

Building Intelligent Chatting Machines: Emotion, Personality, and Commonsense Knowledge

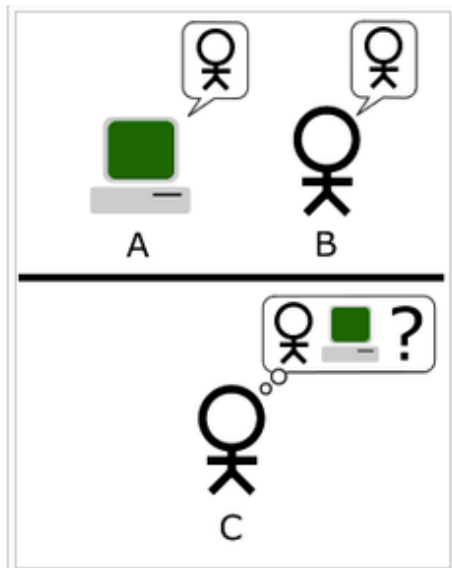
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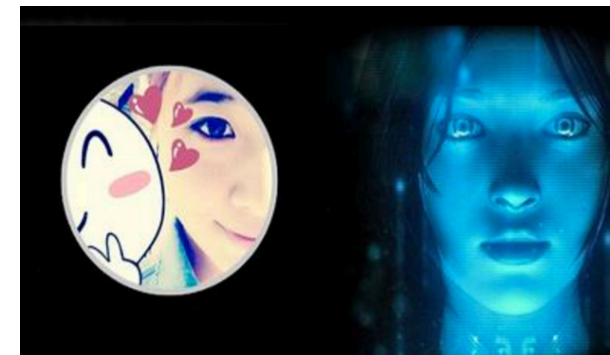
<http://coai.cs.tsinghua.edu.cn/hml/>

Open-domain Chatting and Conversational AI



1950 Turing Test

2010 IBM Watson: Human-level knowledge QA



2014 Xiaoice: virtual partner

Building open-domain chatting machines is one of the most challenging AI tasks.



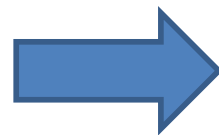
Reshaping Human-Machine Interactions

Microsoft: Conversation
As a Platform (CAAP)



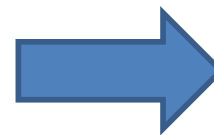
Generation I

Mouse + Keyboard GUI



Generation II

Screen Touch GUI

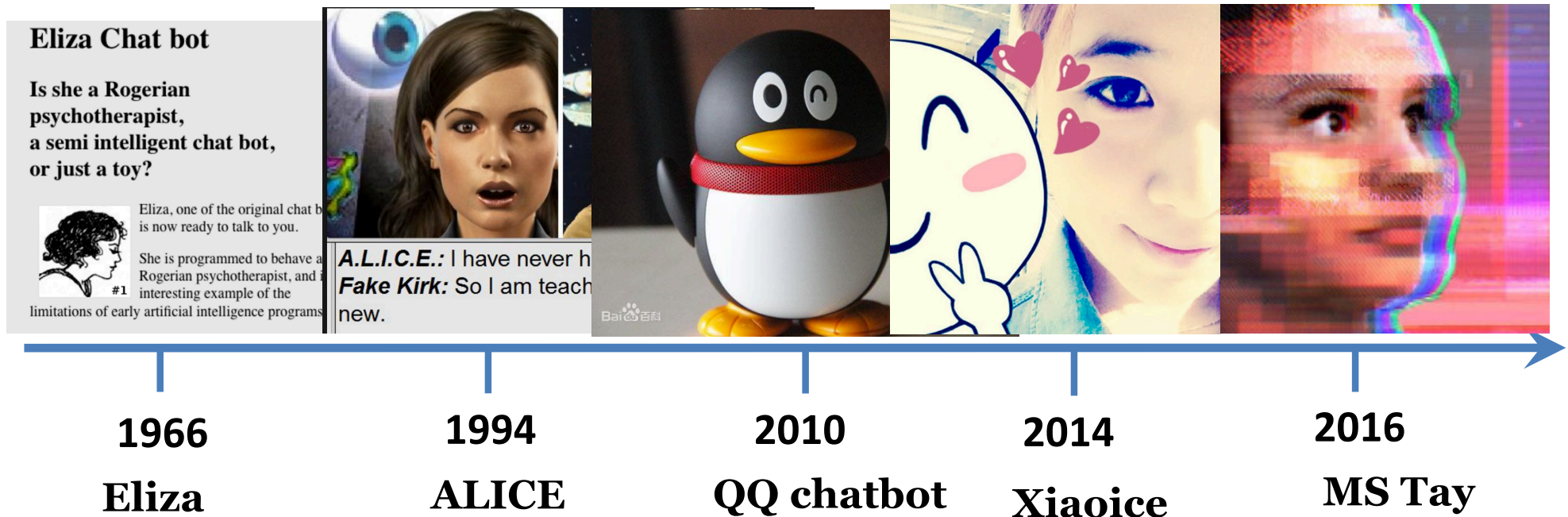


Generation III

Conversational UI

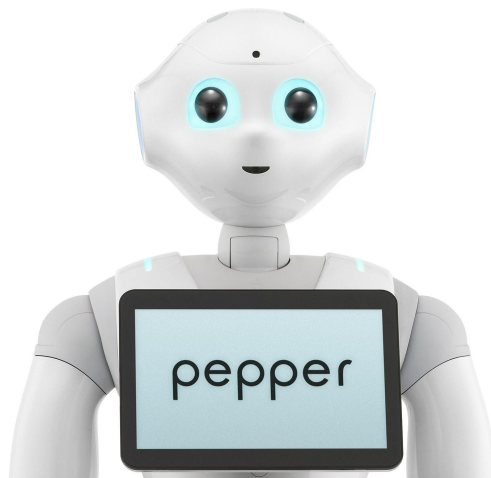


Virtual Conversational Agents



Social Robots (with Physical Body)

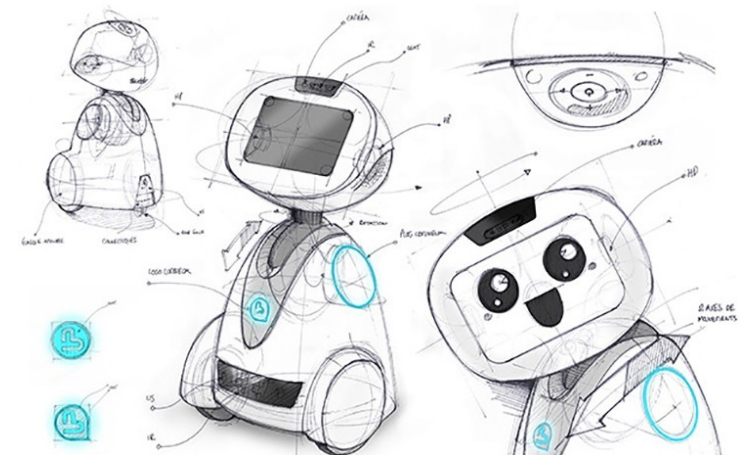
Pepper—humanoid robot
The first robot with
emotions



MIT Jibo: the
world's first social
robot for the home

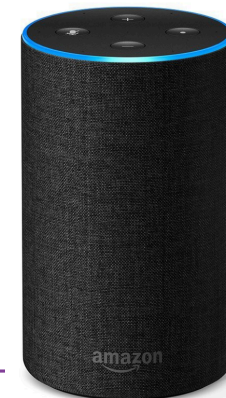


Buddy: protects your home,
entertains the family,
interfaces with devices, and
assists the family

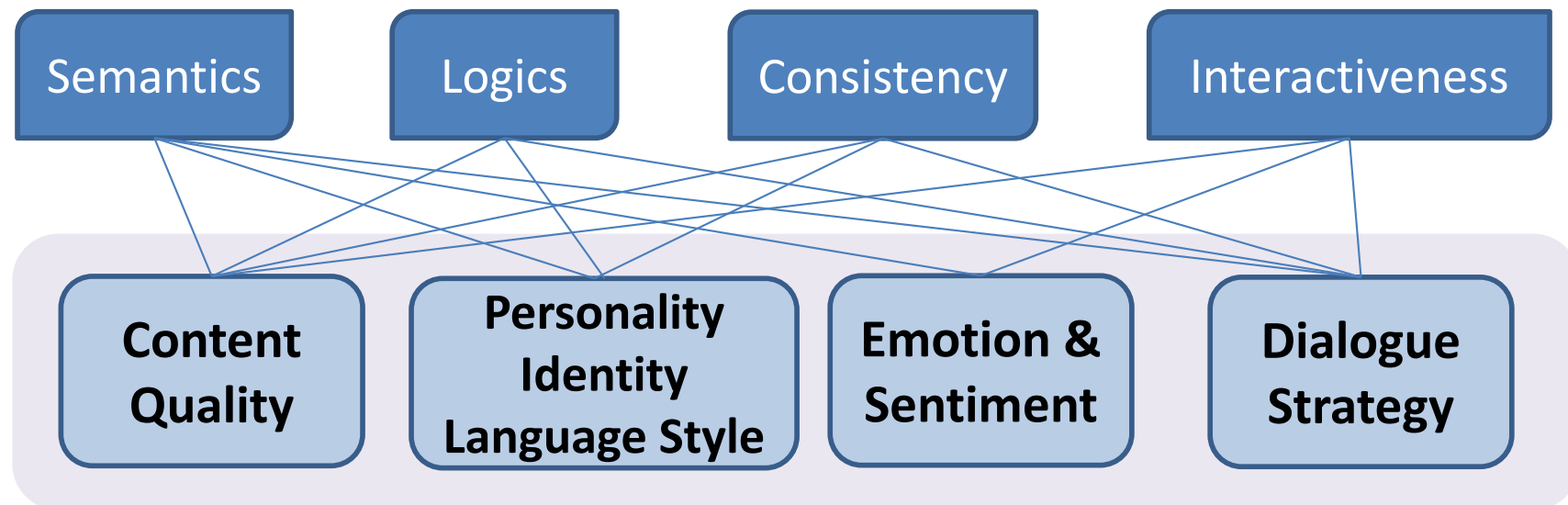


Business Values

- ◎ Personal assistants: **SIRI, DUER, Cortana**
- ◎ AI-aided customer services for industrial companies
- ◎ Robots with HCI (in many scenarios)
- ◎ Natural language interface to recommendation, search and many embedded systems
 - ◆ **Apple homepod**
 - ◆ **Amazon Echo**
 - ◆ **Google Home**



Challenges in Chatting Machines



Open-domain, open-topic conversational agents



Challenges in Chatting Machines

- ◎ **One-to-many:** one input, many many possible responses
- ◎ **Knowledge & Reasoning:** real understanding requires various knowledge, world facts, or backgrounds
- ◎ **Situational Context**
 - ◆ Who are you talking with?
 - Stranger, or friend?
 - ◆ His mood and emotion?
 - ◆ Shared backgrounds that are only accessible by two acquaintances



Good Examples

User: 最幸福的人不是拿到了最好的东西，
而是学会去珍惜手上已经拥有的人。

Machine: 是的，所以我也要珍惜自己的幸福

User: 时间啊，你这把杀猪刀。。。

Machine: 我是被杀的

User: 怕孤独，又捨不下自己的小自由。

Machine: 我想去流浪，但没有人陪我去。



Good Examples

User: 你若安好，便是晴天

Machine: 这句话我爱听，谢谢你的祝福，我会继续努力的！

User: 雪，飘舞。人，行走。树，纯美。天，苍茫。城，安静。

Machine: 好美的意境

User: 欲享受选择之快乐必先经历选择之痛苦

Machine: 是的，人生就是这样，人生的意义就是选择。

User: 有些命里遇见，从相识到相知，到最后的相忘于江湖，似乎都是命中注定。

Machine: 缘来缘去，这就是人生



Bad Examples

User: 其实，他没有那么爱你。

Machine: 幸福的一天开始了。

User: 回北京了！很冷很高兴！

Machine: 什么时候来北京啊？

User: 会做饭的男人是最性感的男人。

Machine: 会做饭的男人是最性感的女人



Bad Examples

User: 猫叔羊毛毡手工作品，太美好了！

Machine: 这是什么品种的猫啊

User: 不得不夸一句广东的饭确实好吃！

Machine: 我也喜欢吃臭豆腐。

User: 我来自上海。

Machine: 真巧，我来自海南，老乡啊



Bad Examples

语义理解的问题

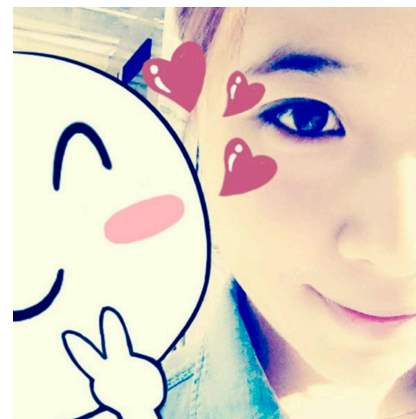
User: 你家多大?

小冰: 这么快就要爆年龄了?

User: 你是素食主义者还是吃肉啊?

小冰: 怎么减肥

微软
小冰



上下文理解的问题

User: 早饭不好吃

小冰: 那明早一起吃

User: 行，你推荐的应该不错

小冰: 是吗?

User: 哈哈，我相信你

小冰: 呃呃

个性身份一致性问题

User: 你几岁了?

小冰: 我啊。。。反正是九零后!

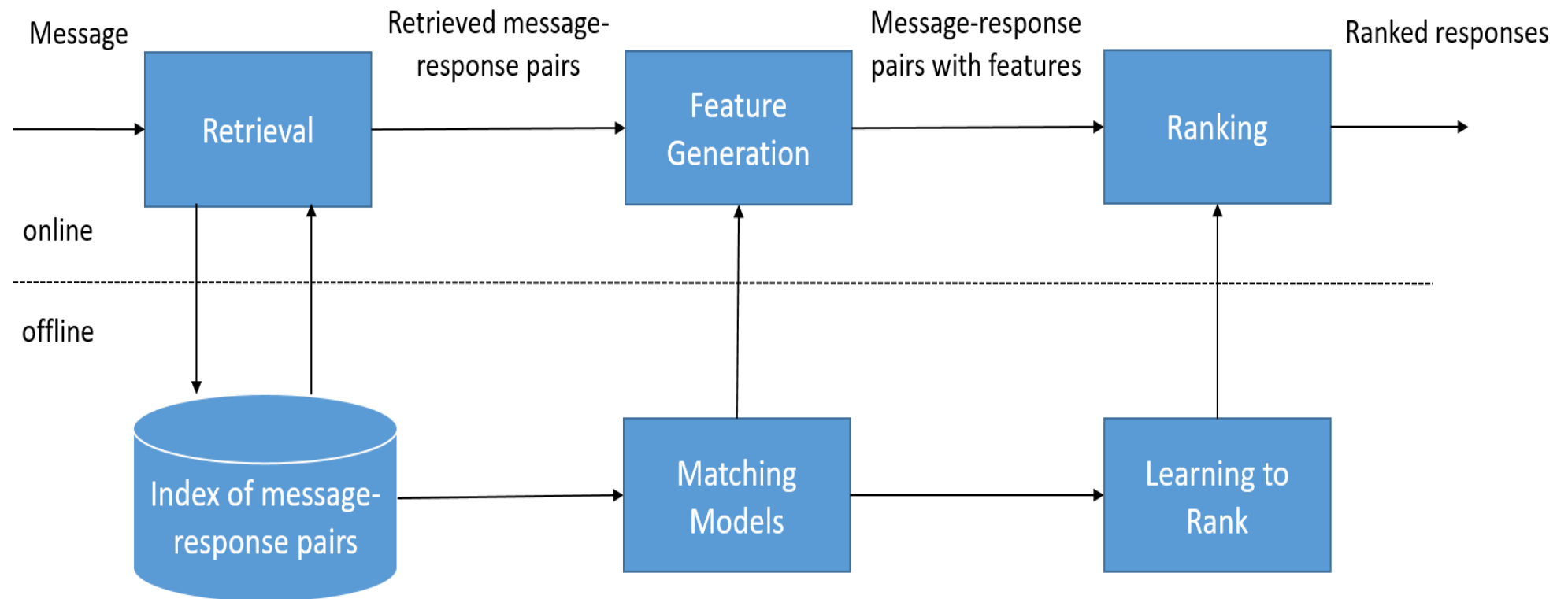
User: 那你是几几年出生的?

小冰: 错，75年阳历一月出生。

User: 你是九零后，怎么会75年出生?

小冰: 生在九零后，在深圳只能被当做八零后了。

Typical Solution I: Retrieval-based



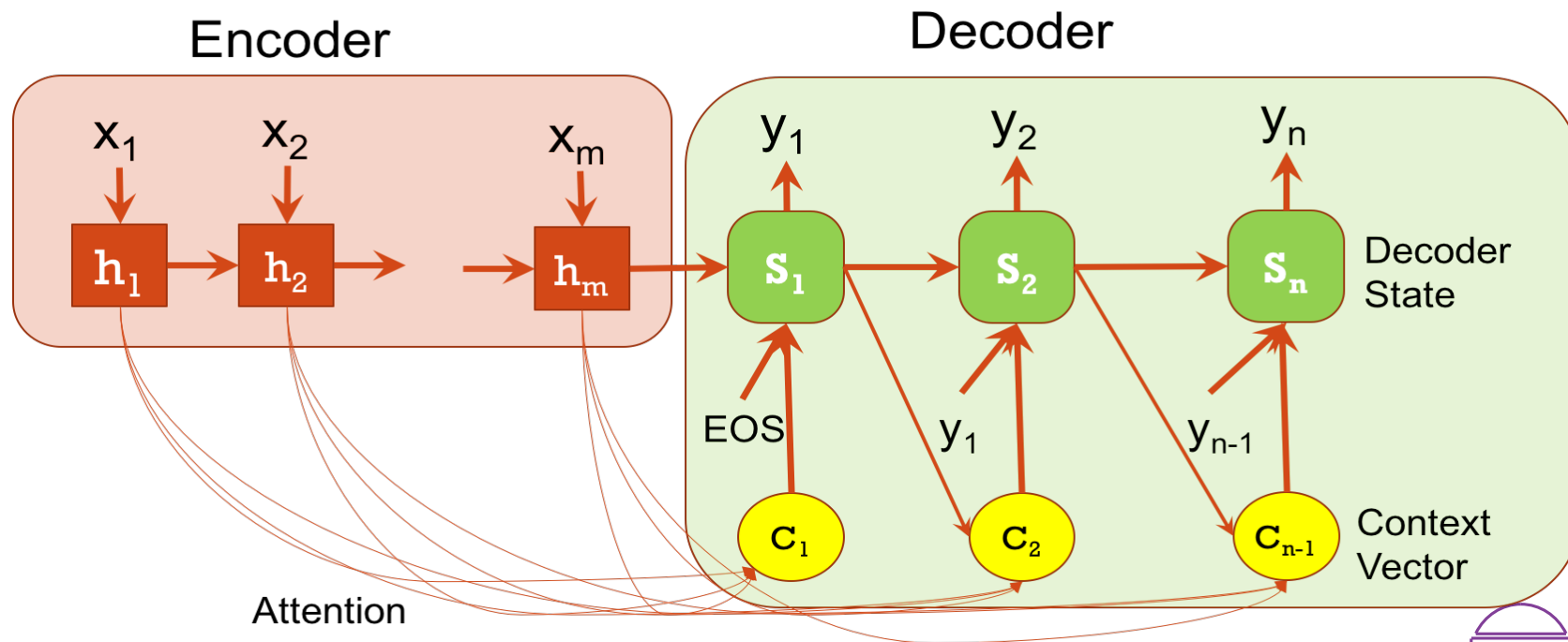
From MSRA Dr. Ming Zhou



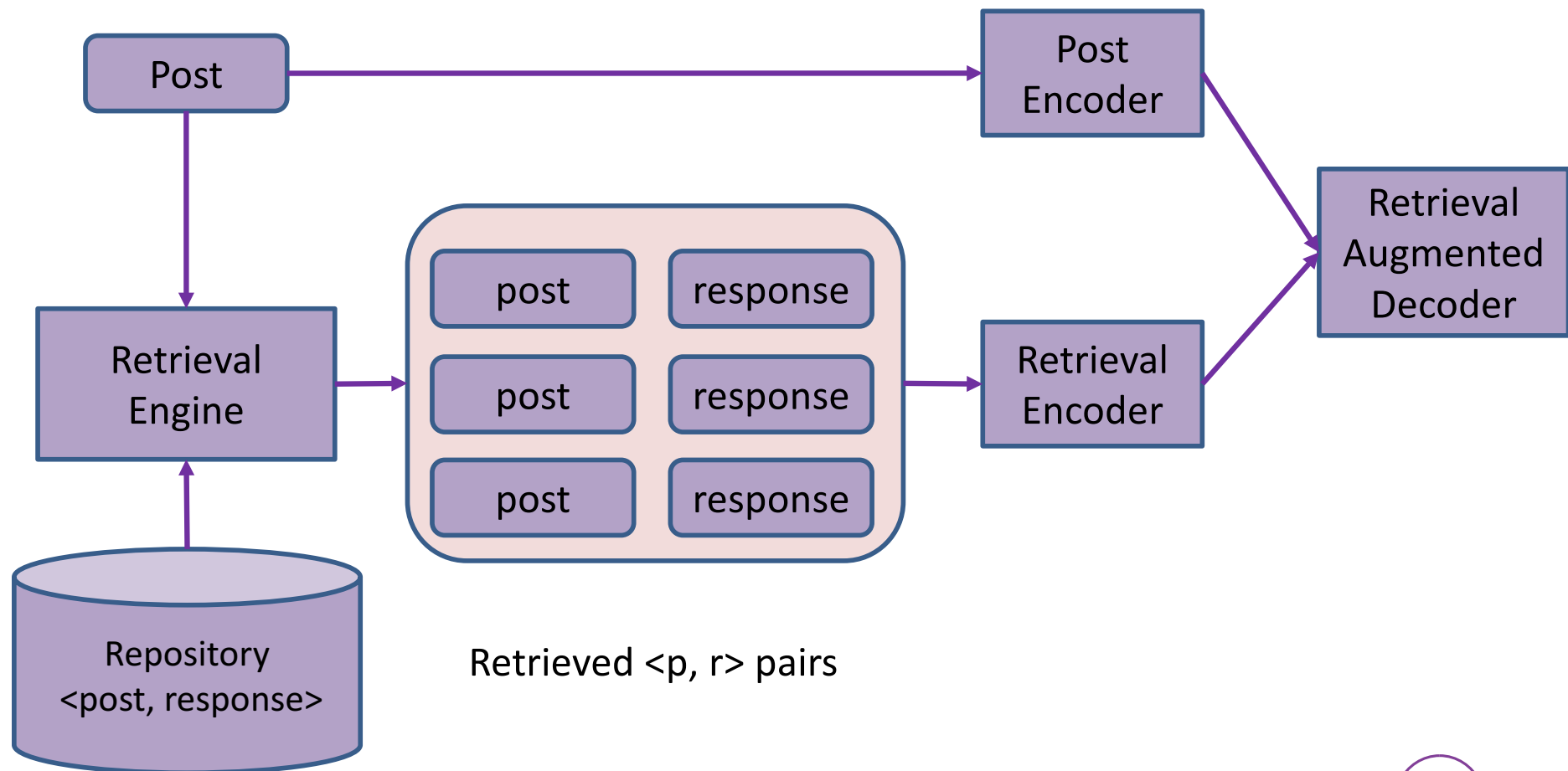
Typical Solution II: Generation-based

User: I am so happy to be here

Machine: Glad with you.



Typical Solution III: Hybrid Methods



Open-domain Chatting Machines

- ① Emotional Chatting Machine (**AAAI 2018**)
- ② Personality Assignment (**IJCAI-ECAI 2018**)
- ③ Commonsense Knowledge (**IJCAI-ECAI 2018**)
- ④ Asking Good Questions (**ACL 2018**)

References:

- ① Emotional Chatting Machine: Emotional Conversation Generation with Internal and External Memory. AAAI 2018.
- ② Assigning personality/identity to a chatting machine for coherent conversation generation. IJCAI-ECAI 2018.
- ③ Commonsense Knowledge Aware Conversation Generation with Graph Attention. IJCAI-ECAI 2018.
- ④ Learning to Ask Questions in Open-domain Conversational Systems with Typed Decoders. ACL 2018.

Emotion



Emotional Chatting Machine

- ◎ **Emotion intelligence** is a key human behavior for intelligence (Salovey and Mayer, 1990; Picard and Picard, 1997)
- ◎ Understanding **emotion and affect** is important for dialogue and conversation
 - ◆ Enhance user performance
 - ◆ Improve user satisfaction
 - ◆ Less breakdowns
- ◎ **Rule-based** emotion adaptation
 - ◆ Widely seen in early dialogue systems

User: Worst day ever. I arrived late because of the traffic.

Chatbot (Basic Seq2seq): You were late.

ECM (*Like*): I am always here to support you.

ECM (*Happiness*): Keep smiling! Things will get better.

ECM (*Sadness*): It's depressing.

ECM (*Disgust*): Sometimes life just sucks.

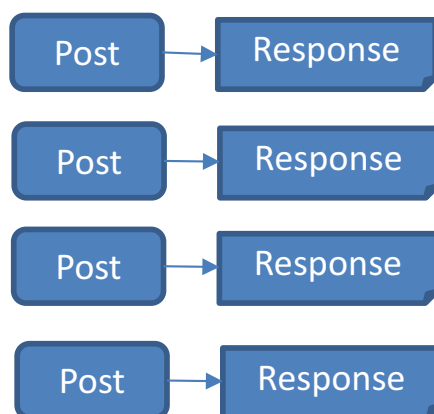
ECM (*Anger*): The traffic is too bad!



Emotional Chatting Machine

Perceiving and Expressing emotion by machine
Closer to human-level intelligence

Social Interaction Data



Emotion
Classifier

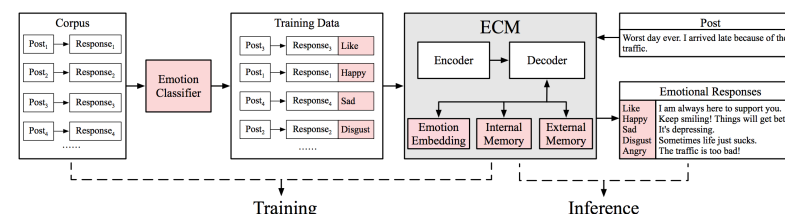


Emotion
Tagged
data



今天领导前来视察工作！
Happy: 哈哈，领导视察工作辛苦了
Like: 这是一个很有特色的领导人
Sad: 我想知道，谁来帮我干活？
Angry: 这是要干什么？领导？

Emotional Chatting
Machine



Our work is reported by **MIT Technology Review, the Guardian, Cankao News, Xinhua News Agency etc.**

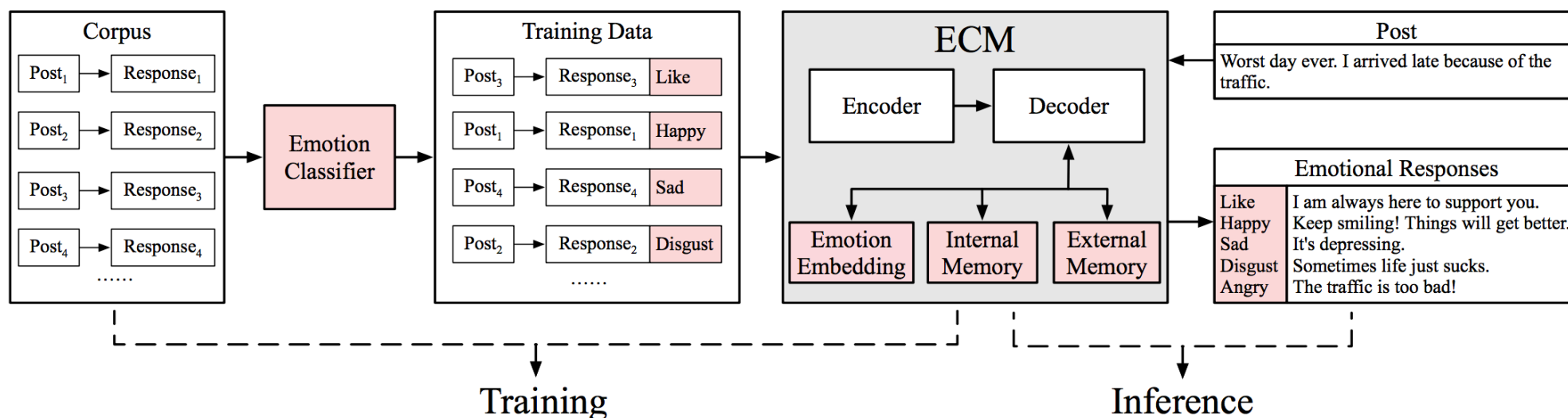
Prof Björn Schuller: “an important step” towards personal assistants that could read the emotional undercurrent of a conversation and respond with something akin to empathy.

•Hao Zhou, Minlie Huang, Xiaoyan Zhu, Bing Liu. Emotional Chatting Machine: Emotional Conversation Generation with Internal and External Memory. **AAAI 2018.**



Emotional Chatting Machine

- Emotion category embedding: High level abstraction of emotions
- Emotion internal state: Capturing the change of emotion state during decoding
- Emotion external memory: Treating emotion/generic words differentially



•Hao Zhou, Minlie Huang, Xiaoyan Zhu, Bing Liu. Emotional Chatting Machine: Emotional Conversation Generation with Internal and External Memory. **AAAI 2018**.



Emotional Chatting Machine

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 专一 的傻子	Promise is a single-minded fool
		Happy 我就是个 开心 的傻子	I'm just a happy fool
		Sad 我就是个 悲伤 的傻子	I am a sad fool
		Disgust 一个 骗子 说给一个 傻子 听	A cheater says to a fool
		Angry 不管你信不信，反正我信了！	Whatever you believe or not, I trust in it!
知道真相的我眼泪笑下来 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 太 可爱 了，太 可爱 了！	Too lovely , it's too lovely .
		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 眼泪 掉下来。	After knowing the truth, I burst into tears .
		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.

•Hao Zhou, Minlie Huang, Xiaoyan Zhu, Bing Liu. Emotional Chatting Machine: Emotional Conversation Generation with Internal and External Memory. **AAAI 2018**.



More Examples

情绪	post:早上的天气不错啊！哈哈
other	哈哈
喜欢	今天是个好天气。
喜欢	今天的天气不错啊！
悲伤	天气好，心情不好。
厌恶	这是哪里啊？求解释
愤怒	怎么了？什么情况？
快乐	今天的天气真好啊！

情绪	post:为了解决抄作业的坏习惯，
other	高数老师这回要出绝招了！
喜欢	这老师是要逆天吗？
喜欢	这老师太有才了！
悲伤	这样的老师伤不起啊
厌恶	这老师也太狠了点吧
愤怒	这老师是要逆天啊！
快乐	哈哈，这老师太有才了

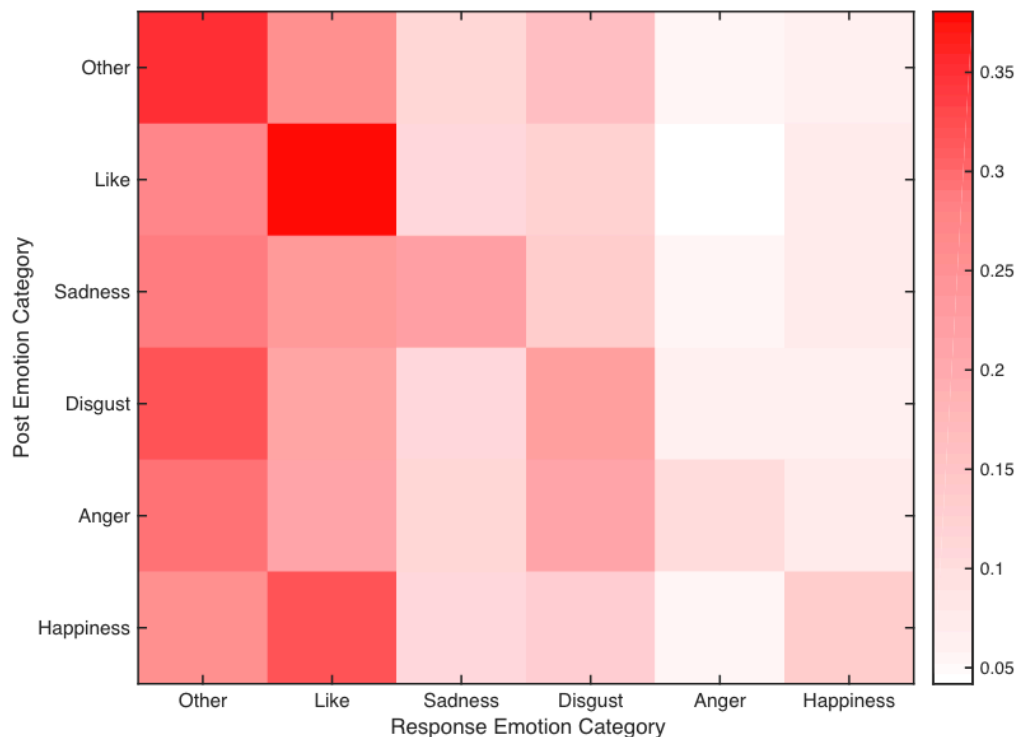
情绪	post:送一个这样的蛋糕，给你美丽的闺蜜吧！
other	这是蛋糕蛋糕吗？
喜欢	好漂亮的蛋糕啊！
悲伤	为什么我觉得很恶心
厌恶	这样的蛋糕你忍心吗？
愤怒	有没有想开网店的？
快乐	哈哈，好可爱的蛋糕！

情绪	post:承诺，就是一个骗子说给一个傻子听的
other	承诺就是一个承诺
喜欢	承诺是一个专一的傻子
悲伤	我就是个悲伤的傻子
厌恶	一个骗子说给一个傻子听
愤怒	不管你信不信，反正我信了！
快乐	我就是个开心的傻子

•Hao Zhou, Minlie Huang, Xiaoyan Zhu, Bing Liu. Emotional Chatting Machine: Emotional Conversation Generation with Internal and External Memory. **AAAI 2018.**



Emotion Interaction Patterns



Like→Like (**empathy**)

Sadness → Sadness (**empathy**)

Sadness → Like (**comfort**)

Disgust → Disgust (**empathy**)

Disgust → Like (**comfort**)

Anger → Disgust

Happiness→Like



Personality



Personality of Chatting Machine

- Personality is important for game, custom service, etc.

Conversation without Chatbot's personality by general sequence-to-sequence models.
User: Are you a boy or a girl? Chatbot: I am a boy. User: Are you a girl? Chatbot: Yes, I am a girl.
Conversation with Chatbot's personality by our model.
User: Are you a boy or a girl? Chatbot: I am a three-year old boy. User: Are you a girl? Chatbot: I am a three-year old boy.



Personality of Chatting Machine

- ◎ Passing the **Turning Test**
 - ◆ Deep semantic understanding
 - ◆ Existing chatting machine lacks **identity or personality**
- ◎ Personality is a well-defined concept in psychology([Norman, 1963](#); [Gosling et al., 2003](#))
- ◎ Clues that portray personality:
 - ◆ Age, gender, language, speaking style, level of knowledge, areas of expertise
- ◎ Existing works
 - ◆ User embedding: learn **implicit** conversation style ([Li et al., 2016](#); [Al-Rfou et al., 2016](#))
 - ◆ Require dialogue data from different users with **user attributes tagged**

Personality of Chatting Machine

Generating coherent conversation w.r.t. **identity/personality**

Generic Dialogue Data for Training

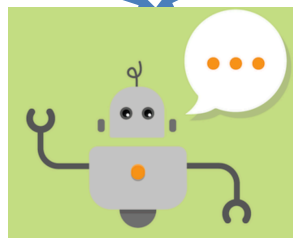
UserA: how old are you?
UserB: I am six.

UserA: do you like to play piano?
UserB: I play violin.

Pre-specified Chatbot Profile

Profile key	Profile value
Name	汪仔(Wang Zai)
Age	三岁(3)
Gender	男孩(Boy)
Hobbies	动漫(Cartoon)
Speciality	钢琴(Piano)

Identity-coherent
Chatbot



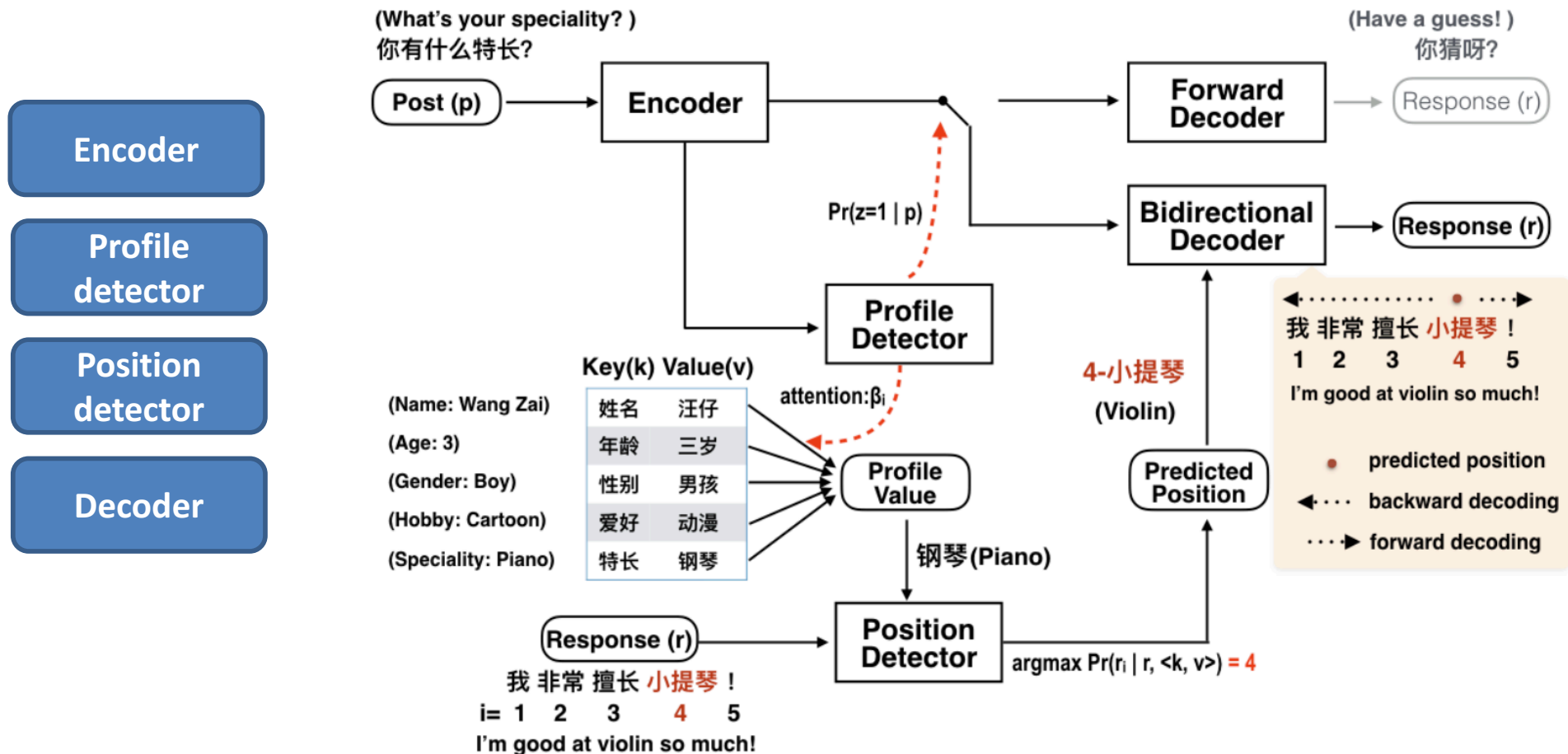
Generated Dialogues

User: how old are you?
Machine: I am **three years old**.

User: do you like to play piano?
Machine: Yes, I play **piano**.



Personality of Chatting Machine



•Qiao Qian, Minlie Huang, Haizhou Zhao, Jingfang Xu, Xiaoyan Zhu. *Assigning personality/identity to a chatting machine for coherent conversation generation*. **IJCAI-ECAL 2018**.



Personality of Chatting Machine

Post-level evaluation

Method	Nat.	Logic	Cor.
Seq2Seq	71.8%	56.0%	23.8%
Seq2Seq +PV	72.0%	56.0%	41.3%
Seq2Seq +PVD	73.3%	52.5%	38.0%
Our Model -PD	82.7%	51.7%	38.3%
Our Model	83.3%	59.5%	45.8%

Session-level evaluation

Method	Consistency	Variety
Seq2Seq	1.3%	1.0%
Seq2Seq +PV	47.0%	1.3%
Seq2Seq +PVD	40.0%	7.5%
Our Model -PD	38.8%	16.0%
Our Model	49.5%	27.8%

Generated sample responses that exhibit session-level consistency

Chinese	English(Translated)
U:你对什么事感兴趣 S:打篮球 U:你都有啥爱好呀 S:篮球 U:告诉我你兴趣所在 S:我喜欢篮球	U:What are you interested in? S:Playing basketball. U:What's your hobby? S:Basketball. U:Tell me your interest. S:I like to play basketball.
U:你还没说你几岁呢 S:我三岁了 U:你今年有15了不 S:我还没到呢 U:你多大啦 S:3岁了	U:You haven't told me your age. S:I'm three years old. U:Are you 15 years old or not? S:I'm not yet. U:How old are you? S:Three years old.

•Qiao Qian, Minlie Huang, Haizhou Zhao, Jingfang Xu, Xiaoyan Zhu. *Assigning personality/identity to a chatting machine for coherent conversation generation.* **IJCAI-ECAI 2018.**



Commonsense Knowledge

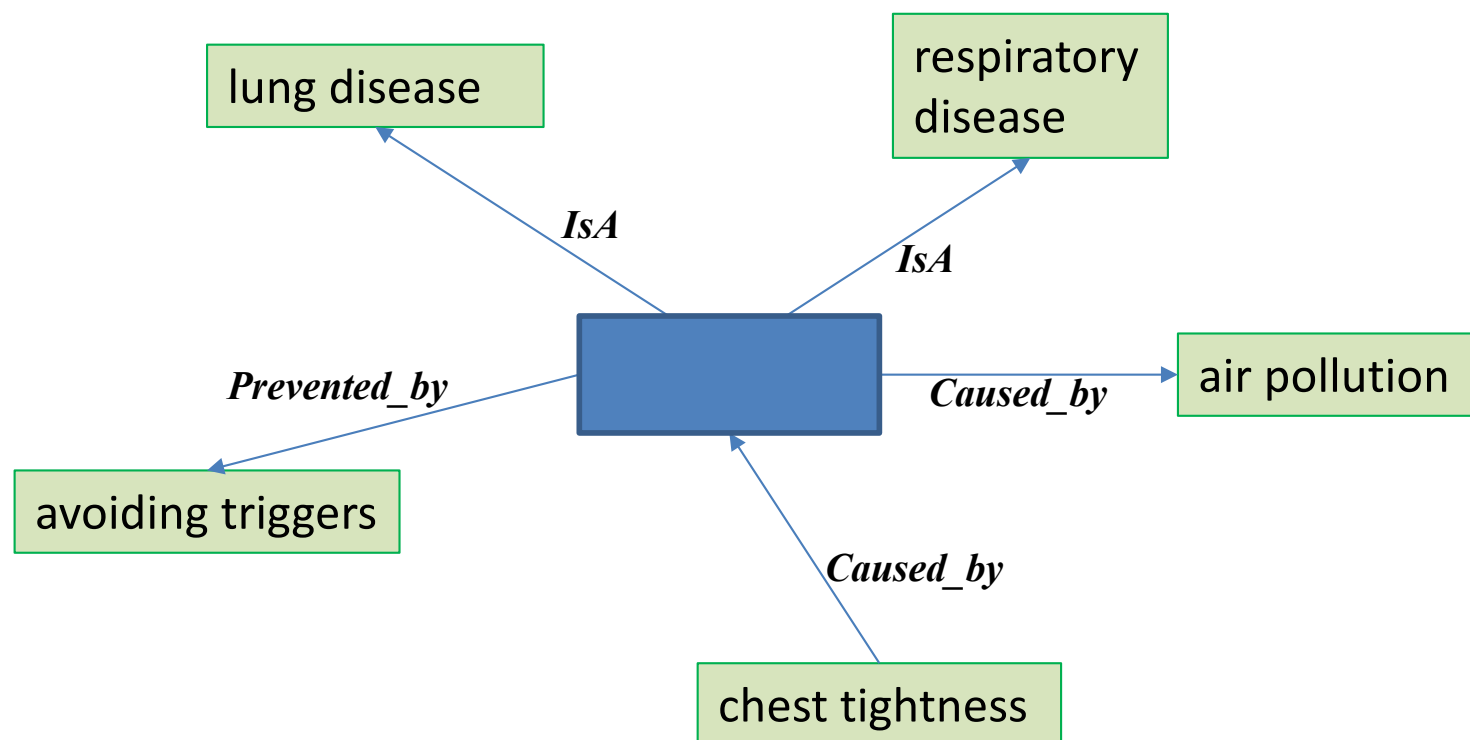


Commonsense Knowledge

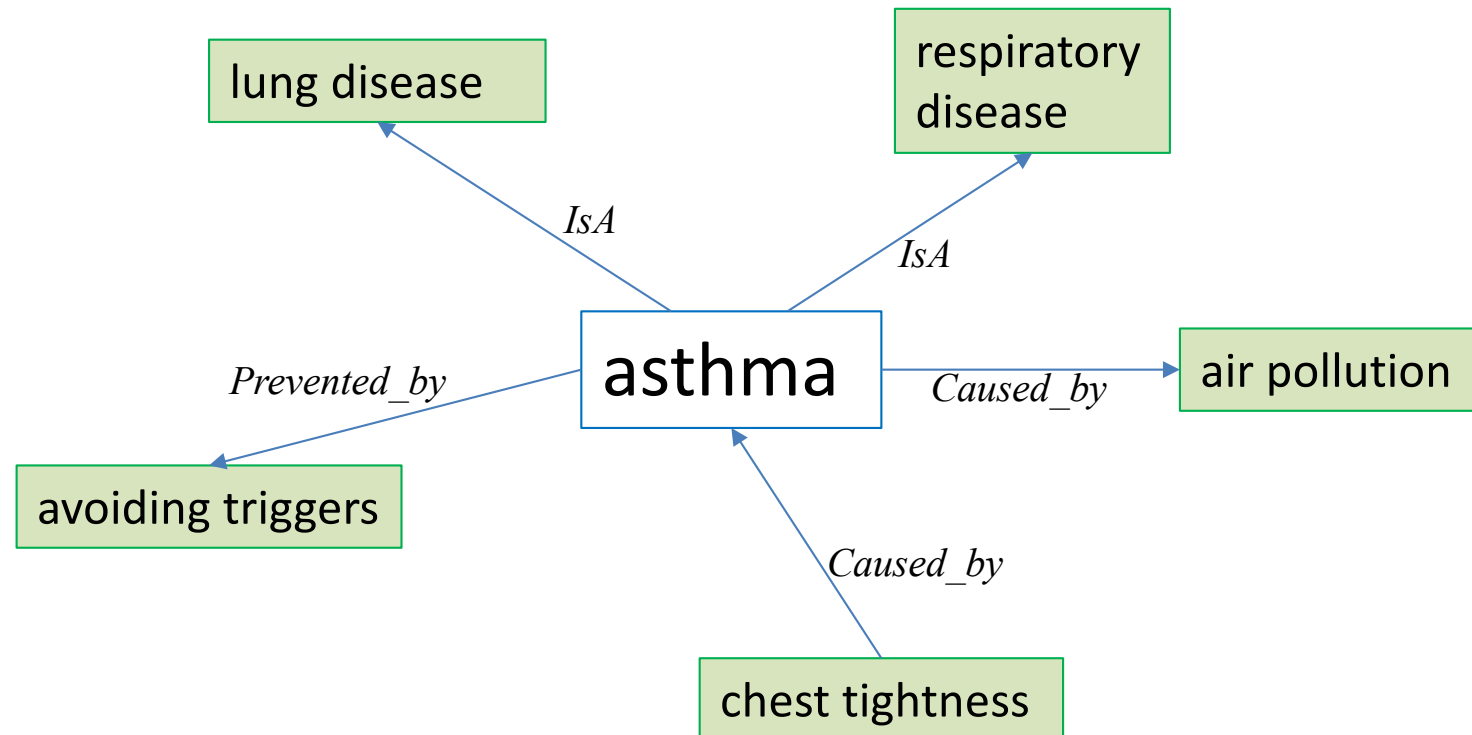
- ◎ **Commonsense knowledge** consists of facts about the everyday world, that all humans are expected to know. (Wikipedia)
 - ◆ Lemons are sour
 - ◆ Tree has leafs
 - ◆ Dog has four legs
- ◎ The main focus of the Paul [Allen Institute for Artificial Intelligence](#) (\$125 million in 2018)
- ◎ Commonsense Reasoning ~ **Winograd Schema Challenge**:
 - ◆ The trophy would not fit in the brown suitcase because it was too **big** (*small*). What was too **big** (*small*)?



Commonsense Knowledge in Chatbots



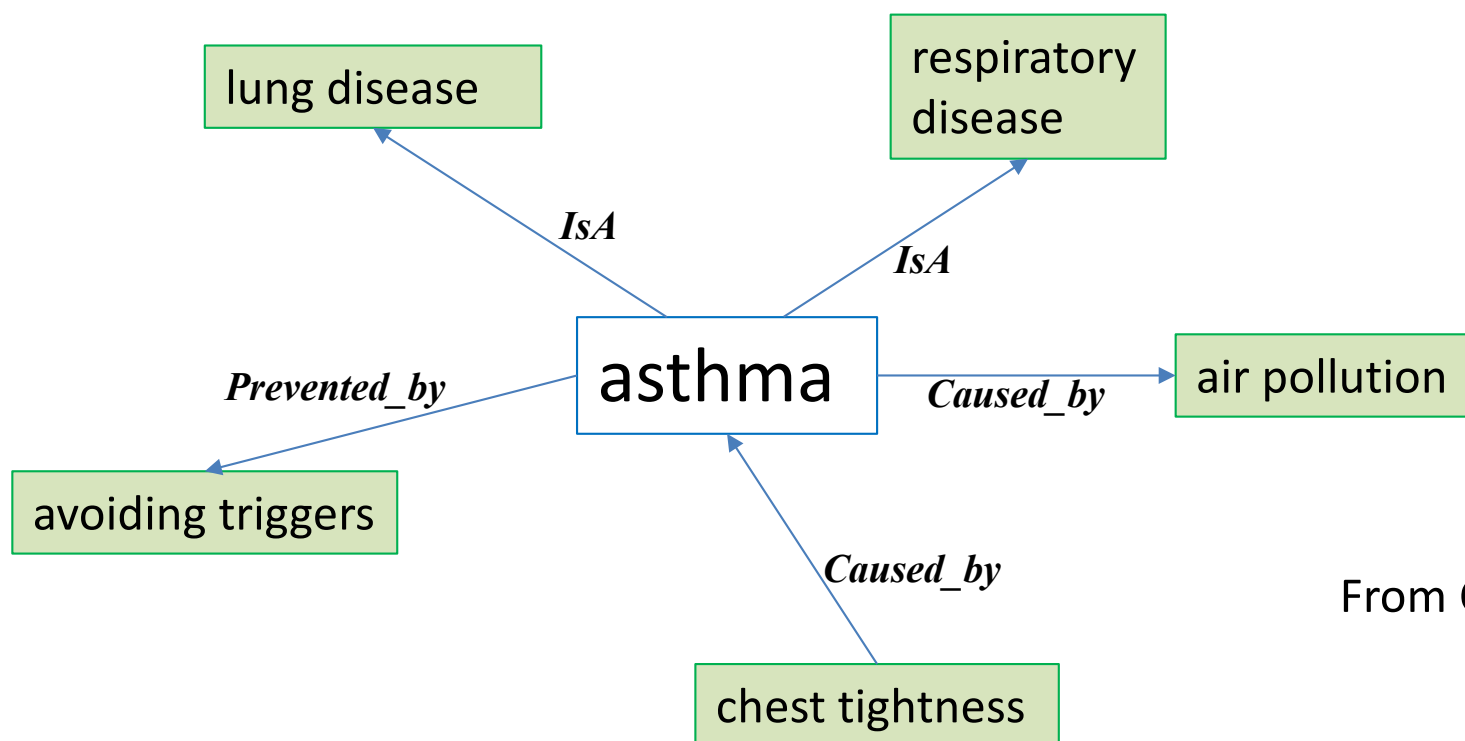
Commonsense Knowledge in Chatbots



Commonsense Knowledge in Chatbots

I have an **asthma** since three years old.

Triples in knowledge graph:
(lung disease, IsA, **asthma**)
(**asthma**, Caused-by, chest tightness)



From ConceptNet



Commonsense Knowledge in Chatbots

- ⊙ Conversation is all about **semantic understanding**
- ⊙ Commonsense knowledge is important for **language understanding and generation**

Post	Why are you so breakable ?
Knowledge	(glass , RelatedTo, breakable), (brittle , RelatedTo, breakable), (rule , RelatedTo, breakable)
Seq2Seq	I'm not a OOV , i 'm just a OOV .
MemNet	I'm not OOV . I'm just a really nice person.
CopyNet	I'm not. I'm just a lurker.
CCM	Because I'm a brittle man .



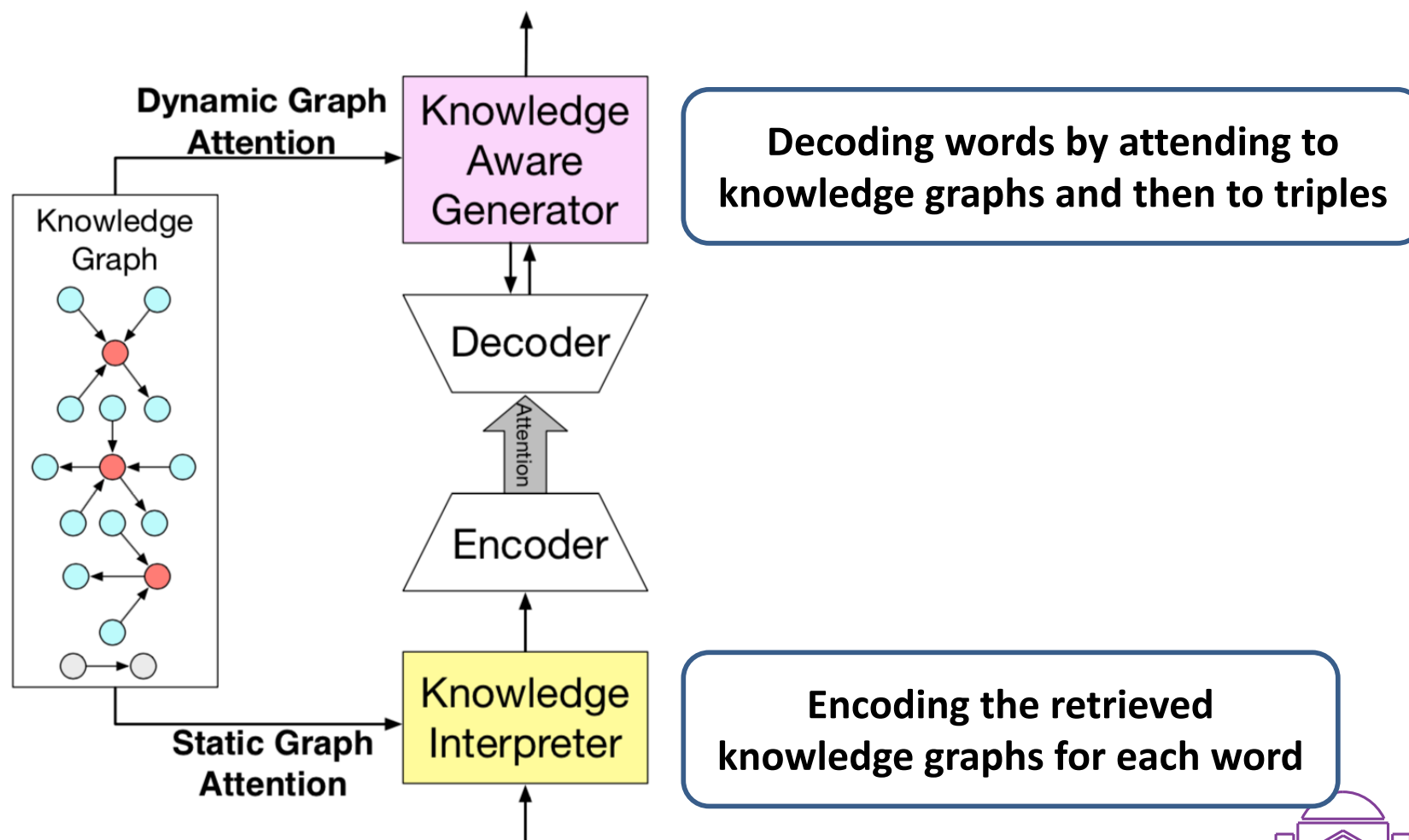
Commonsense Knowledge in Chatbots

- ⊙ **Challenge I:** applying large-scale, high-quality commonsense knowledge
- ⊙ **Challenge II:** an elegant way of using commonsense knowledge in open-domain, open-topic conversation generation
- ⊙ **Our solution:**
 - ◆ Static graph attention
 - ◆ Dynamic graph attention
 - ◆ **Treating a knowledge graph as a whole**



Commonsense Knowledge in Chatbots

Output: Because I'm a brittle man.

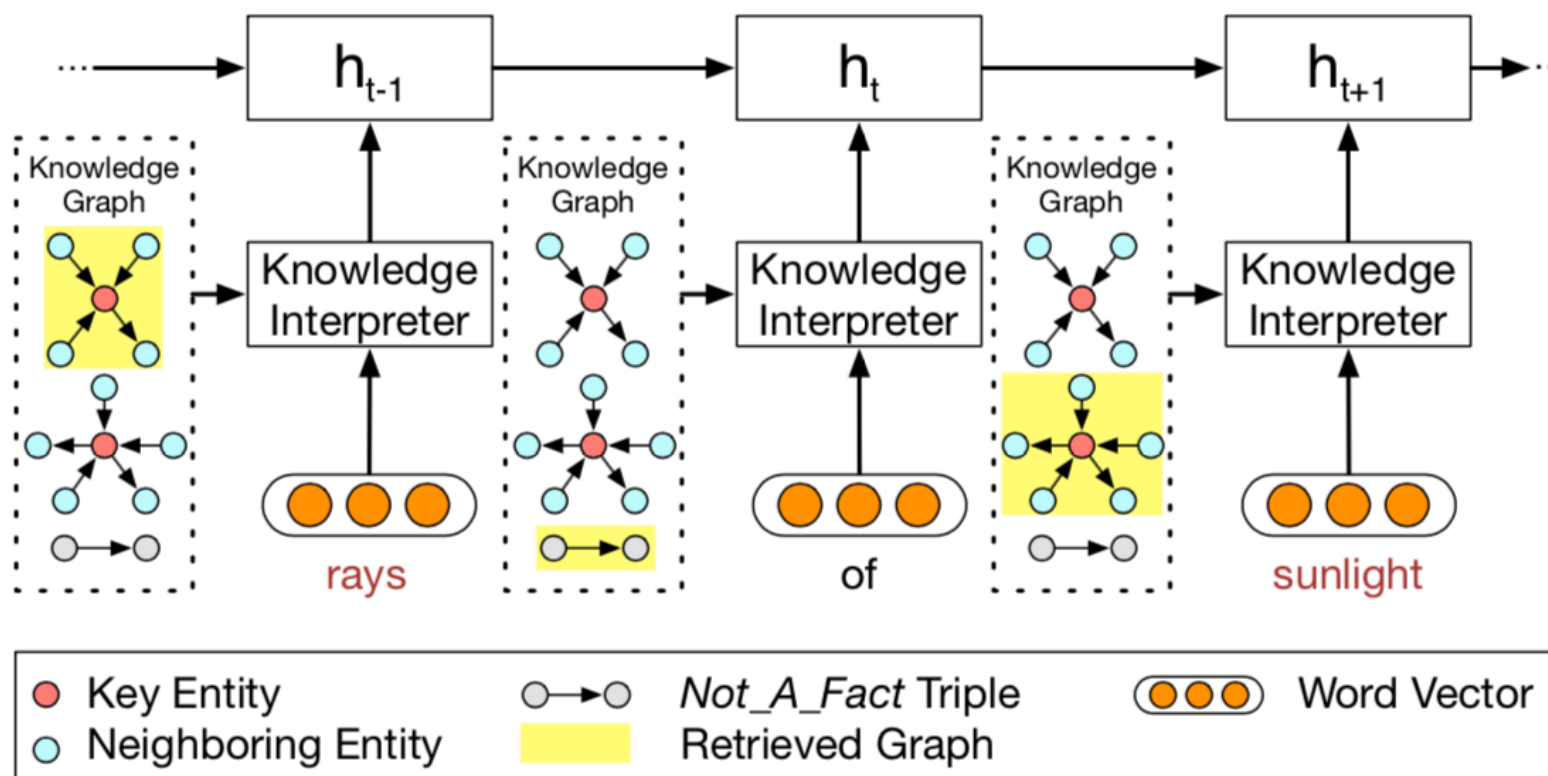


Input: why are you so breakable?



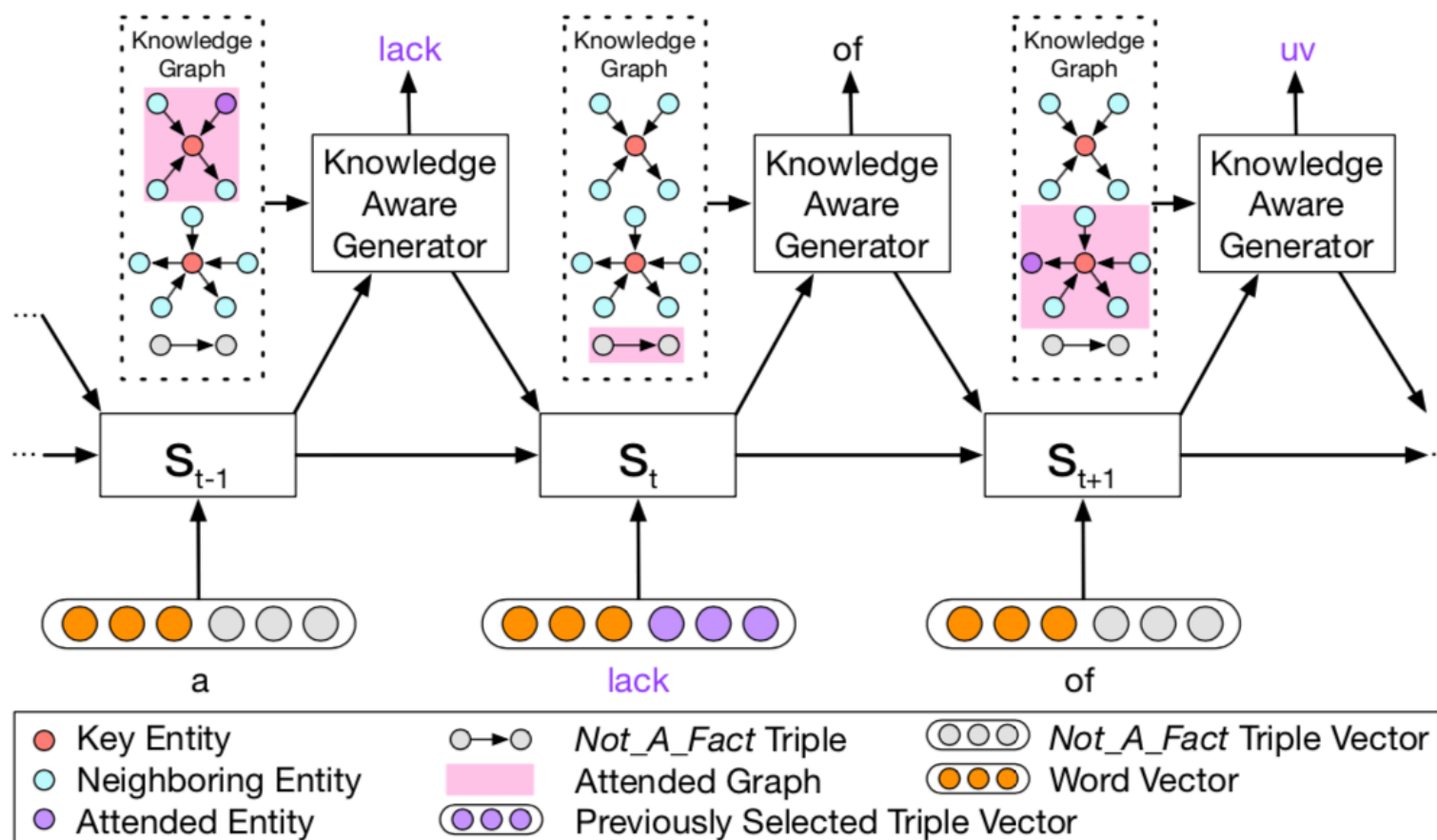
Commonsense Knowledge in Chatbots

Static graph attention: encoding semantics in graph,
Feeding knowledge-enhanced info. into the encoder



Commonsense Knowledge in Chatbots

Dynamic graph attention: first attend a graph, then to a triple within that graph, finally generate with the words in a graph



Commonsense Knowledge in Chatbots

Automatic evaluation

Model	Overall		High Freq.		Medium Freq.		Low Freq.		OOV	
	ppx.	ent.	ppx.	ent.	ppx.	ent.	ppx.	ent.	ppx.	ent.
Seq2Seq	47.02	0.717	42.41	0.713	47.25	0.740	48.61	0.721	49.96	0.669
MemNet	46.85	0.761	41.93	0.764	47.32	0.788	48.86	0.760	49.52	0.706
CopyNet	40.27	0.96	36.26	0.91	40.99	0.97	42.09	0.96	42.24	0.96
CCM	39.18	1.180	35.36	1.156	39.64	1.191	40.67	1.196	40.87	1.162

Manual evaluation (Sign-test, p-value<0.005)

Model	Overall		High Freq.		Medium Freq.		Low Freq.		OOV	
	app.	inf.	app.	inf.	app.	inf.	app.	inf.	app.	inf.
CCM vs. Seq2Seq	0.616	0.662	0.605	0.656	0.549	0.624	0.636	0.650	0.673	0.716
CCM vs. MemNet	0.602	0.647	0.593	0.656	0.566	0.640	0.622	0.635	0.626	0.657
CCM vs. CopyNet	0.600	0.640	0.606	0.669	0.586	0.619	0.610	0.633	0.596	0.640

Hao Zhou, Tom Yang, Minlie Huang, Haizhou Zhao, Jingfang Xu, Xiaoyan Zhu.
Commonsense Knowledge Aware Conversation Generation with Graph
Attention. **IJCAI-ECAI 2018**, Stockholm, Sweden.



Generation Examples 1

Post: He proposed March 5th. We will be married October 10th.
So 7 months

Knowledge: (engaged, RelatedTo, married), (wedding, RelatedTo, married), (miss, DistinctFrom, married), (March, RelatedTo, months)

- ◉ **Seq2Seq:** I'm not sure how to answer that. I'm not sure how to make a date.
- ◉ **MemNet:** I'm assuming he's married to a gay marriage?
- ◉ **CopyNet:** I'm sorry, I'm not sure what you mean by that.
- ◉ **CCM:** I'm pretty sure he's going to be engaged in the next 6 months.



Generation Examples 2

Post: Totally thought it was going to be doug's grave.

Knowledge: (thought, RelatedTo, thinking), (doug, HasProperty, dead), (dead, RelatedTo, grave), (grave, RelatedTo, death)

- ◎ **Seq2Seq:** I was thinking the same thing.
- ◎ **MemNet:** I thought it was a dead end.
- ◎ **CopyNet:** I think it's a bit of a stretch.
- ◎ **CCM:** I thought it was doug's death. I was thinking the same thing.



Asking Good Questions



Asking Questions in Chatbots

- ◉ Responding + asking (Li et al., 2016)
- ◉ Proactive behaviors (Yu et al., 2016)
- ◉ Asking good questions are indication of **machine understanding**
- ◉ Key differences to traditional question generation:
 - ◆ **Different goals**: Information seeking vs. Enhancing interactiveness and persistence of human-machine interactions
 - ◆ **Various patterns**: YES-NO, WH-, HOW-ABOUT, etc.
 - ◆ **Topic transition**: from topics in post to topics in response

Yansen Wang, Chenyi Liu, Minlie Huang, Liqiang Nie.

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Asking Questions in Chatbots

- ◎ A good question is a natural composition of
 - ◆ **Interrogatives** for using various questioning patterns
 - ◆ **Topic words** for addressing interesting yet novel topics
 - ◆ **Ordinary words** for playing grammar or syntactic roles

Example 1:

User: I am too fat ...

Machine: **How about** climbing this weekend?

Example 2:

User: Last night, I stayed in KTV with friends.

Machine: **Are you** happy with your singing?



Asking Questions in Chatbots

- Asking **good** questions requires **scene understanding**

Scene: Dining at a restaurant

我昨天晚上去聚餐了
I went to dinner yesterday night.

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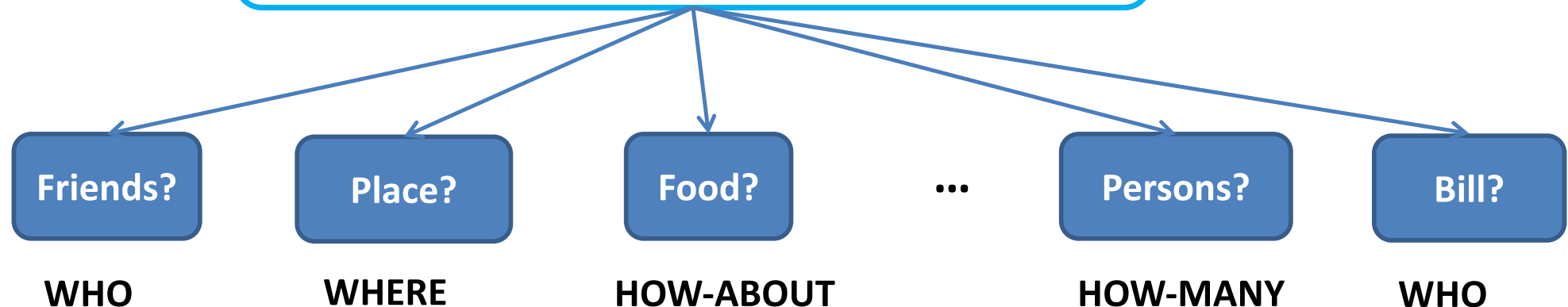


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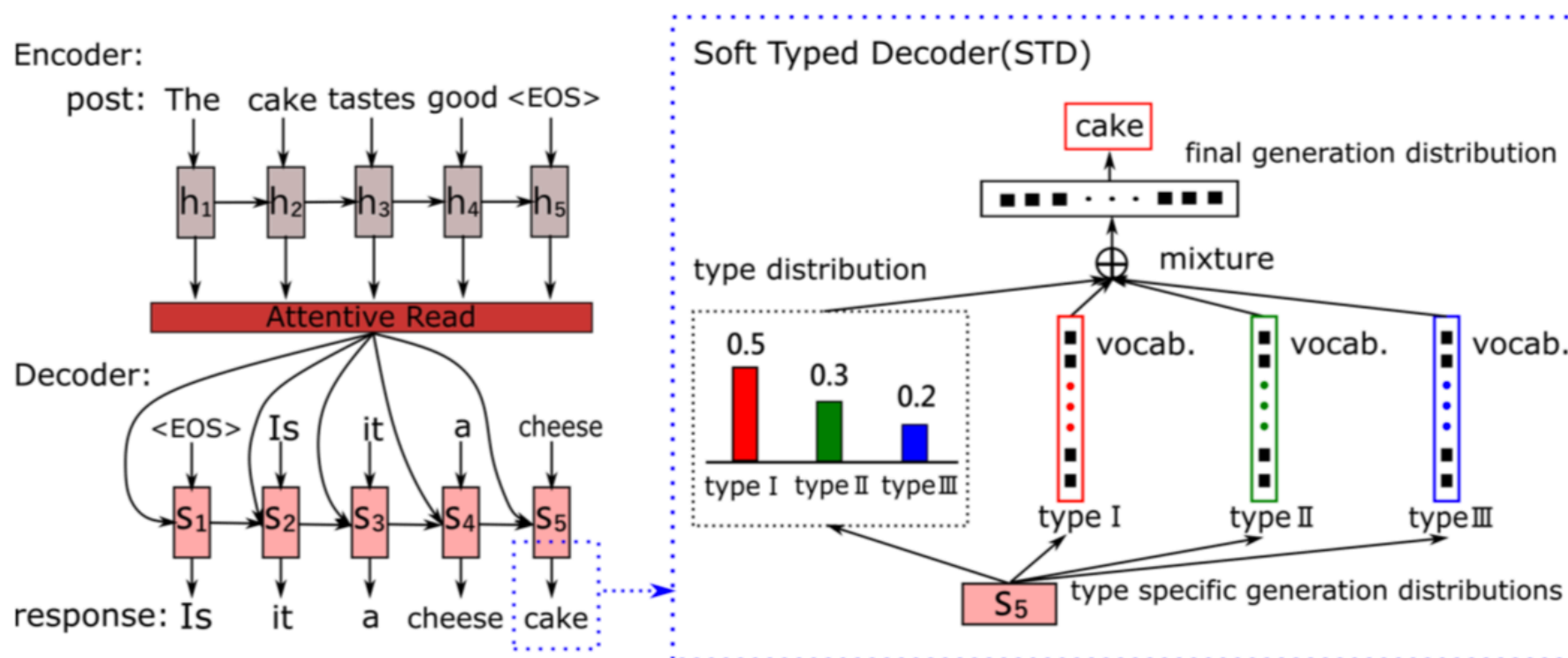
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Asking Questions in Chatbots

Typed decoders: soft typed decoder



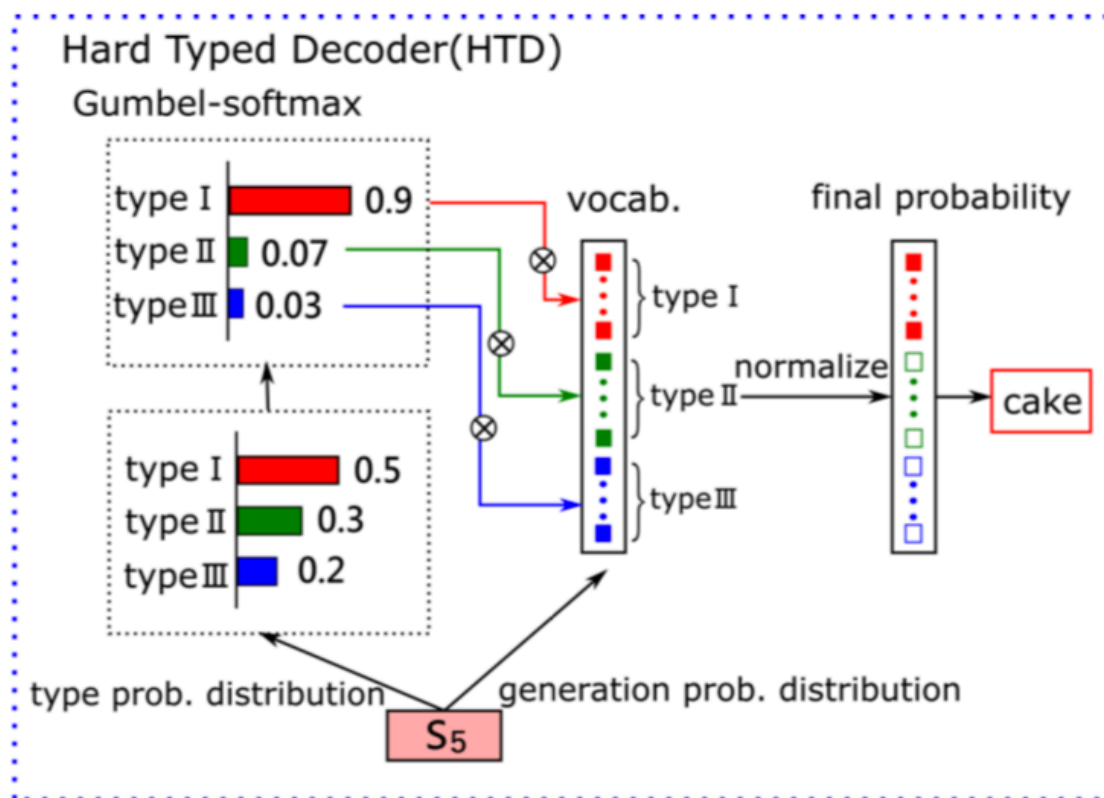
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Asking Questions in Chatbots

⊙ Metrics: Appropriateness, richness, willingness

Models	Appropriateness			Richness			Willingness		
	Win (%)	Lose (%)	Tie (%)	Win (%)	Lose (%)	Tie (%)	Win (%)	Lose (%)	Tie (%)
STD vs. Seq2Seq	42.0	38.6	19.4	37.2**	15.2	47.6	45.4*	38.6	16.0
STD vs. MA	39.6*	31.2	29.2	32.6**	16.8	50.6	49.4**	27.0	23.6
STD vs. TA	42.2	40.0	17.8	49.0**	5.4	45.6	47.6*	40.2	12.2
STD vs. ERM	43.4*	34.4	22.2	60.6**	13.2	26.2	43.2*	36.8	20.0
HTD vs. Seq2Seq	50.6**	30.6	18.8	46.0**	10.2	43.8	58.4**	33.2	8.4
HTD vs. MA	54.8**	24.4	20.8	45.0**	17.0	38.0	67.0**	18.0	15.0
HTD vs. TA	52.0**	38.2	9.8	55.0**	5.4	39.6	62.6**	31.0	6.4
HTD vs. ERM	64.8**	23.2	12.0	72.2**	8.4	19.4	56.6**	36.6	6.8
HTD vs. STD	52.0**	33.0	15.0	38.0**	26.2	35.8	61.8**	30.6	7.6

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Asking Questions in Chatbots

Post:	我们昨天去 <u>唱歌</u> 了 We <u>went to karaoke</u> yesterday.
Seq2Seq:	什么时候? When?
MA:	你怎么知道我是在问 How did you know I am questioning you?
TA:	什么? What?
ERM:	什么情况? What happened ?
STD:	去 <u>哪里</u> <u>唱歌</u> ? Where did you <u>sing karaoke</u>?
HTD:	你们 <u>几个人</u> <u>唱歌</u> ? How many people were <u>singing</u> with you?

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Asking Questions in Chatbots

Post-3: 我在体育中心上班。

I work at the sports center.

Human: 你每天从家过去要多久?

How long does it take you to go there from home?

STD: 你是什么部门的啊?

Which department are you from?

HTD: 那你是体育学院的学生吗?

Are you a student from the College of Physical Education?

Post-4: 今天的寿司真好吃。

The sushi today is so delicious!

Human: 我记得你不喜欢吃日式料理的不是吗?

I remember you didn't like eating Japanese food, **did** you?

STD: 你什么时候来无锡, 我请你。

When will you come to Wuxi? It is my treat.

HTD: 是吗?改天尝尝!

Really? I will try sometime!

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Asking Questions in Chatbots

- Type prediction at each decoding position

Post:	我喜欢小动物(I like little animals)					
Response:	你(you)	喜欢(like)	兔子(rabbit)	吗(<i>particle</i>)	?	_EOS
Interrogative	0.09	0.02	0.01	0.85	1.00	0.01
Topic word	0.26	0.35	0.71	0.14	0.00	0.02
Ordinary word	0.65	0.63	0.28	0.01	0.00	0.97



Summary

- ◎ **Emotion, personality, and knowledge** is important to Chatbots
- ◎ Open-domain chatting machine is one of the most challenging AI tasks
 - ◆ Requires the ability of understanding **semantics, knowledge, and situational context**
 - ◆ Ability of making **reasoning**
 - ◆ Exhibits **consistent personality**
- ◎ Still a long way to go: existing generation models are still far from the expectation of real-world applications



Future Research Problems

- ◎ **Multi-modality** emotion perception and expression (**voice, vision, text**)

- ◎ **Personality, identity, style** → “**human-like robot**”
 - ◆ **Introvert or extrovert**
 - ◆ **Personalized (style, or profile)**

- ◎ **Learning to learn**
 - ◆ **Grow up from interactions with human partners and environment**



Thanks for Your Attention

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- ◎ <http://coai.cs.tsinghua.edu.cn/hml>
- ◎ Recruiting post-doctors and international PhDs!

