



# Conversational AI Research

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Recent Advances and Challenges on  
Human-Computer Conversational Systems

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# Commercial Conversational Systems in Progress



## Problem Formulation

- What makes a conversation
  - Given a user utterance as the query
  - The system returns with a response
  - How to “think” like humans?
    - Contexts
    - World knowledge
    - Logic consistency
- Why so hot?
  - Timing
  - (Big) Data Driven
- Challenges
  - Do we really understand instincts about conversations?
  - Relevance, interestingness, and informativeness



## ■ Categorization by Peking University [IJCAI 2018]

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- Domain
  - Open domain: chit-chat
  - Vertical domains: finance, law, and healthcare, etc.
- How to Respond
  - Retrieval-based conversational system
    - Mainstream in industry
  - Generation-based conversational system
    - Rising trend w/ deep learning
  - System ensemble
- Scenario
  - Single turn vs. multi-turn conversations
- “Style”
  - Passive conversational system vs. proactive conversational system

## Matching for Retrieval

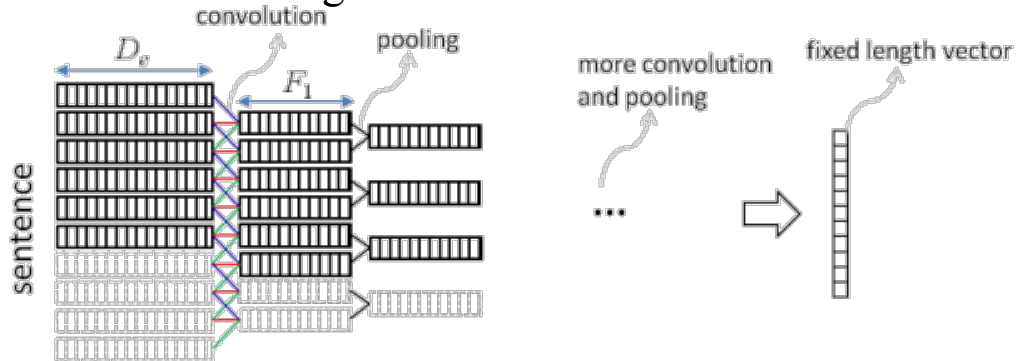
### - Matching Model

- Inner product between two representations

$$\text{match}(x, y) = \langle \Phi_y(x), \Phi_x(y) \rangle_{\mathcal{H}}$$

$$\text{match}(\mathbf{x}, \mathbf{y}) = \mathbf{x}^T \mathbf{A} \mathbf{y} = \sum_{m=1}^{D_x} \sum_{n=1}^{D_y} A_{nm} x_m y_n$$

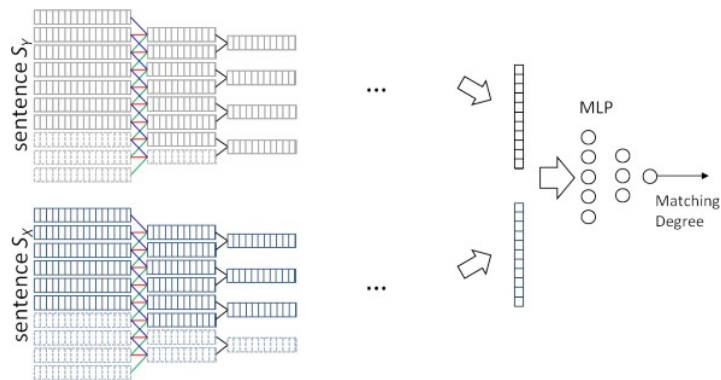
- One-hot Representation
- Representation learning: convolutional and/or recurrent NN



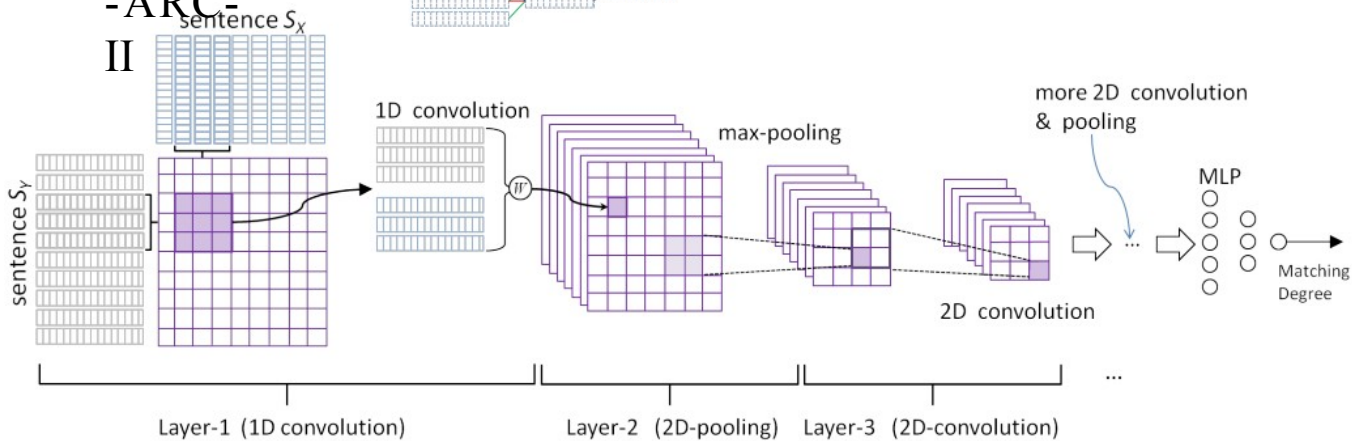
# Classic Matching Models

-Huawei Noah Lab [NIPS 2014]

- ARC-I



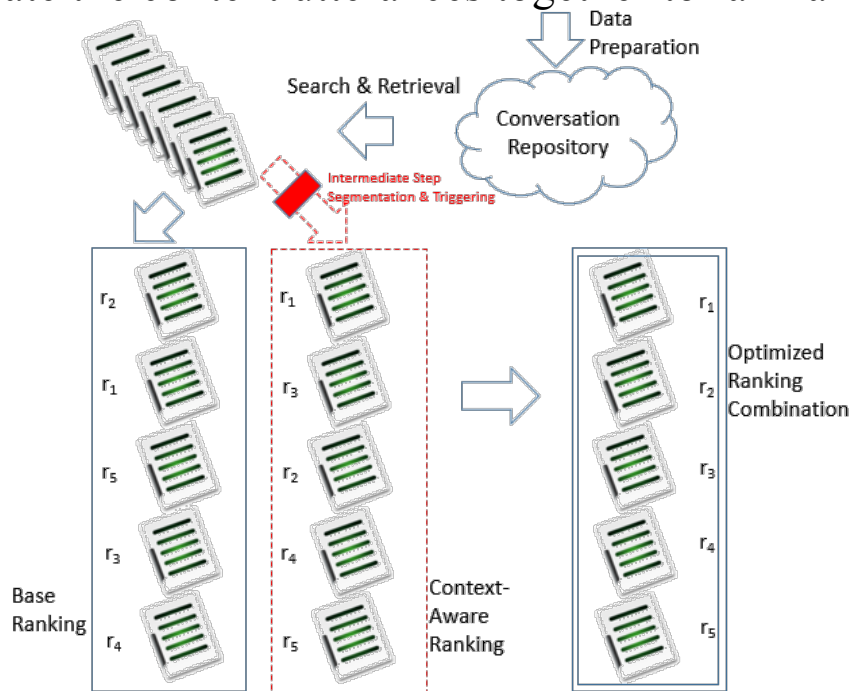
-ARC-II



## Retrieval-based System for Multi-Turn Conversations

- Baidu Inc. and **Peking University [CIKM 2016]**

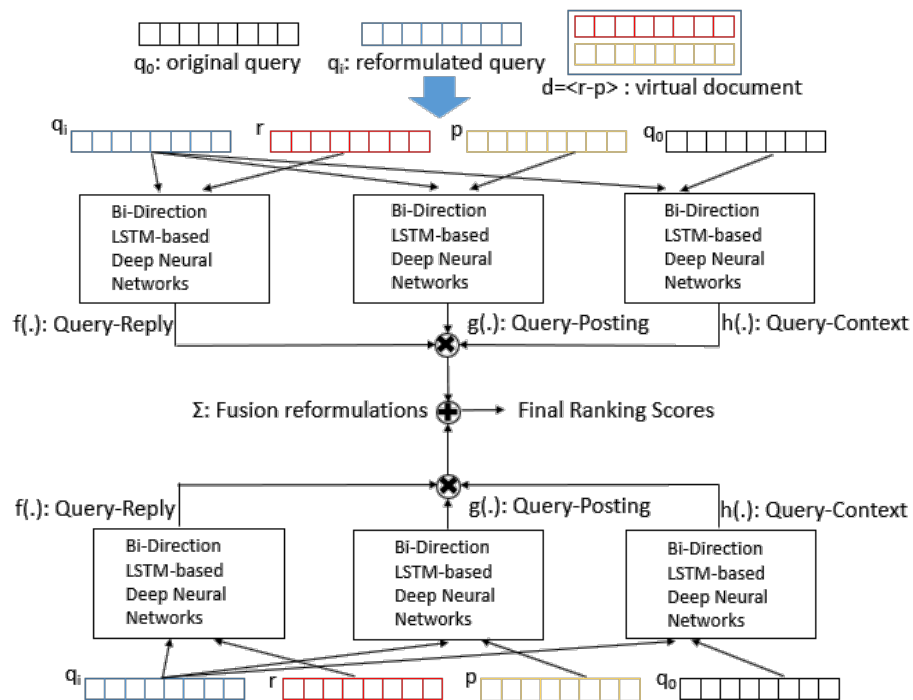
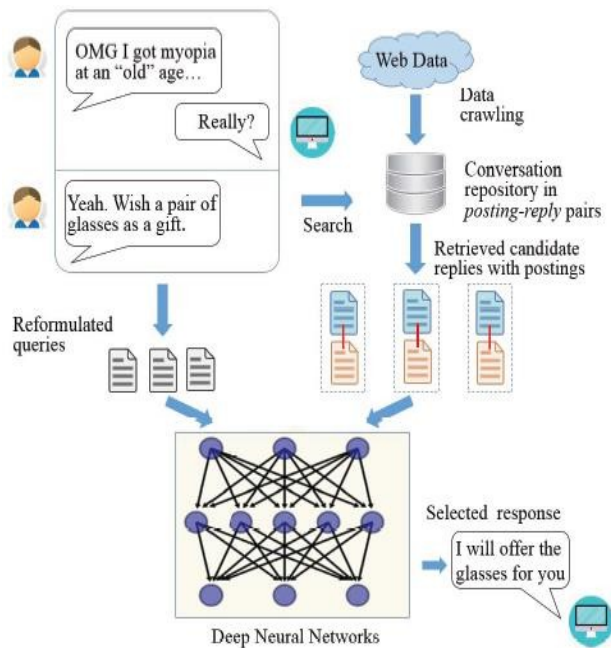
- Context-aware
- To incorporate the context utterances together to rank and re-rank



# Enhanced Context Modeling

- Baidu Inc. [SIGIR 2016]

- A query reformulation framework
- Sum-product process

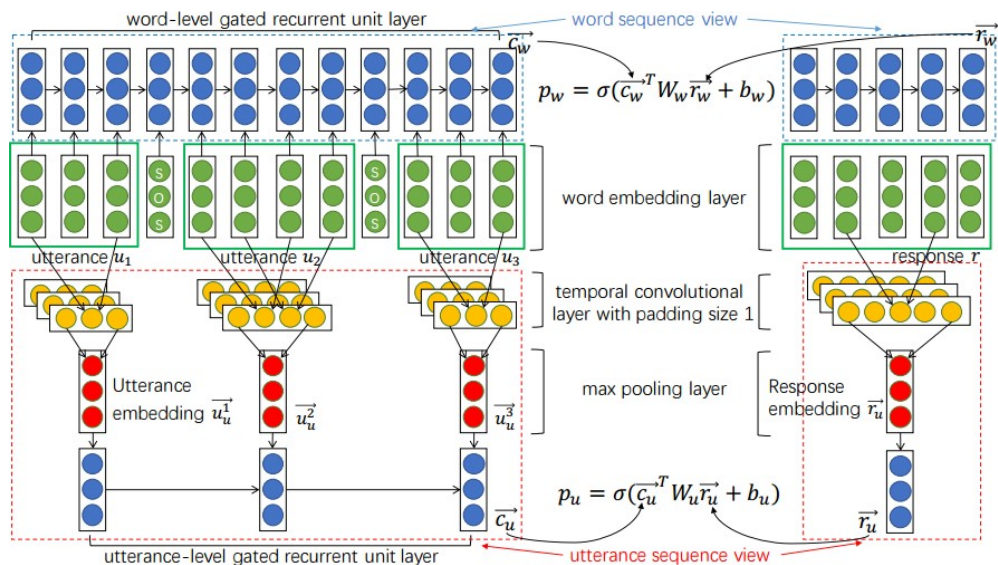
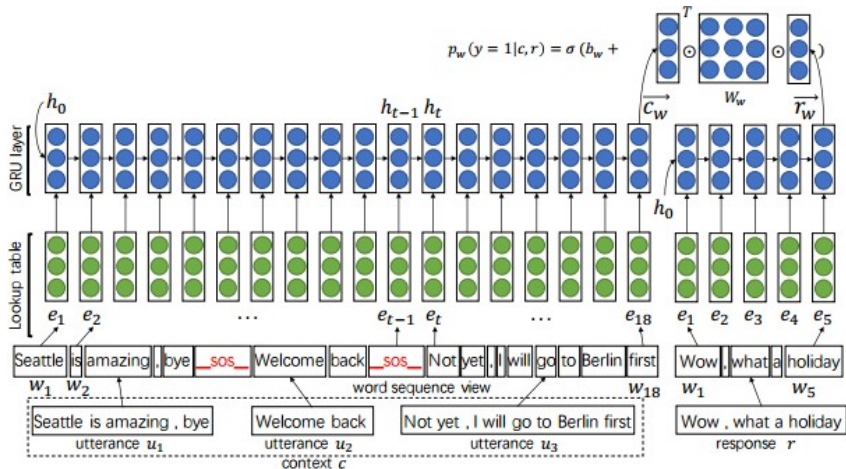




# Multi-View in Matching

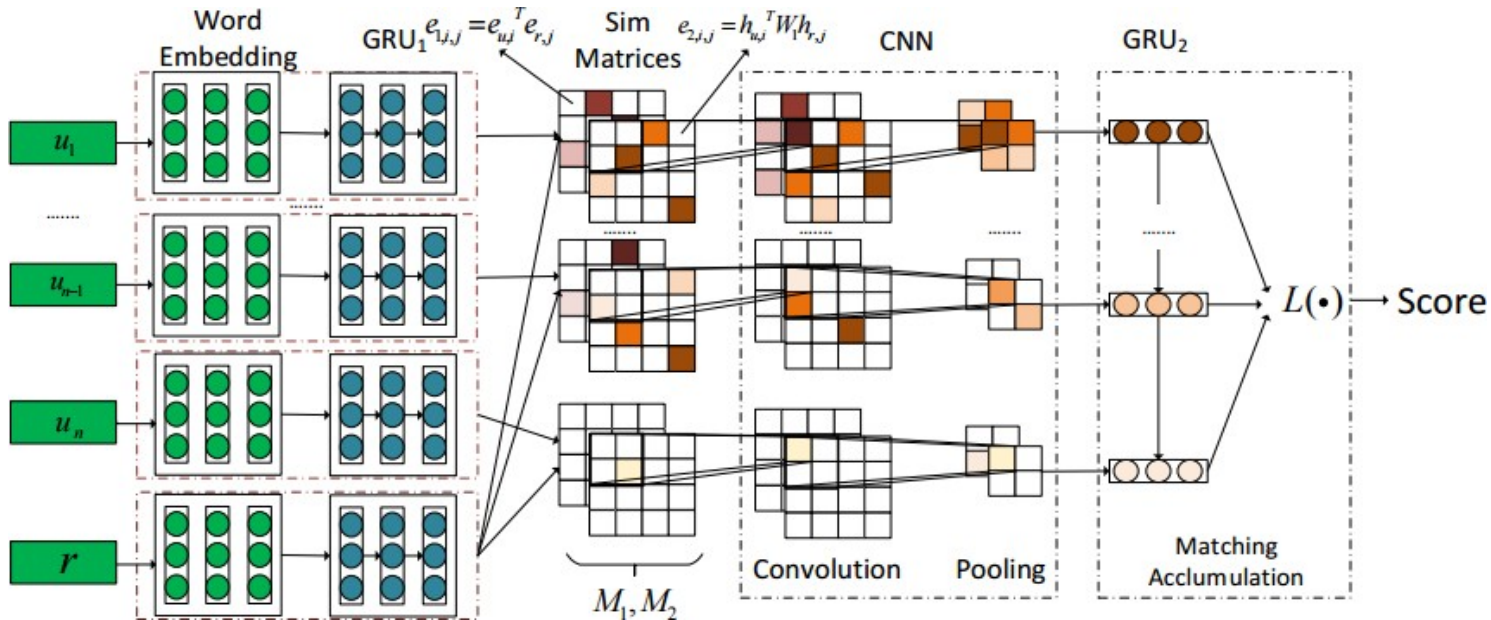
- Baidu Inc. [EMNLP 2016]

- Multi-View
- Hierarchical formulation: word-level and sentence-level



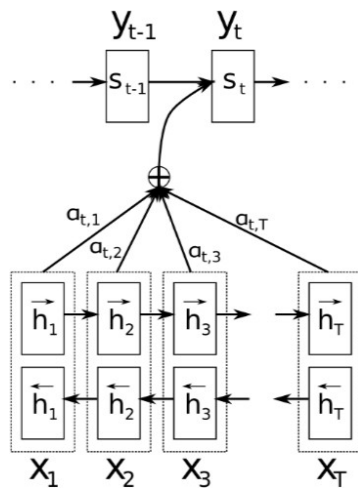
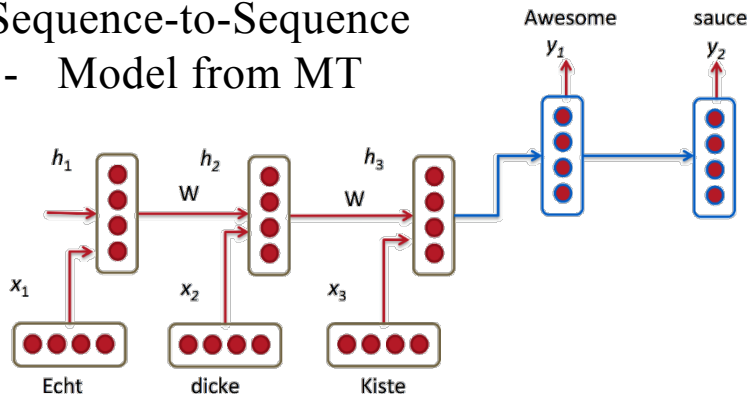
## Matching as a Sequence

- Microsoft Research Asia [ACL 2017]
  - A sequential matching network
  - Hierarchical representation: word-level and segment-level in multi-channel

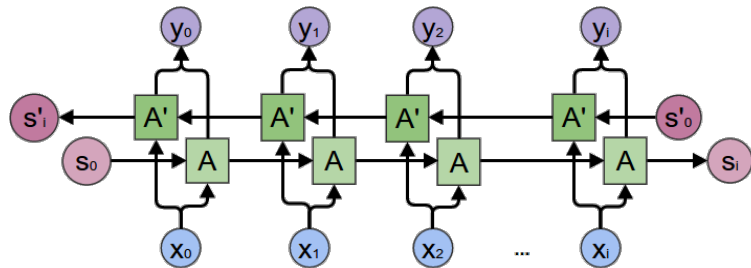


# Generation-based Conversations

- Sequence-to-Sequence
  - Model from MT

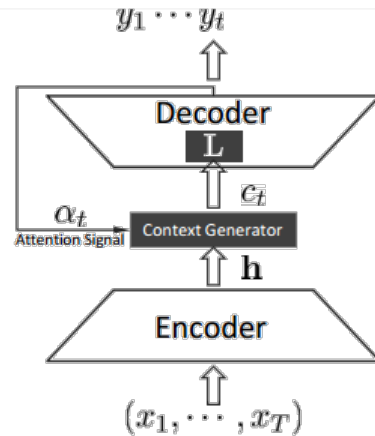


- Attention mechanism
- Bi-directional modeling
- Context modeling, [Peking University \[ACL 2017\]](#)

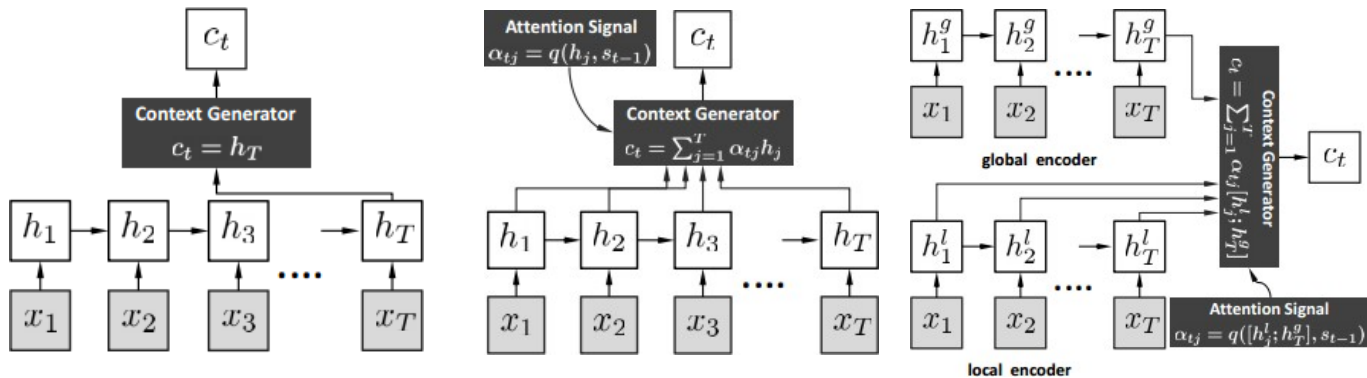


# Seq2Seq w/ Attention

- Huawei Noah Lab [ACL 2015]
  - Encoder-Decoder

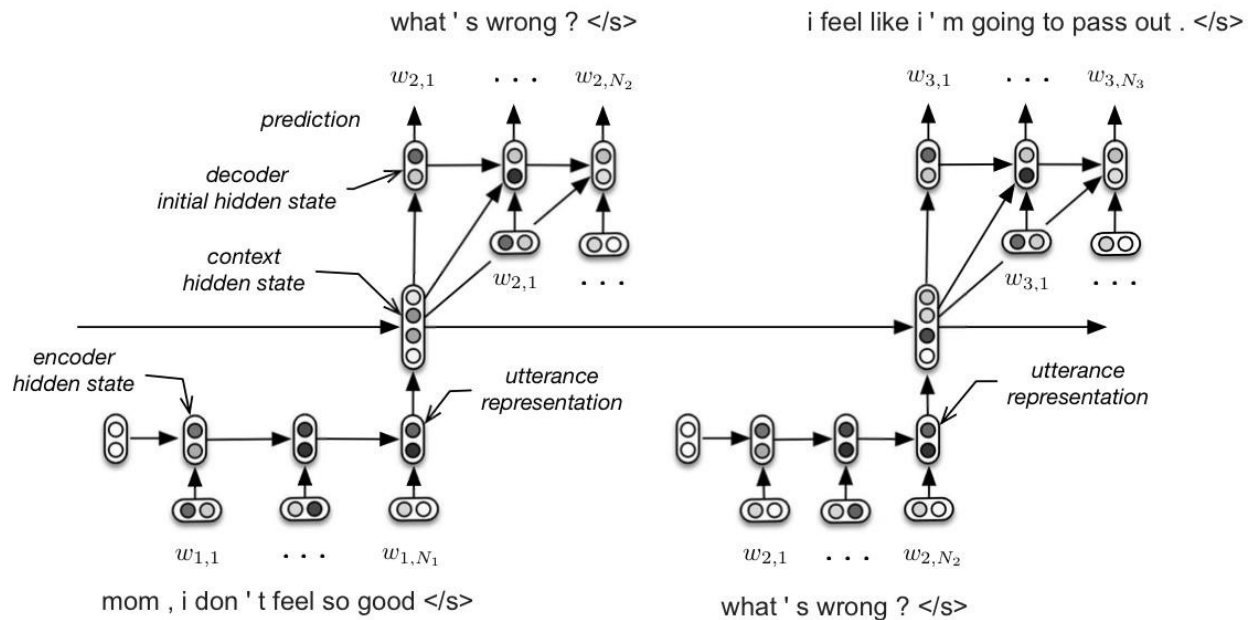
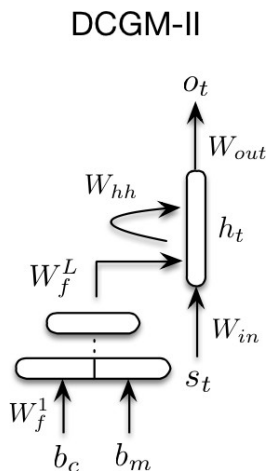
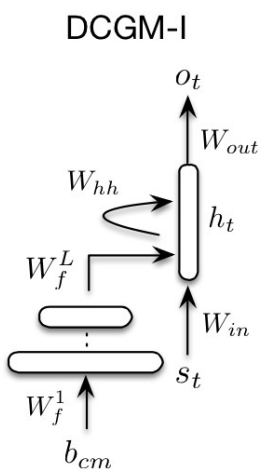


- Model variants  $\times 3$



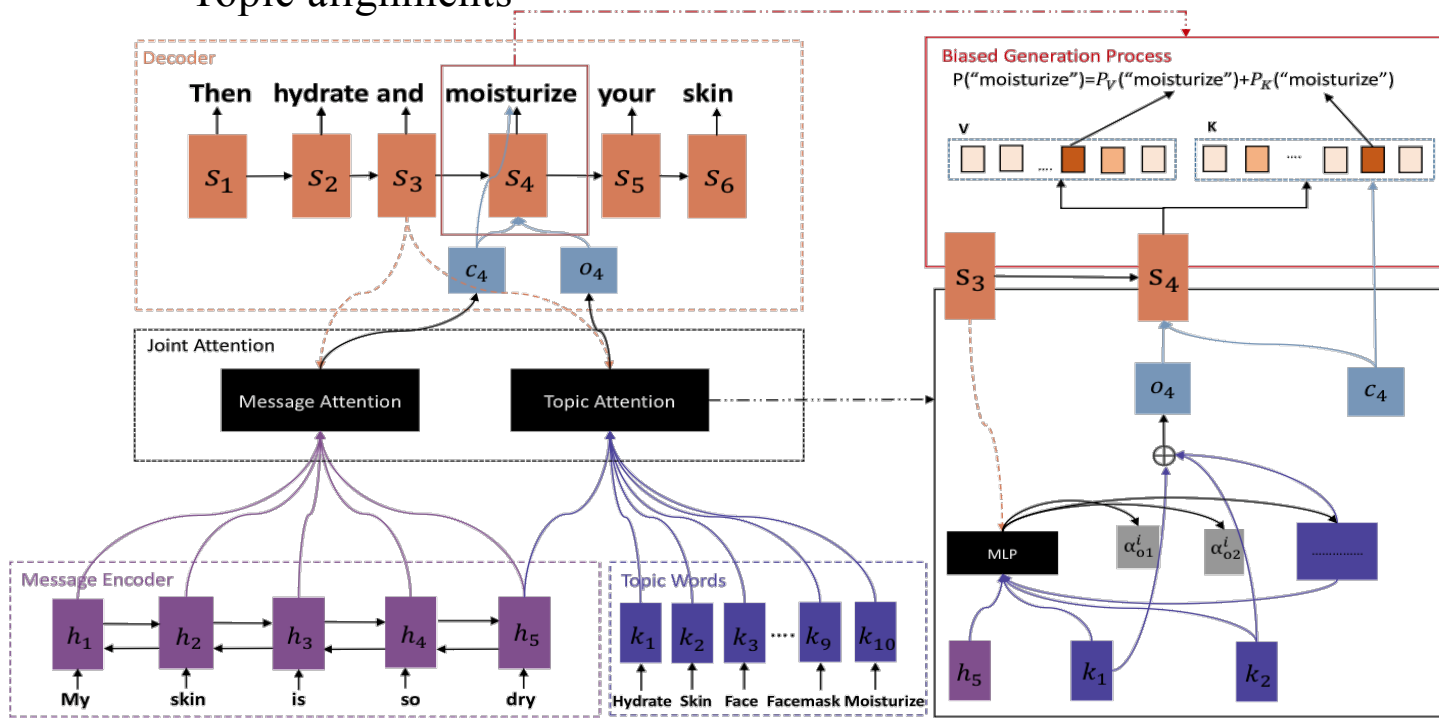
## Generation-based Conversations: Multi-Turn

- University of Montreal [NAACL 2015 ; AAAI 2016]
  - Context-aware
  - In hierarchies



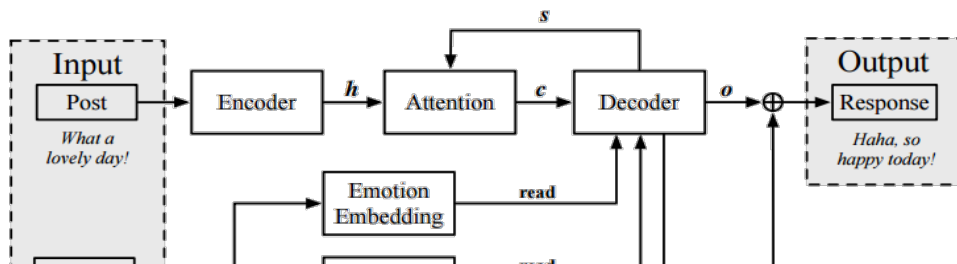
# Topic in Conversations

- Microsoft Research Asia [AAAI 2017]
  - Seq2Seq for semantics
  - Topic alignments



# Emotions in Conversations

- Tsinghua University [AAAI 2018]
  - Emotion classification
  - Emotion control and fusion

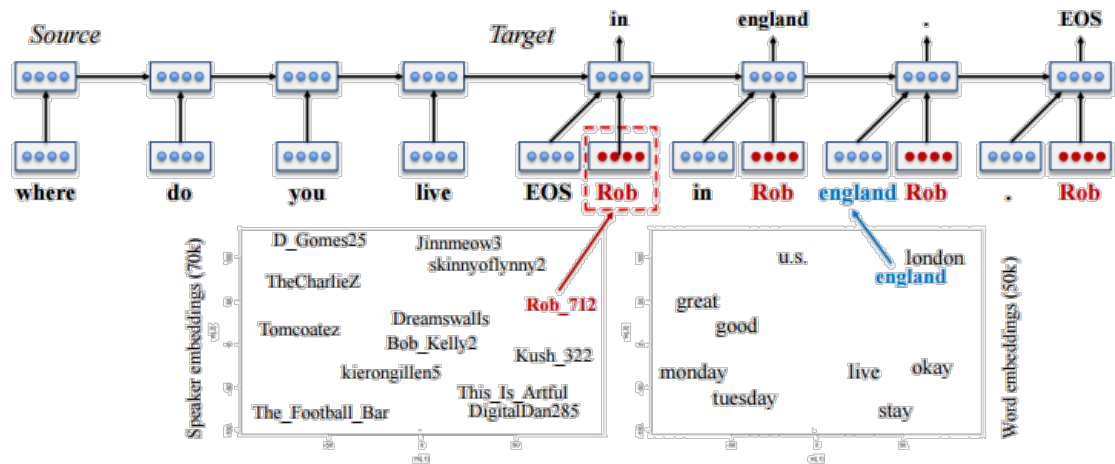


Post	Model	Response(Original)	Response(Translated)	
承诺，就是一个骗子说给一个傻子听的。 A promise is what a cheater says to a fool.	Seq2Seq	承诺，就是一个骗子说给一个傻子听的。	A promise is what a cheater says to a fool.	
	ECM	Like	承诺是一个 <b>专一</b> 的傻子	Promise is a <b>single-minded</b> fool
		Happy	我就是 <b>一个开心的</b> 傻子	I'm just a <b>happy</b> fool
		Sad	我就是 <b>一个悲伤的</b> 傻子	I am a <b>sad</b> fool
		Disgust	一个 <b>骗子</b> 说给一个 <b>傻子</b> 听	A <b>cheater</b> says to a <b>fool</b>
		Angry	不管你信不信，反正我信了！	Whatever you believe or not, I trust in it!
知道真相的我眼泪掉下来 Knowing the truth, I laughed myself to tears	Seq2Seq	知道真相的我眼泪掉下来。	After knowing the truth, I burst into tears.	
	ECM	Like	<b>太可爱了，太可爱了！</b>	<b>Too lovely, it's too lovely.</b>
		Happy	笑得我眼泪都出来了。	I can't help laugh myself to tears.
		Sad	知道真相的我 <b>眼泪</b> 掉下来。	After knowing the truth, I burst into <b>tears</b> .
		Disgust	这是真的还是假的？	Is this true?
		Angry	什么意思？没看懂。	What do you mean? I don't understand.

# Persona in Conversations

- Stanford University [ACL 2016]
  - Persona in conversations
  - Consistency in personality and languages

<i>message</i>	Where do you live now?
<i>response</i>	I live in Los Angeles.
<i>message</i>	In which city do you live now?
<i>response</i>	I live in Madrid.
<i>message</i>	In which country do you live now?
<i>response</i>	England, you?
<i>message</i>	Where were you born?
<i>response</i>	I was born in Canada.
<i>message</i>	Where are you from?
<i>response</i>	England, you?
<i>message</i>	Where did you grow up?
<i>response</i>	I grew up in Texas.
<i>message</i>	How old are you?
<i>response</i>	16 and you?
<i>message</i>	What's your age?
<i>response</i>	18.
<i>message</i>	What is your major?
<i>response</i>	I'm majoring in psychology
<i>message</i>	What did you study in college?
<i>response</i>	English lit.





## Diversity in Conversations

- Stanford University [NAACL 2016]
  - Why lack of diversity in generation-based conversations
    - I don't know
    - Me too
  - Traditional objective function:

$$\hat{T} = \arg \max_T \{ \log p(T|S) \}$$

- Optimized objective function with a penalty factor

$$\hat{T} = \arg \max_T \{ \log p(T|S) - \lambda \log p(T) \}$$

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**Input:** What are you doing?

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1. I've been looking for you.
2. I want to talk to you.
3. Just making sure you're OK.

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**Input:** What is your name?

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1. Blue!
2. Peter.
3. Tyler.

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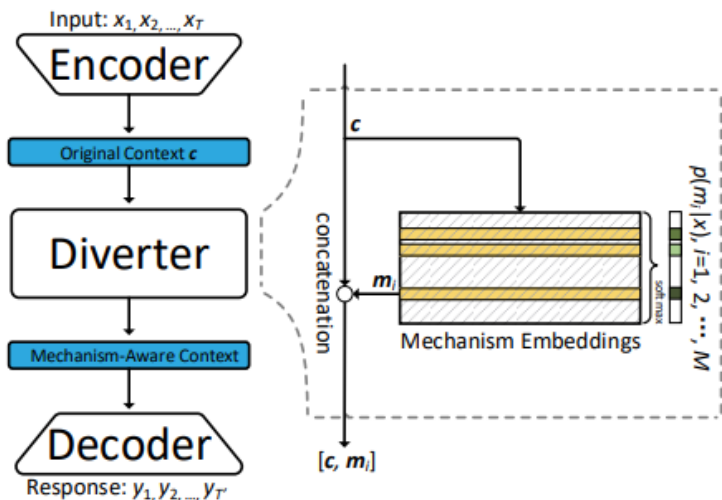
**Input:** How old are you?

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1. Twenty-eight.
  2. Twenty-four.
  3. Long.
-

# Mechanism-Aware Conversations

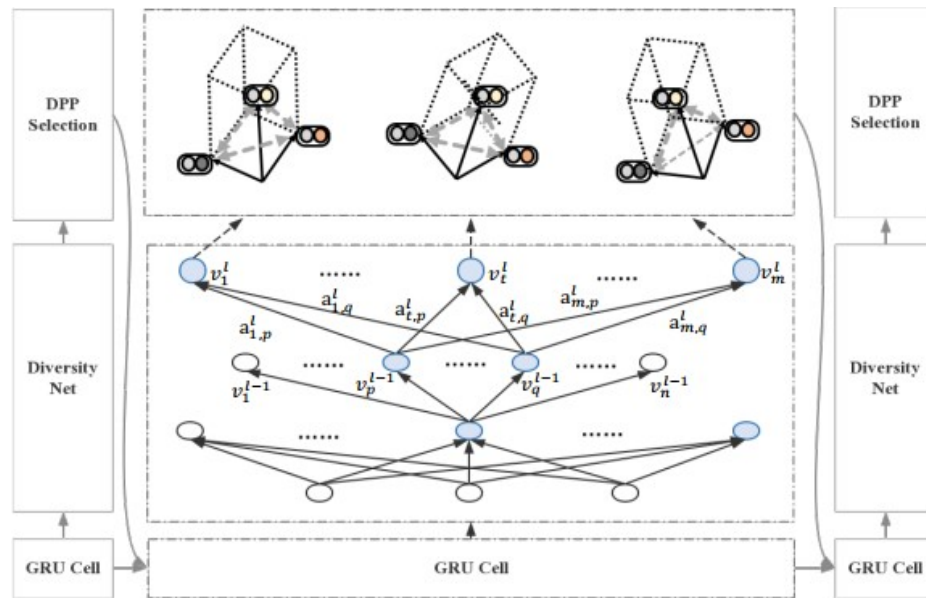
- Chinese Academy of Science [AAAI 2017]
  - Mechanism: hidden categories of representations
  - Seq2Seq -> Seq2Mechanism2Seq



Questions	Mechanism 1	Mechanism 2	Mechanism 3	Mechanism 4
我要坐地铁回家 I take subway back home	好的，路上注意安全 Ok, be safe on the subway	真是不错的选择 That's a good choice	坐车去哪里 Where are you going on the subway	坐车一定要注意安 Be careful on the subway
生活中怎样感到开心快乐 How do I feel happy in my life	开心就来和我聊天 Have a talk with me if you are happy	看来你今天心情很不错 You seem to be happy today	有什么开心的事情 What are the happy things you have experienced	和我聊天就很开心 Talk with me and you will be happy
明天考试、求安慰 I have a test tomorrow, and I need some solace	好好复习就好了 Just work hard on the reviews	我会为你加油的 I will stand by you	你要去哪里试试 Where are you taking the test	我会一直安慰你的 I will always be on your side
上班好累啊 The work is really hard	那就好好休息 Take a good rest	要懂得劳逸结合 You need to balance work and life	你是不是累了 Are you tired	上班就是这样 That is work

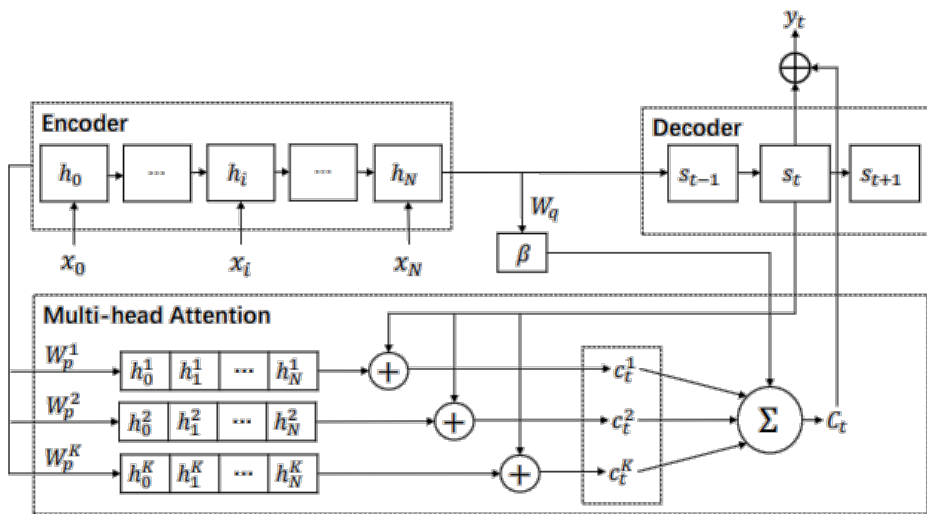
## Diversity in Conversations

- Peking University [AAAI 2018]
  - Determinantal Point Process
  - Two model variants
    - DPP Re-Ranker vs DPP Decoder



# Explainable Diversity in Conversations

- Peking University [IJCAI 2018]
  - Why is there diversity in conversations
  - Multi-Head Attention



**Query:** 今天下雨，我们一起去吃火锅吧！

It's rainy today, let's go to eat hot pot!

**Candidate 1:** 我觉得不应该出门，还是在家做饭吧！

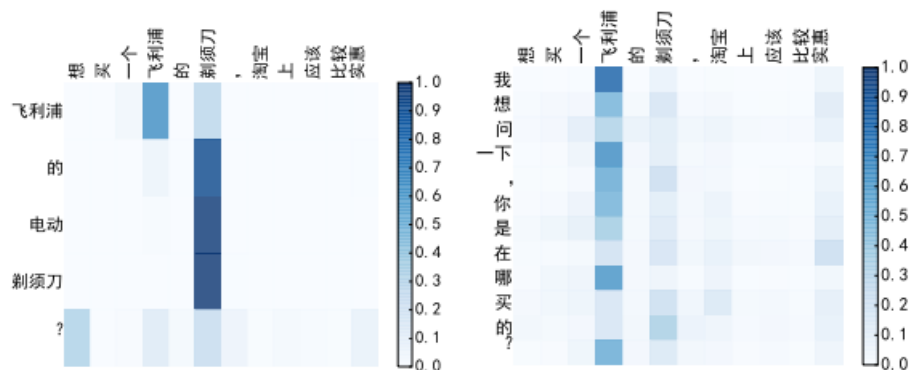
I think we shouldn't go out, let's cook at home!

**Candidate 2:** 好啊，我很久没吃火锅了。

Ok, I have not eaten the hotpot for a long time.

**Candidate 3:** 开车去还是坐地铁？

drive or take the subway?

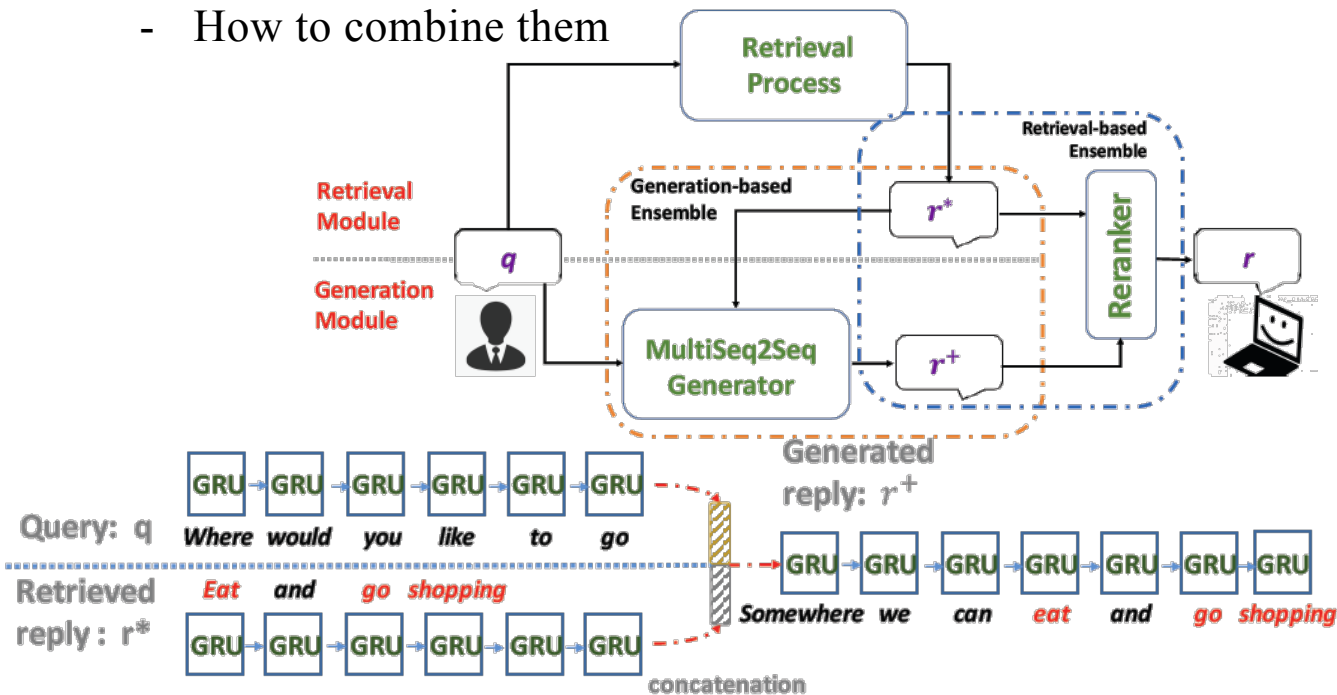


(a) Head-1

(b) Head-2

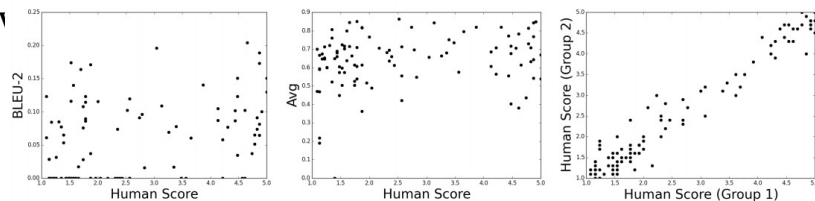
## System Ensemble

- Peking University [IJCAI 2018]
  - Pros and cons in retrieval-based conversational systems
  - Pros and cons in generation-based conversational system
  - How to combine them

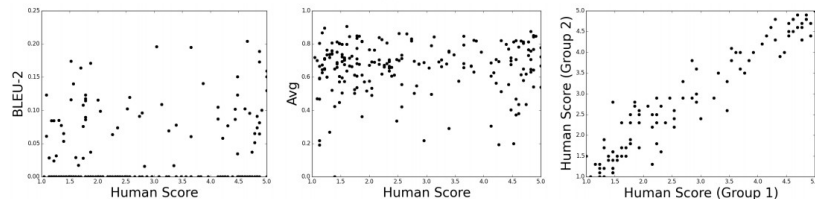


## Evaluation Metrics for Conversations

- Automatic Evaluation Metrics
  - Machine translation: BLEU, METEOR, NIST
  - Summarization ROUGE, Pyramid
  - Dialogue: ?
- Human Evaluations: pair-wise vs point-wise
- University of Montreal [EMNLP 2016]
  - How



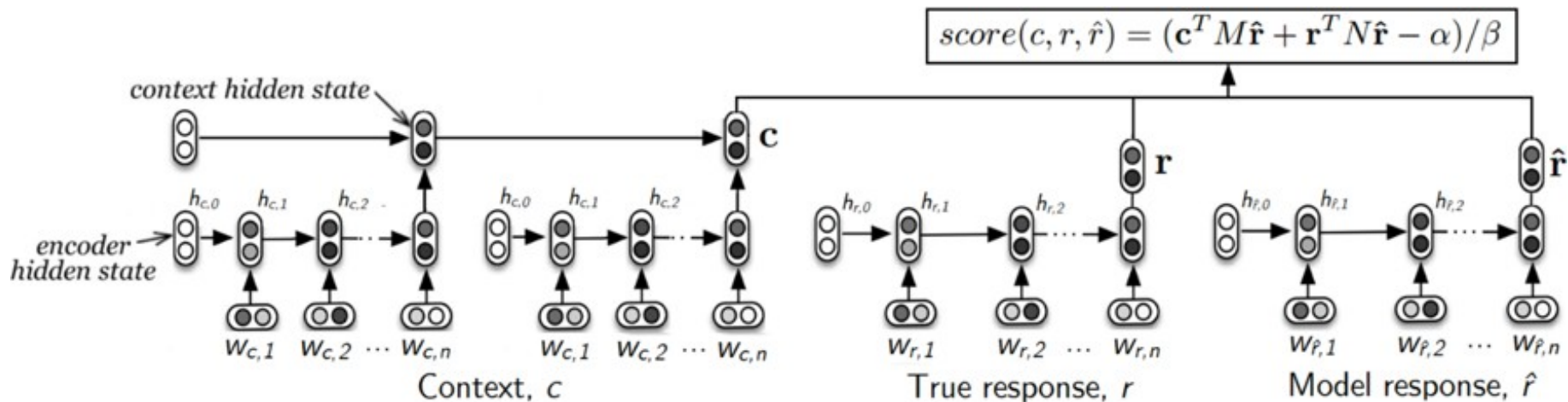
(a) Twitter



(b) Ubuntu

## Learnable Evaluation Metric

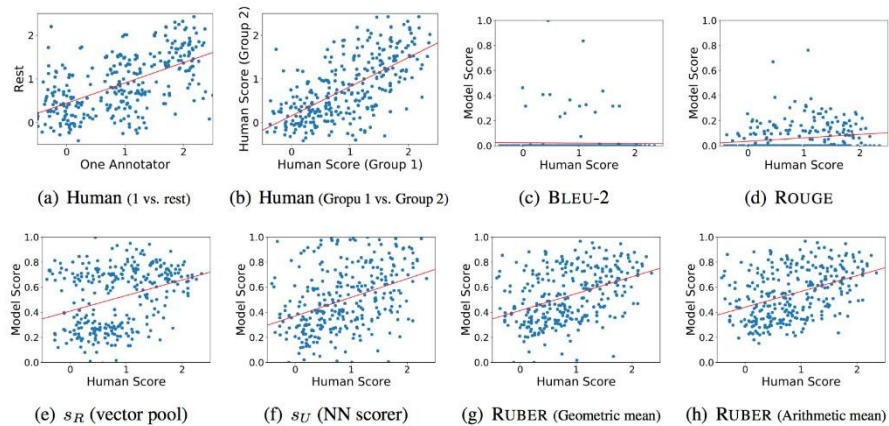
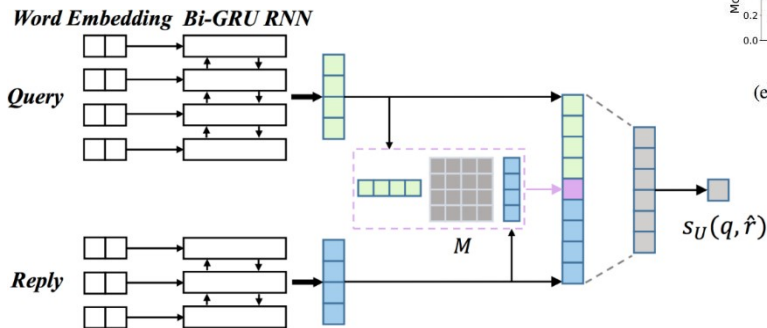
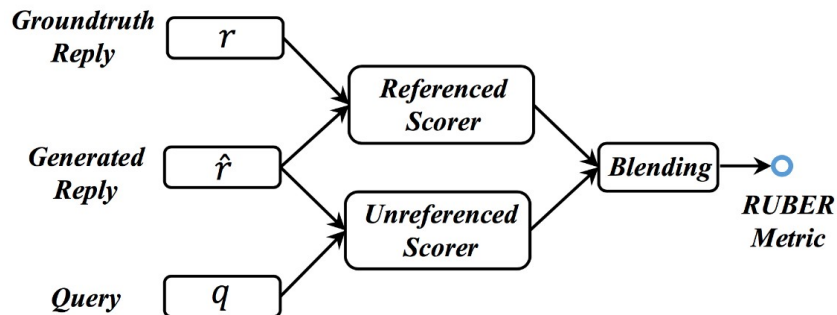
- University of Montreal [ACL 2017]
  - Hierarchical modeling
  - Learning to fit human ratings with labels
  - Predicting human scores



# Referenced and Unreferenced Evaluation: Blending as RUBER

- Peking University [AAAI 2018]

- No human scores are required
- Blending the reference part and the unreferenced part





## Where Are We Now?

- Are we doing just fine?
- Media propaganda
  - Users may have unrealistic expectations...
  - but the AI still looks really stupid
- We still have a long way to go towards conversational AI



# Q & A

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