemoyer, End-to-end Neural Coreference Resolution, EMNLP, 2017
- [Su, et al., ACL'19] Hui Su, Xiaoyu Shen, Rongzhi Zhang, Fei Sun, Pengwei Hu, Cheng Niu, Jie Zhou, Improving Multi-turn Dialogue Modelling with Utterance ReWriter, ACL, 2019
- [Wu, et al., ACL'20] Wei Wu, Fei Wang, Arianna Yuan, Fei Wu, Jiwei Li, Coreference Resolution as Query-based Span Prediction, ACL, 2020
- [Lee, et al., NAACL'18] Kenton Lee, Luheng He, and Luke Zettlemoyer, Higher-order coreference resolution with coarse-to-fine inference, NAACL, 2018
- [Joshi, et al., EMNLP'19] Mandar Joshi, Omer Levy, Luke Zettlemoyer, Daniel Weld, BERT for Coreference Resolution: Baselines and Analysis, EMNLP, 2019
- [Kantor, et al., ACL'19] Ben Kantor, Amir Globerson, Coreference Resolution with Entity Equalization, ACL, 2019
- [Kocijan, et al., EMNLP'19] Vid Kocijan, Oana-Maria Camburu, Ana-Maria Cretu, Yordan Yordanov, Phil Blunsom, Thomas Lukasiewicz, WikiCREM: A Large Unsupervised Corpus for Coreference Resolution, EMNLP, 2019