The Hong Kong Polytechnic University
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Research on Deep Learning for Natural Language Processing at Huawei Noah's Ark Lab

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Noah's Ark Lab
Huawei Technologies

Talk Outline

- *Research at Huawei Noah's Ark Lab*
- New Breakthrough in Natural Language Processing with Deep Learning
- Research on DL for NLP at Noah's Ark Lab
- Summary

Noah's Ark Lab

- Our future challenge is not about better chips, larger bandwidth, and more complex signal interference models,
  - **It is about data**
- Have you seen the movie '2012' ?
  - The flood is coming, but this time it is the 'data flood'
  - Once here, it will never recede
- Noah's Ark Lab will lead us to tackle the challenges in
  - Data Mining
  - Artificial Intelligence

Founder and President:
Mr. **Ren, Zhengfei**

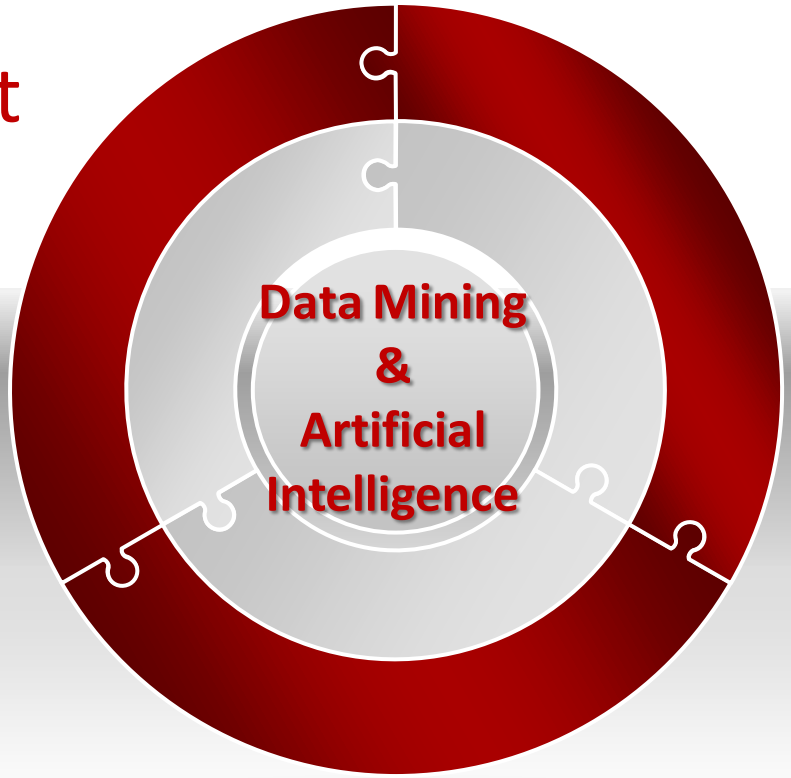
Noah's Ark Lab

- Research Areas
  - Machine Learning
  - Data Mining
  - Speech and Language Processing
  - Information and Knowledge Management
  - Intelligent Systems
  - Human Computer Interaction

- Founded in 2012
- Located in Hong Kong and Shenzhen
- Collaborations with Universities in Hong Kong
  - A large number of researchers earned PhD at the universities
  - Many interns
  - Strong connections with professors and students

We want to build

Intelligent Mobile Devices



Intelligent Telecommunication Networks

Intelligent Enterprise

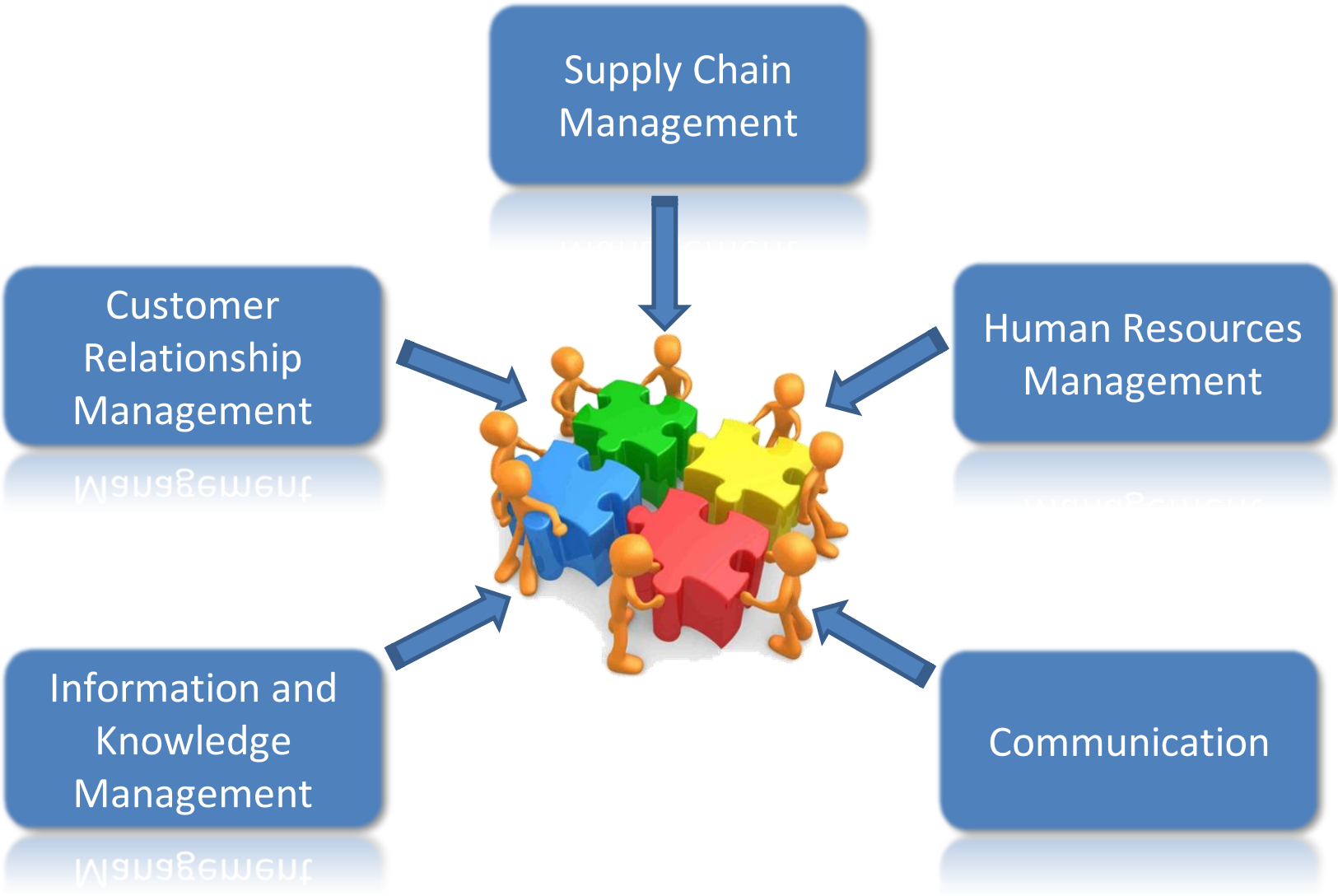
Intelligent Telecommunication Networks

Software-defined Network

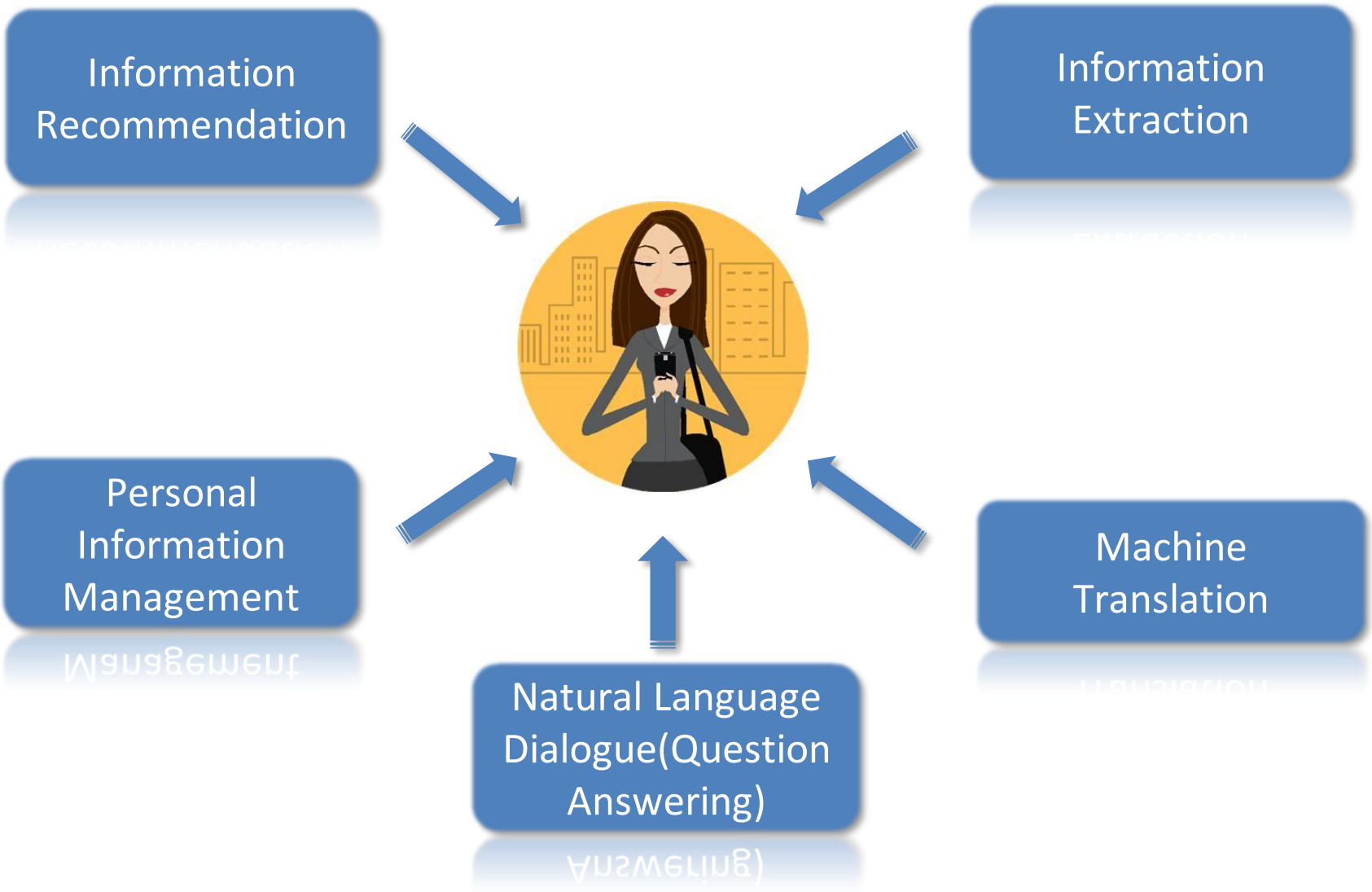
Network Maintenance

Network Planning and Optimization

Intelligent Enterprise



Intelligent Mobile Devices



Better Communications

Research Topics We Are Working on

- Machine Translation
- Natural Language Dialogue
- Automatic Speech Recognition
- Image Retrieval
- Deep Learning Platform

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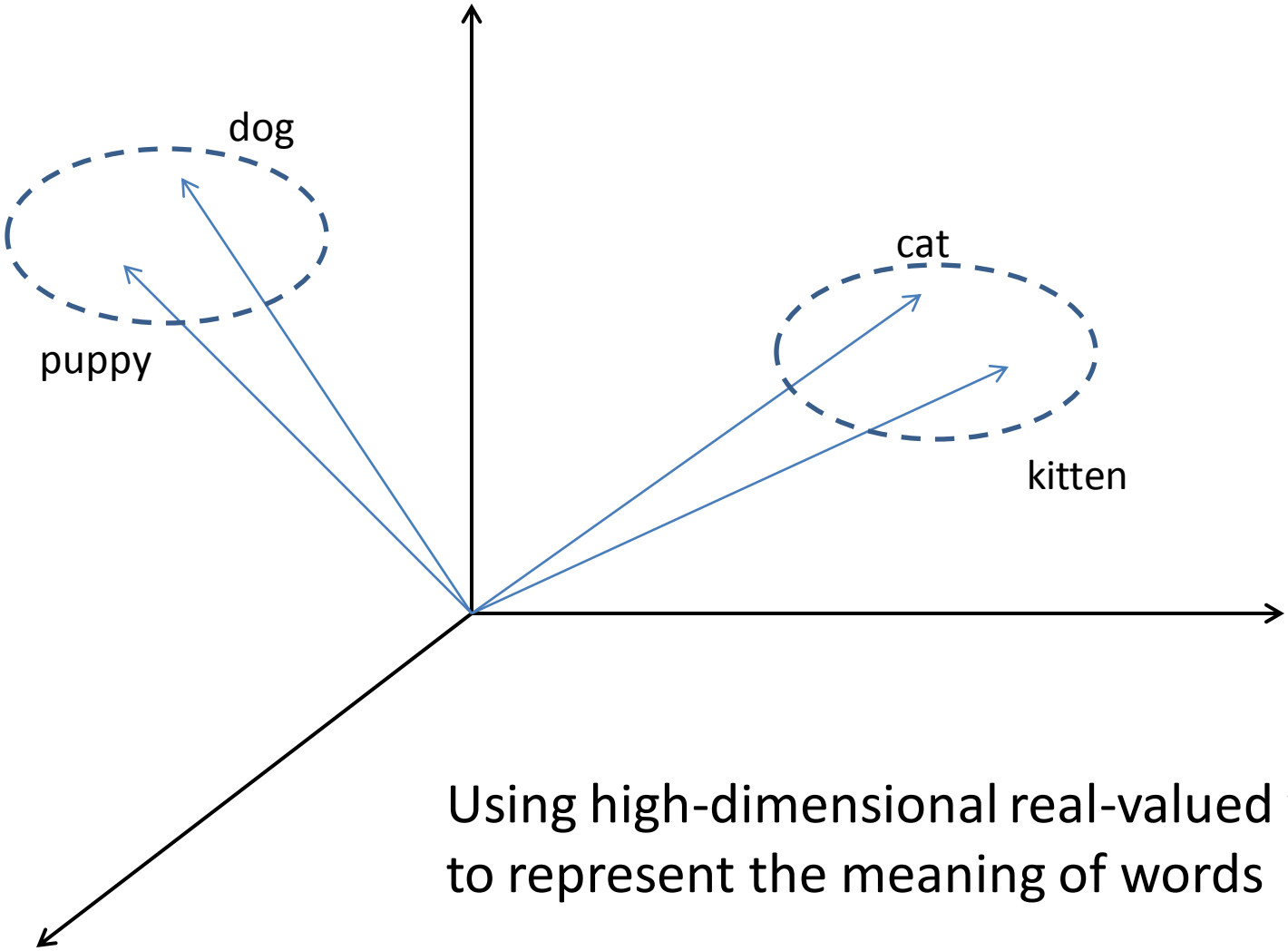
Distributional Linguistics

- Distributional semantics
- *You shall know a word by the company it keeps* - John Firth

- Sylvan?
- Companying words: woods, forest, tree, living, woodland, beautiful, grove

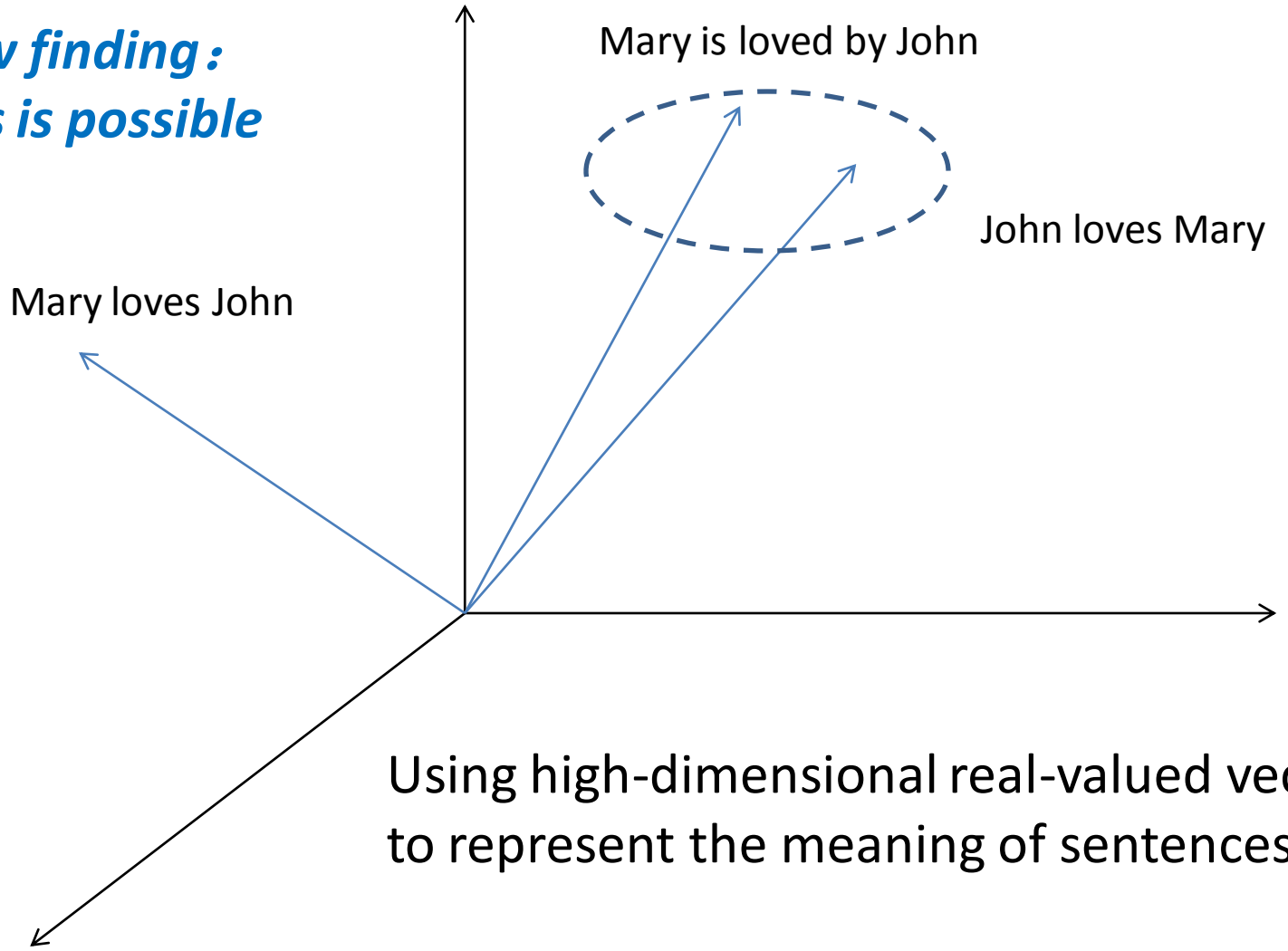
Representation of Word Meaning



Using high-dimensional real-valued vectors to represent the meaning of words

Representation of Sentence Meaning

New finding :
This is possible



Using high-dimensional real-valued vectors to represent the meaning of sentences

Recent Breakthrough in Distributional Linguistics

- From words to sentences
- Representing syntax, semantics, even pragmatics

How Is Learning of Sentence Meaning Possible?

- Neural networks (complicated non-linear models) , i.e., deep learning
- Big Data
- Task-oriented
- Error-driven learning, gradient based
- Compositional

Natural Language Tasks

- Classification: assigning a label to a string

$$s \rightarrow c$$

- Generation: creating a string

$$\rightarrow s$$

- Matching: matching two strings

$$s, t \rightarrow \mathbf{R}^{+}$$

- Translation: transforming one string to another

$$s \rightarrow t$$

Natural Language Applications Can Be Formalized as Tasks

- Classification
  - Sentiment analysis
- Generation
  - Language modeling
- Matching
  - Information retrieval
  - Question answering
- Translation
  - Machine translation
  - Natural language dialogue (single turn)
  - Text summarization
  - Paraphrasing

Learning of Representations in Tasks

- Classification

$$s \rightarrow r \rightarrow c$$

- Generation

$$\rightarrow s(r)$$

- Matching

$$s, t \rightarrow r \rightarrow \mathbf{R}^{+}$$

- Translation

$$s \rightarrow r \rightarrow t$$

Deep Learning Tools for Learning Sentence Representations

- Neural Word Embedding Techniques
- Recurrent Neural Networks
- Recursive Neural Networks
- Convolutional Neural Networks

Word Representation: Neural Word Embedding

M	c_1	c_2	c_3	c_4	c_5
w_1	10		1	5	
w_2		2			1
w_3	2.5			1	

$$\log \frac{P(w,c)}{P(w)P(c)}$$

$$M = WC^T$$

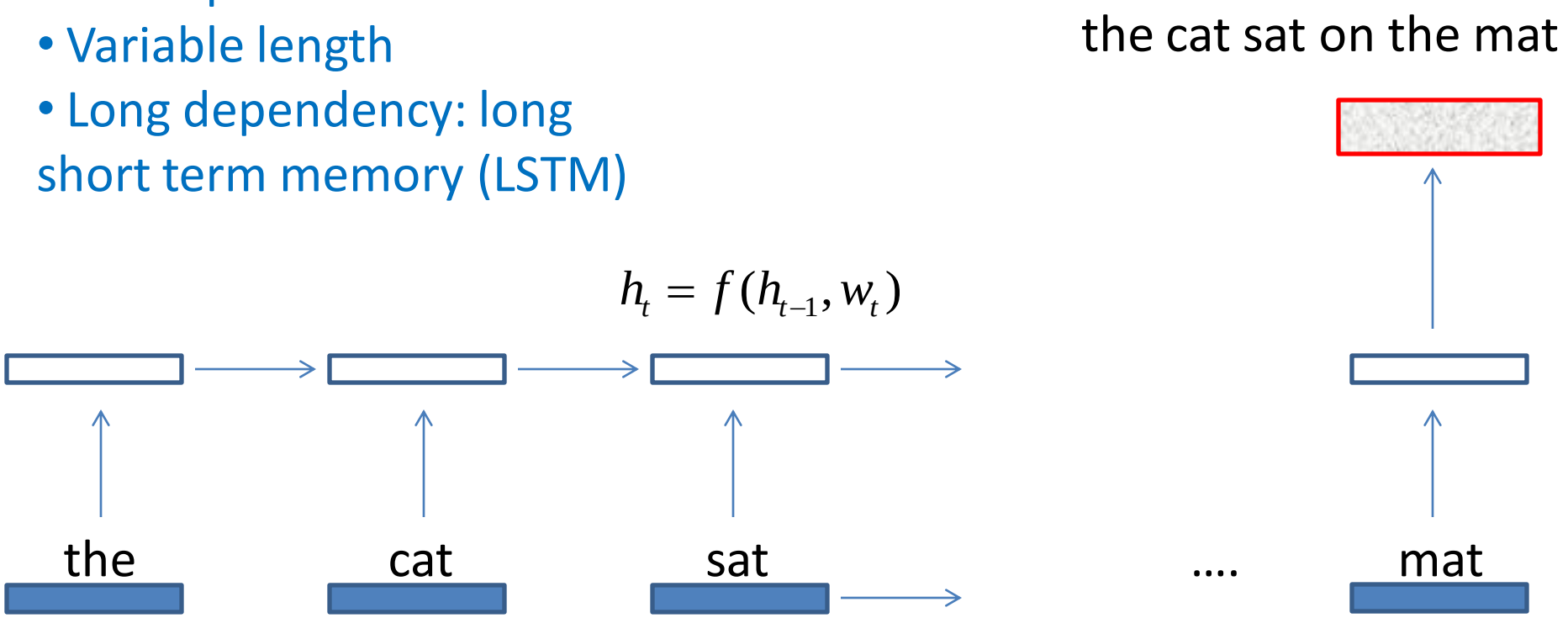
matrix factorization

W	t_1	t_2	t_3
w_1	7	1	1
w_2		2	3
w_3	1	1.5	2

word embedding
or word2vec

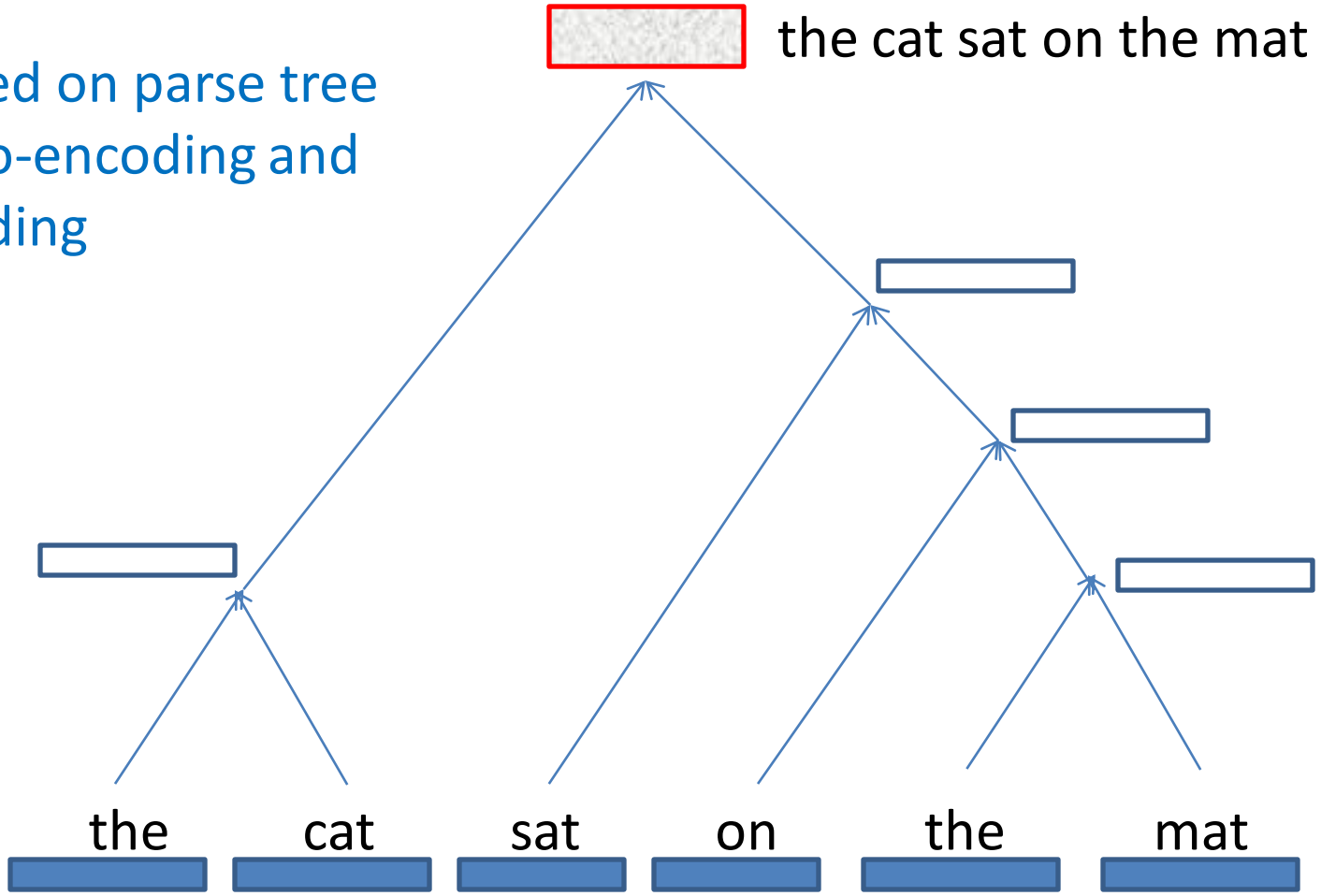
Recurrent Neural Network (RNN) (Mikolov et al. 2010)

- On sequence
- Variable length
- Long dependency: long short term memory (LSTM)

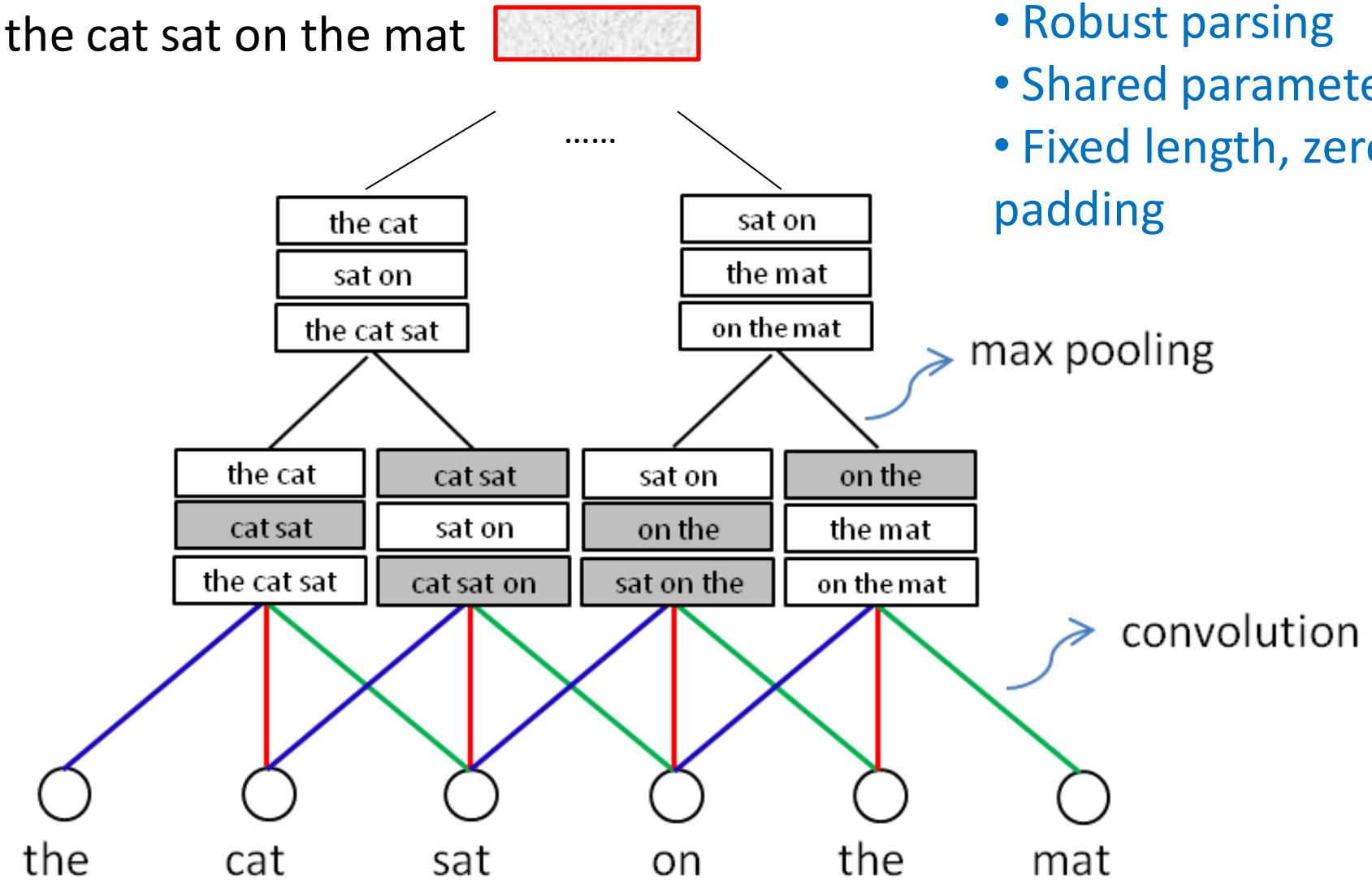


Recursive Neural Network (RNN) (Socher et al. 2011)

- Based on parse tree
- Auto-encoding and decoding



Convolutional Neural Network (CNN) (Hu et al. 2014)



- Robust parsing
- Shared parameter
- Fixed length, zero padding

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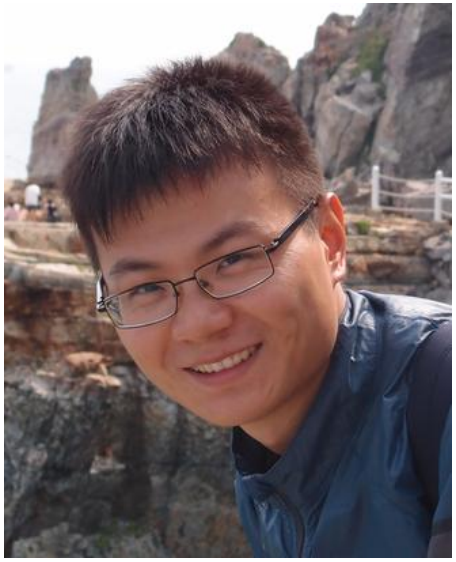
Researchers Working on Deep Learning in Noah's Ark Lab

Zhengdong Lu

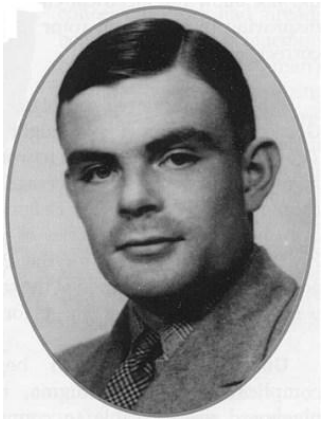
Lifeng Shang



Lin Ma

Natural Language Dialogue

- Vast amount of conversation data is available
- Powerful technologies like deep learning developed
- Single turn vs multi-turn dialogue
- Two approaches
  - Retrieval based
  - Generation based

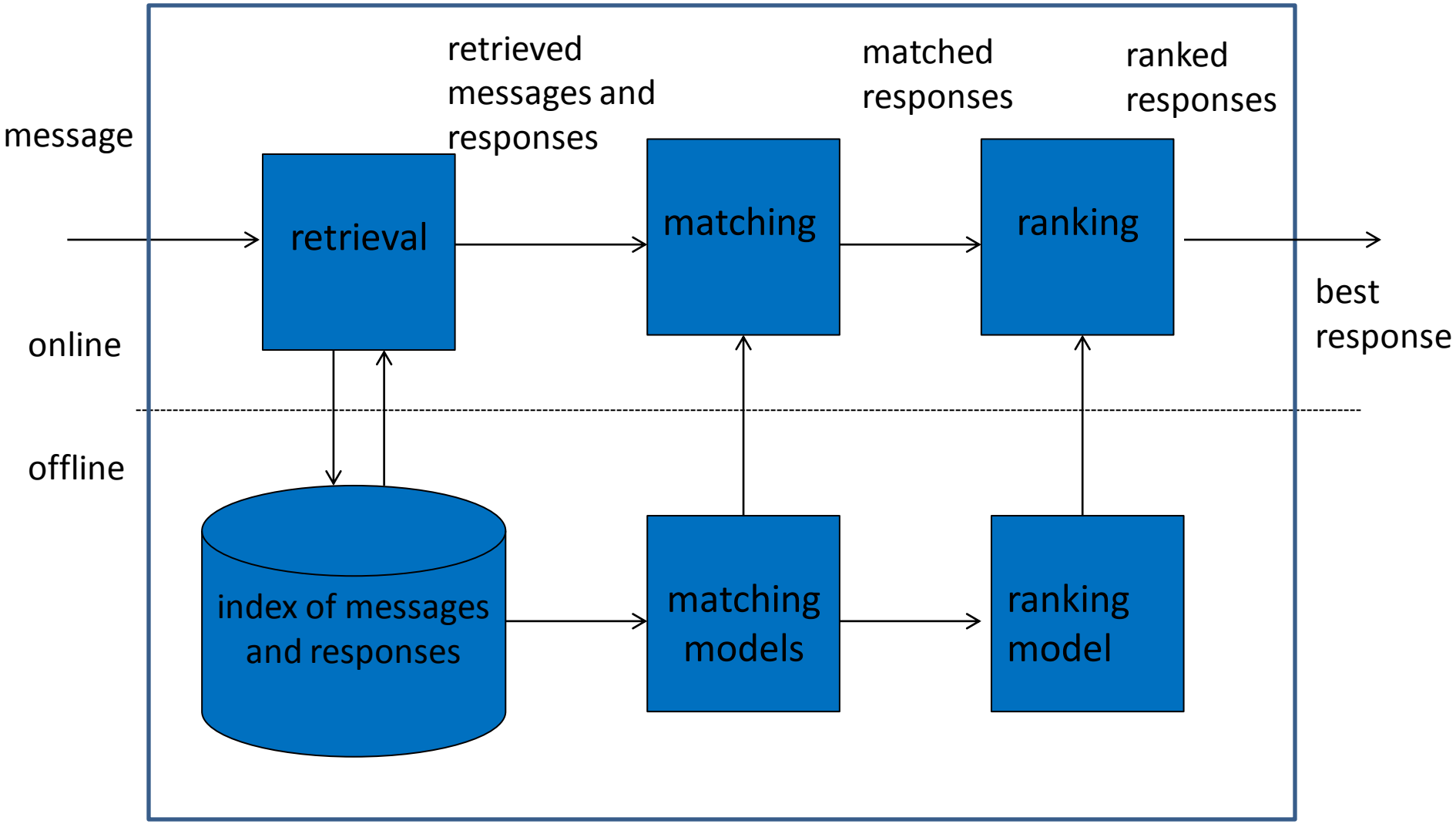


Alan Turing

NTCIR: Short Text Conversation Contest

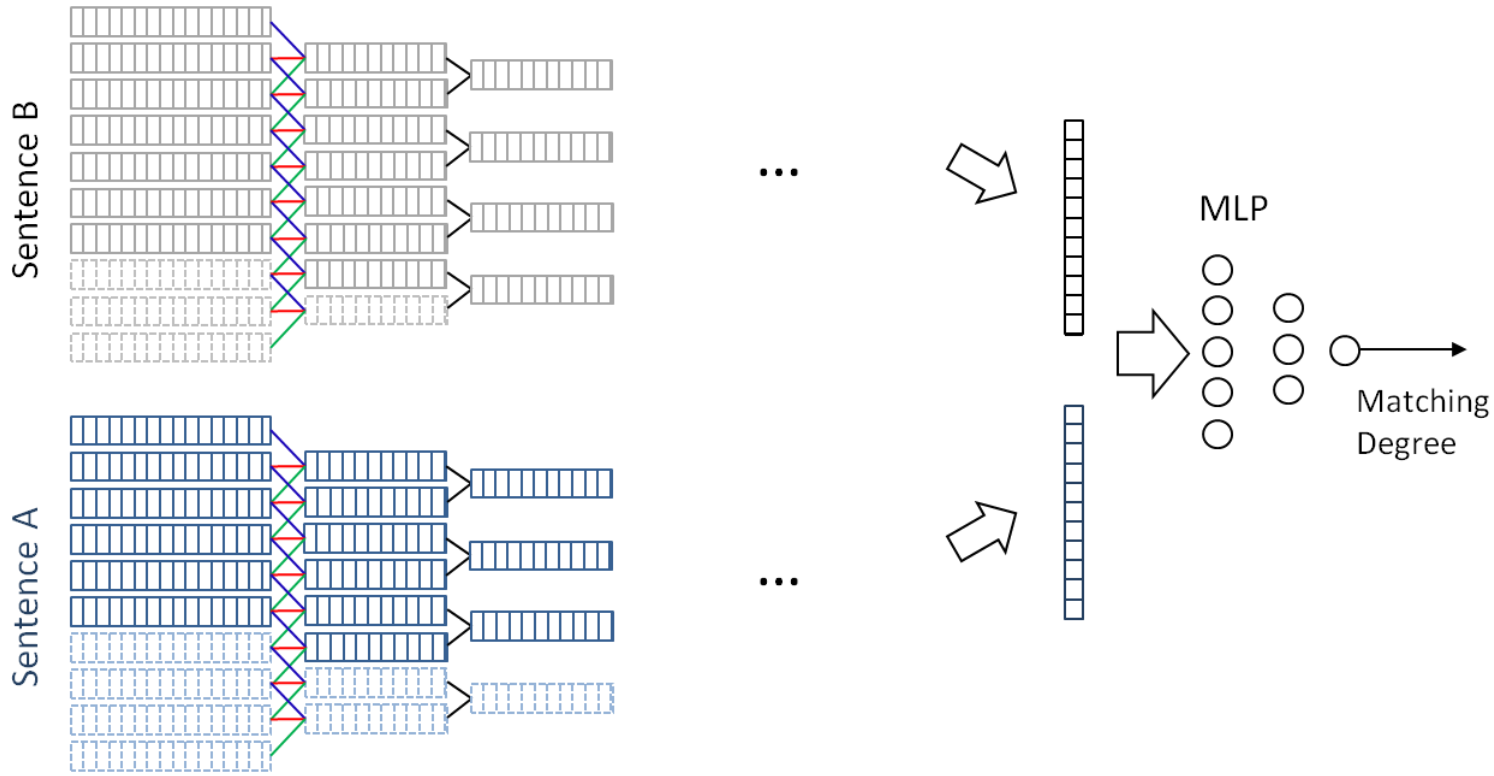
5.5 million message response pairs

Natural Language Dialogue System - Retrieval based Approach



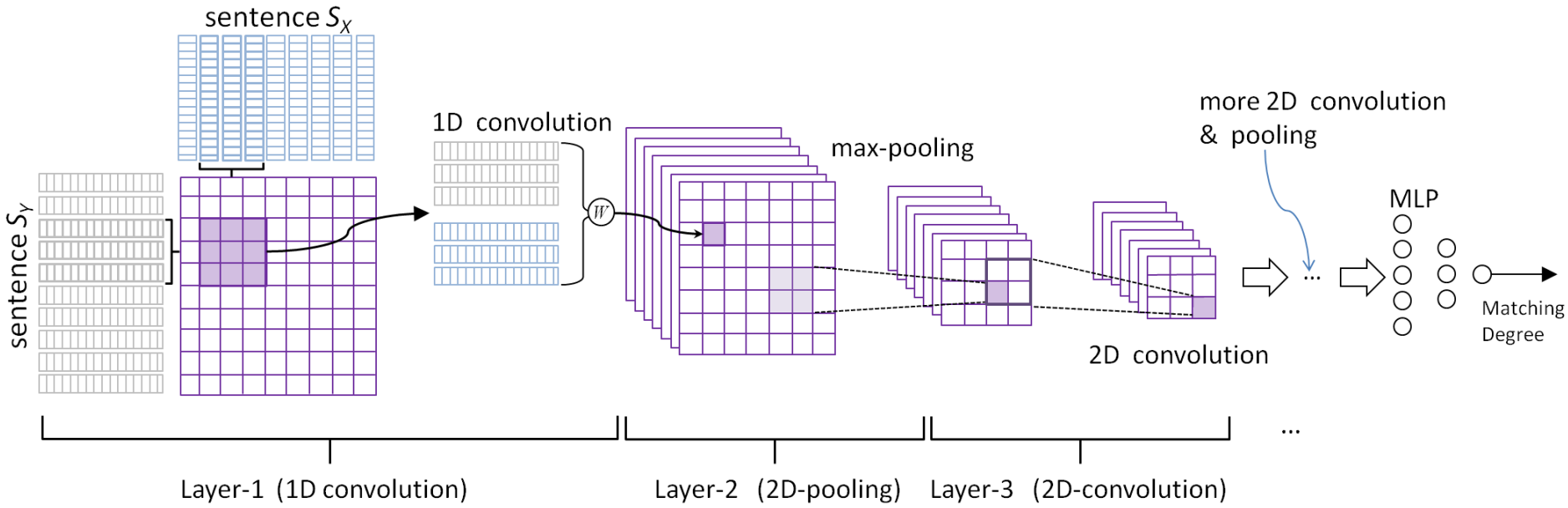
Deep Match CNN
- Archtecture I

- First represent two sentences, and then match



Deep Match CNN - Architecture II

- Represent and match two sentences simultaneously
- Two dimensional convolution and pooling



Retrieval based Approach:

Accuracy = 70%+

上海今天好熱，堪比新加坡。

It is very hot in Shanghai today, just like Singapore .
It is unusually hot.

上海今天热的不一般。

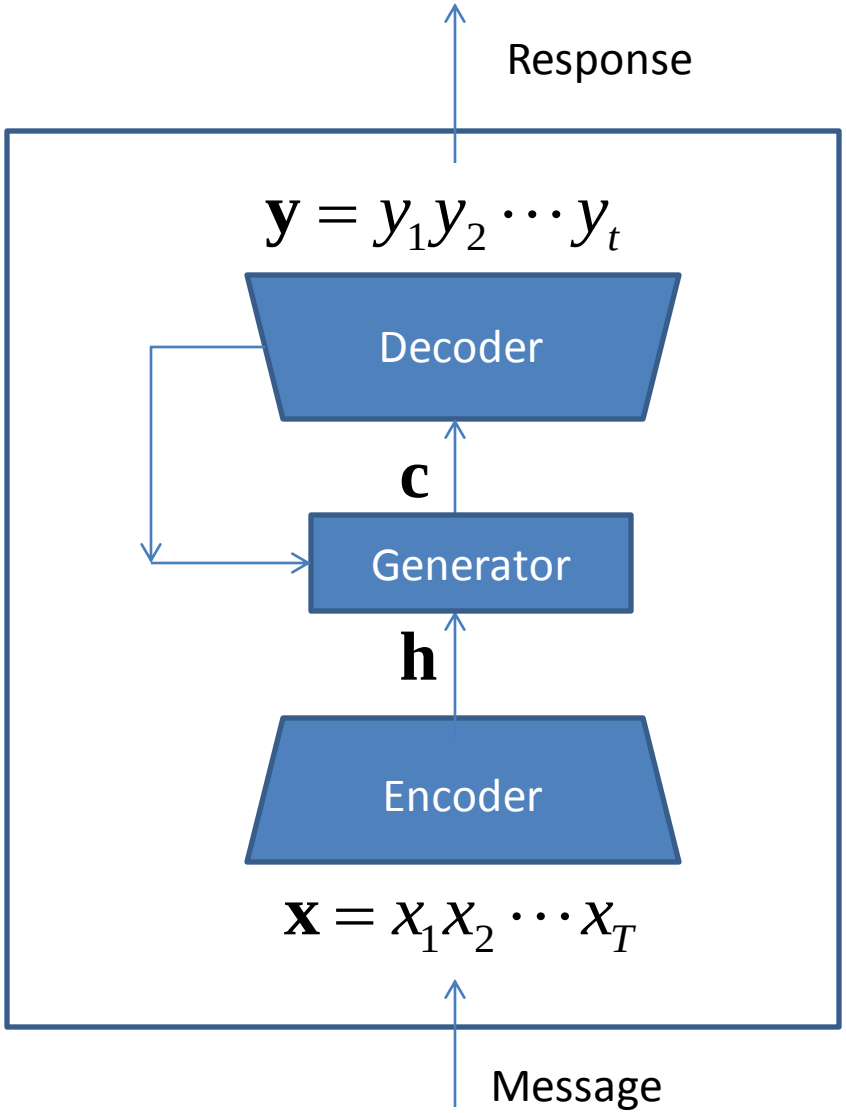
想去武当山 有想同游的么？

I want to go to Mountain Wudang, it there anybody going together with me?

我想跟帅哥同游~哈哈

Haha, I want to go with you, handsome boy

Natural Language Dialogue System - Generation based Approach



- Encoding messages to intermediate representations
- Decoding intermediate representations to responses
- Recurrent Neural Network (RNN)

Generation based Approach

Accuracy = 70%+

占中终于结束了。

Occupy Central is finally over.

下一个是陆家嘴吧？

Will Lujiazui (finance district in Shanghai) be the next?

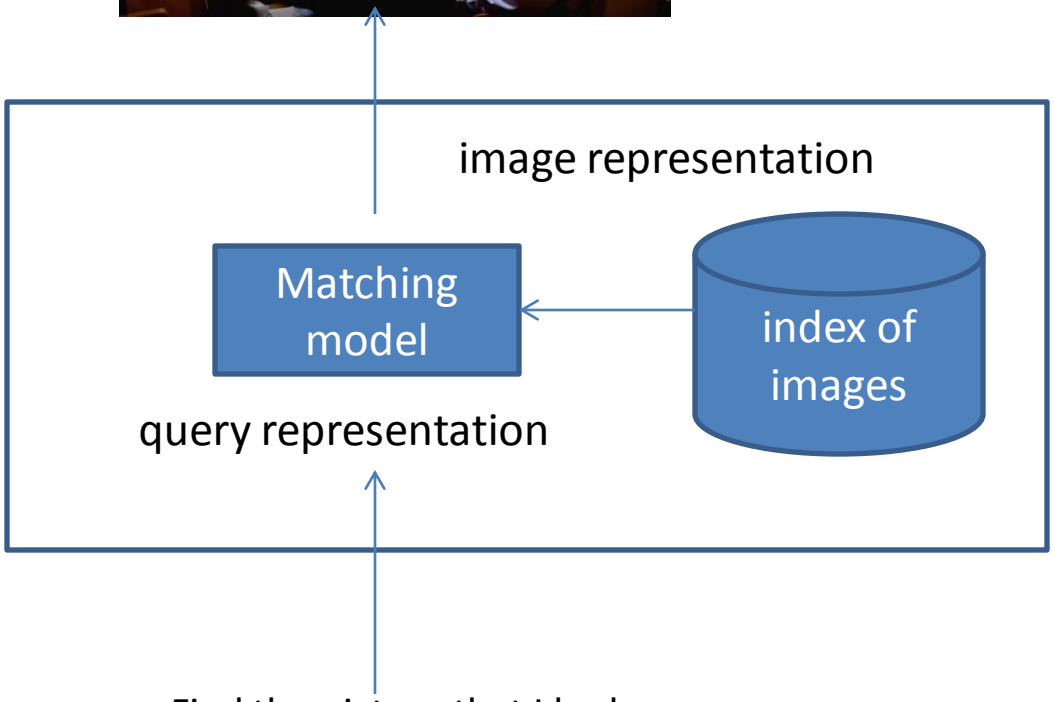
我想买三星手机。

I want to buy a Samsung phone

还是支持一下国产的吧。

Why not buy our national brands?

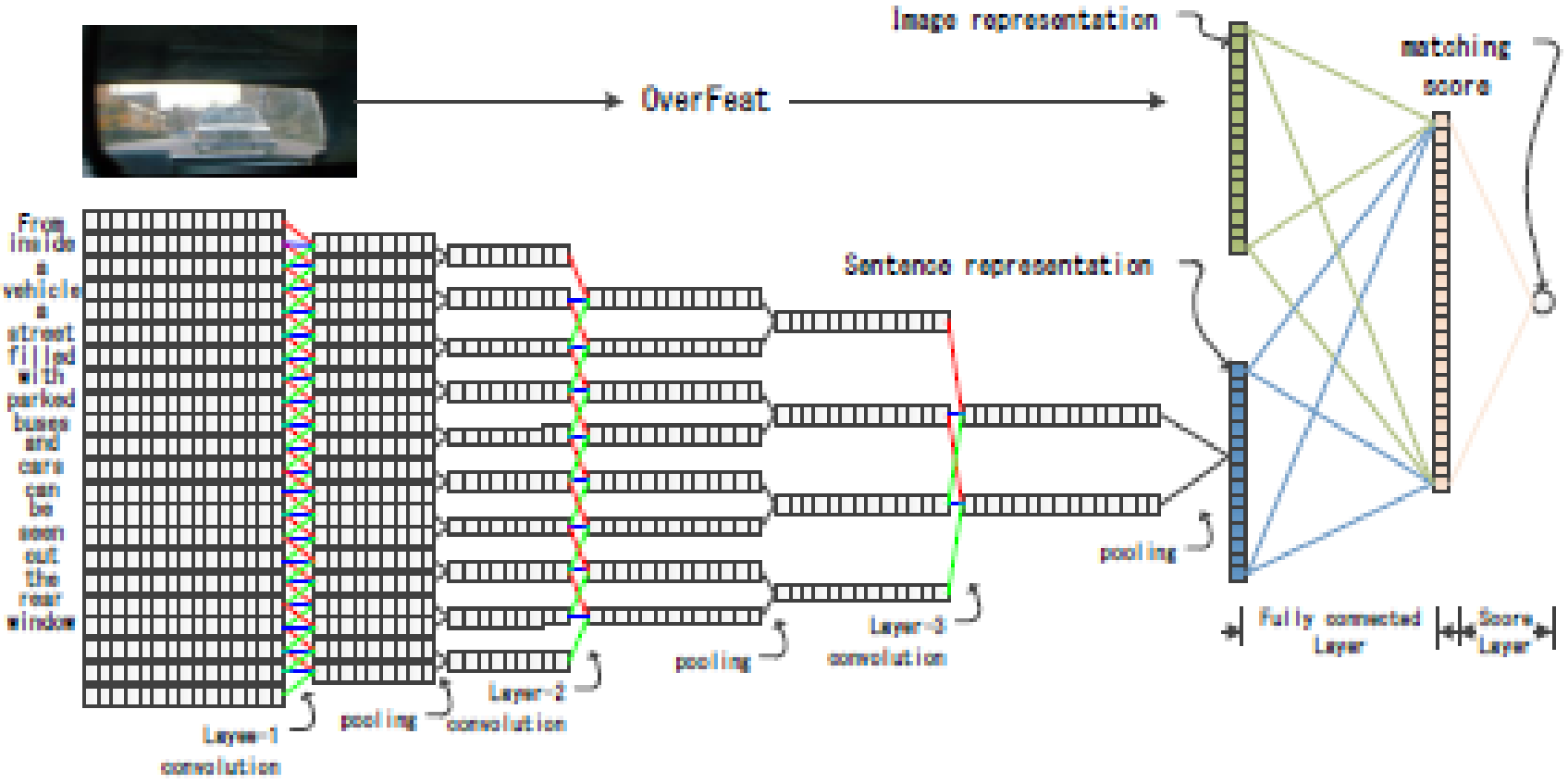
Image Retrieval System



- Task
  - Image search on smartphone
  - Key: matching text to images
- Technology
  - Deep model for matching text and image

Deep Match Model for Image and Text - CNN Based

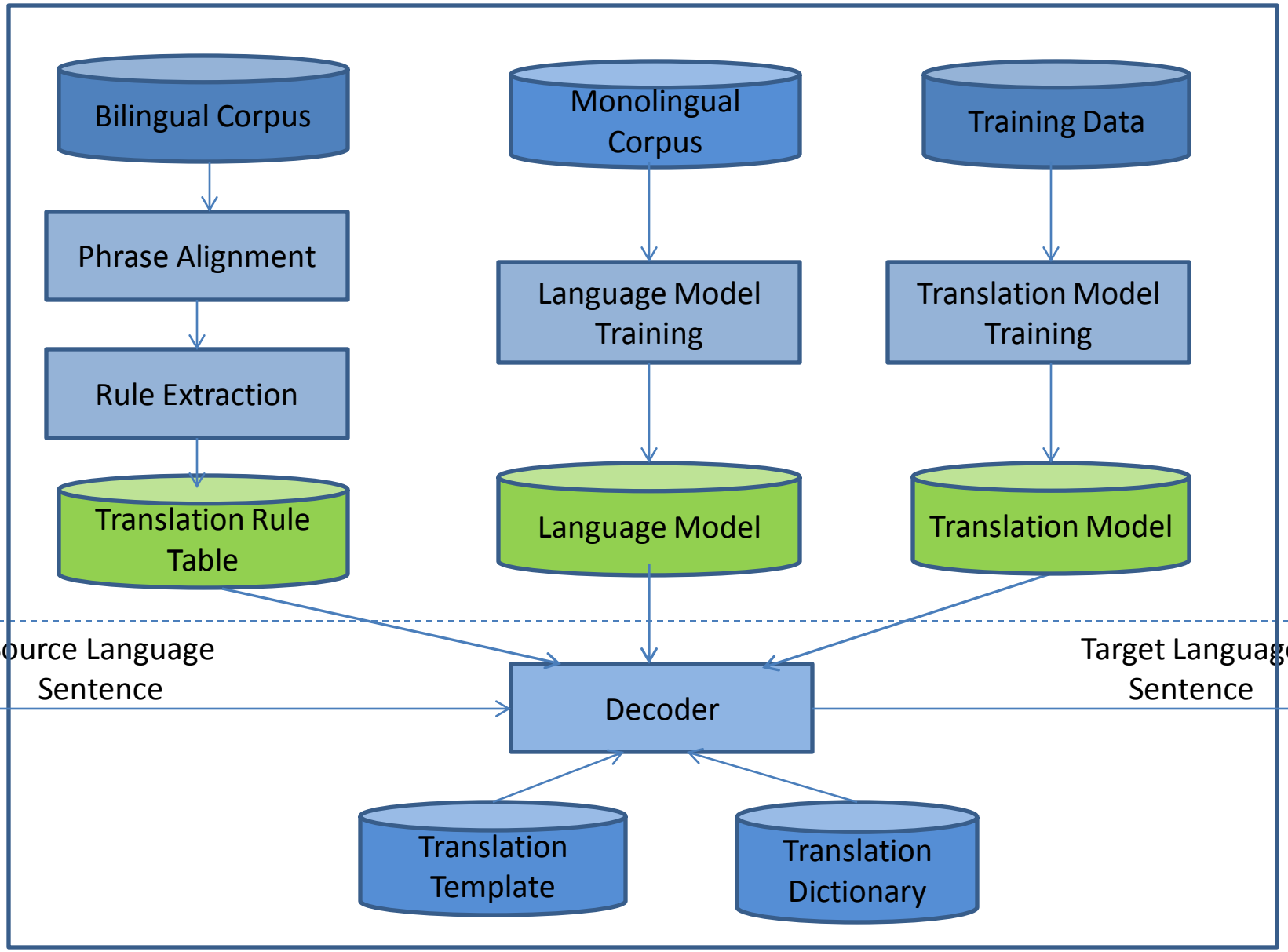
- Represent text and image and then match the two



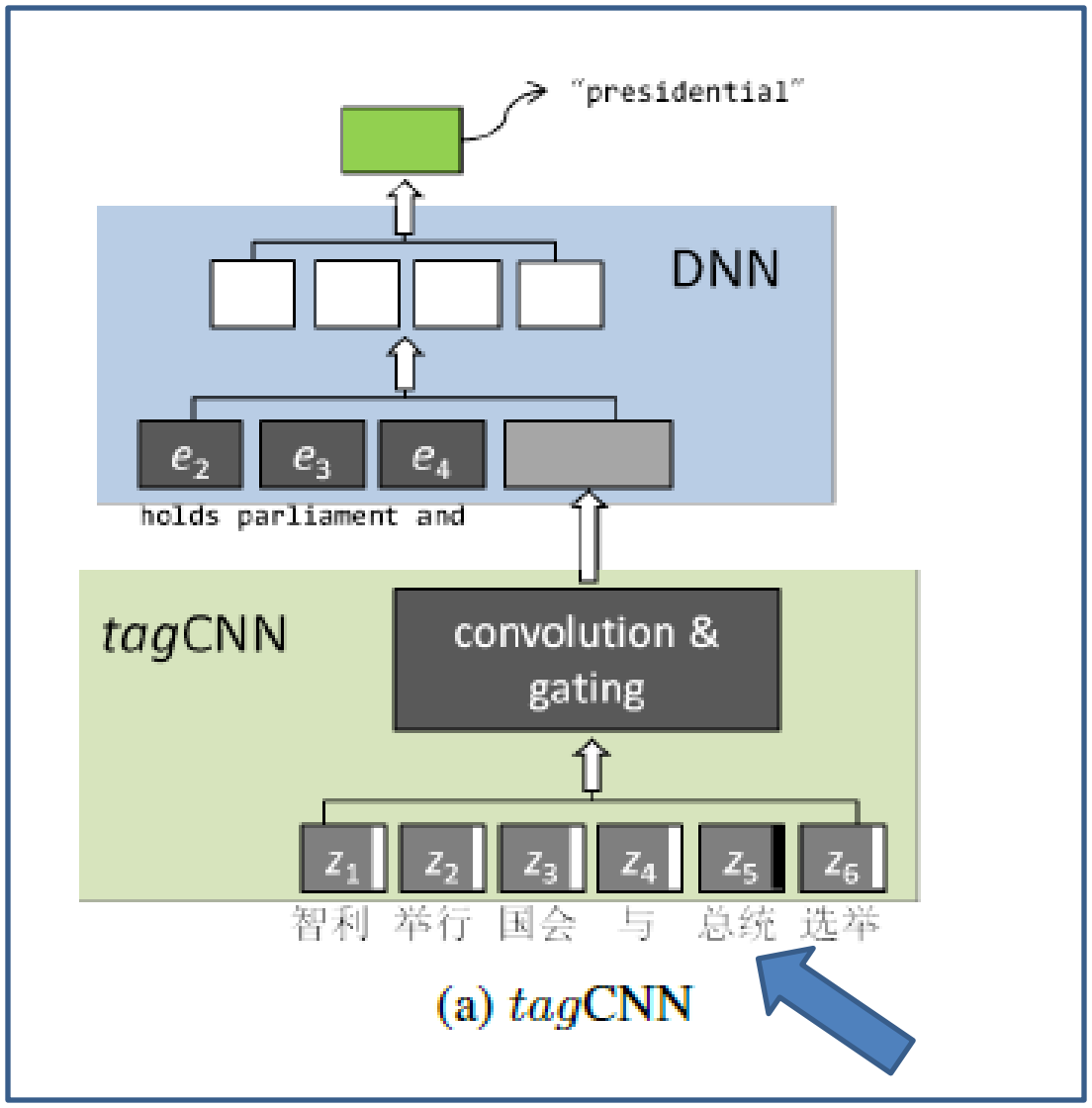
Deep Match Model for Image and Text - Top 10 Recall > 60%

Outperforms all existing methods in image retrieval

Machine Translation System



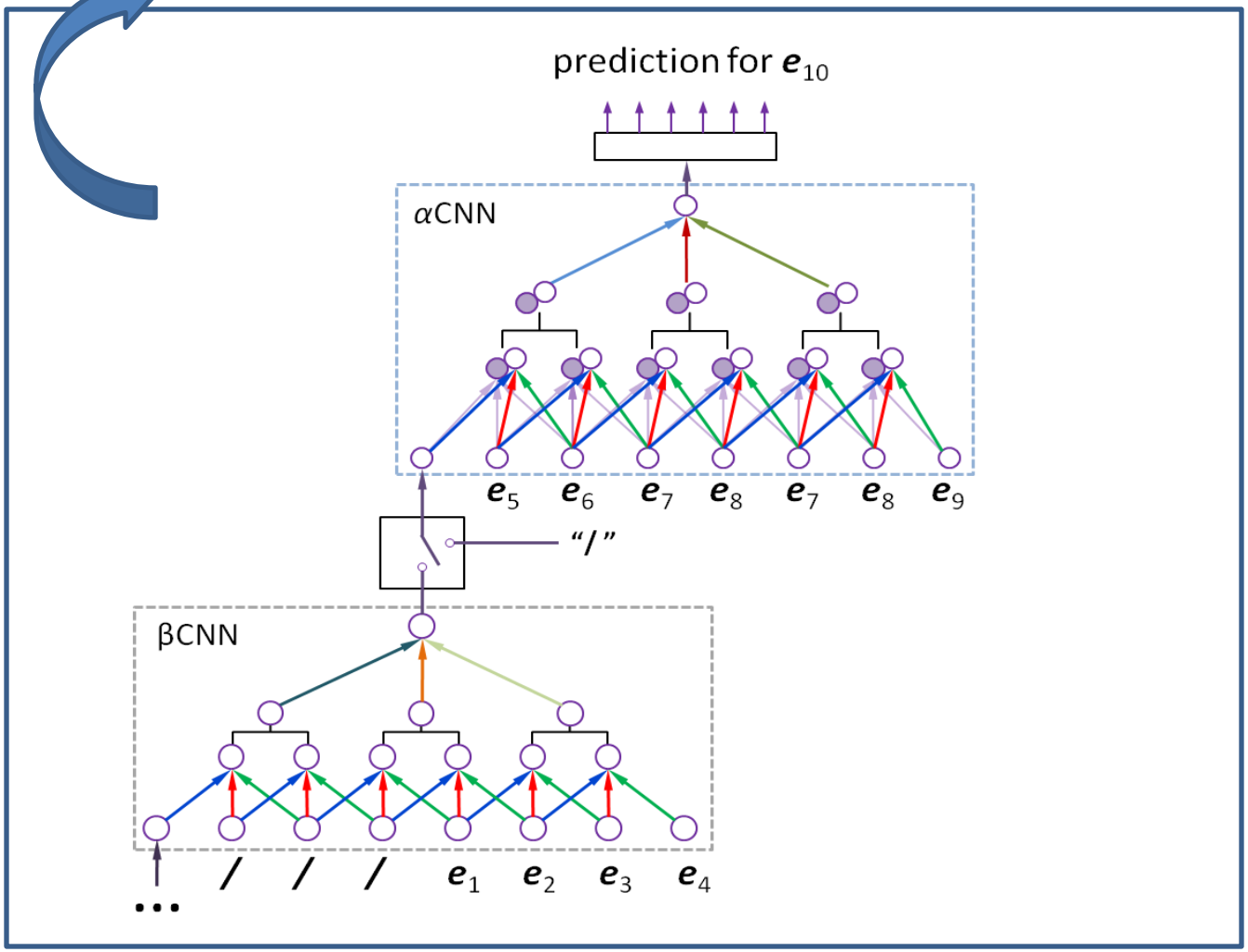
CNN based Translation Model



- Improved BLEU Score 1 point vs BBN model (ACL'14 best paper) on benchmark data

CNN based Language Model

Chile holds parliament and presidential election



Improved BLEU Score 1 point on benchmark dataset

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Research Finding and Advantages

- Possible to learn sentence representations in different tasks
- Completely data-driven, no human knowledge
- With big data and power computer, we can really build human intelligence

Limitation and Challenges

- Black box: difficult to understand mechanism
- Naturalness vs factualness
  - E.g. “Clinton was born in DDDD, and was educated in the university of edinburg”
- Negation
  - E.g. “love” vs “does not love”
- Non-compositional expressions
  - E.g. “kick the bucket”

Take-away Messages

- Noah's Ark Lab is working on
  - Intelligent telecommunication networks
  - Intelligent mobile devices
  - Intelligent enterprise
- Recent breakthrough in representation learning of sentence meaning
  - Neural networks, i.e., deep learning
  - Big Data
  - Task-oriented
  - Error-driven learning, back-propagation
  - Compositional
- Noah's Ark Lab is working on DL for NLP
  - Natural language dialogue
  - Machine translation
  - Image retrieval

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Thank you!

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