

Knowledge Graph Grounded Goal Planning for Open-Domain Conversation Generation

Jun Xu,¹ Haifeng Wang,² Zhengyu Niu,² Hua Wu,² Wanxiang Che¹

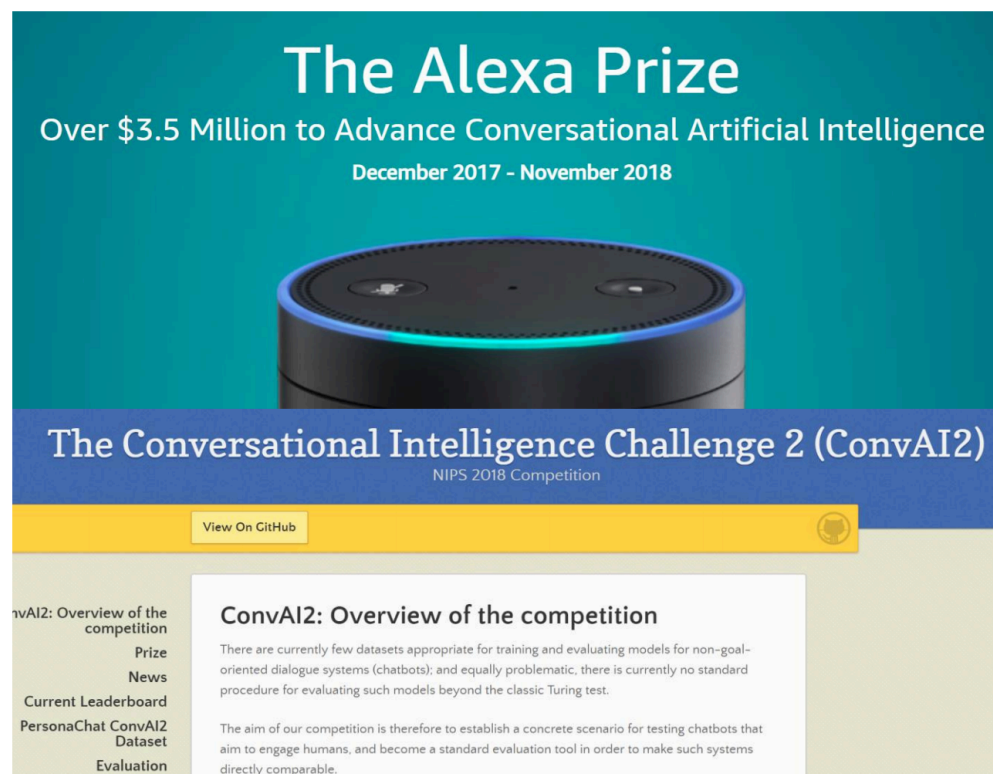
¹Harbin Institute of Technology, Harbin, China

²Baidu Inc., Beijing, China

{jxu, car}@ir.hit.edu.cn, {wanghaifeng, niuzhengyu, wu_hua}@baidu.com

Chitchat

Academia



The Alexa Prize
Over \$3.5 Million to Advance Conversational Artificial Intelligence
December 2017 - November 2018

The Conversational Intelligence Challenge 2 (ConvAI2)
NIPS 2018 Competition

[View On GitHub](#)

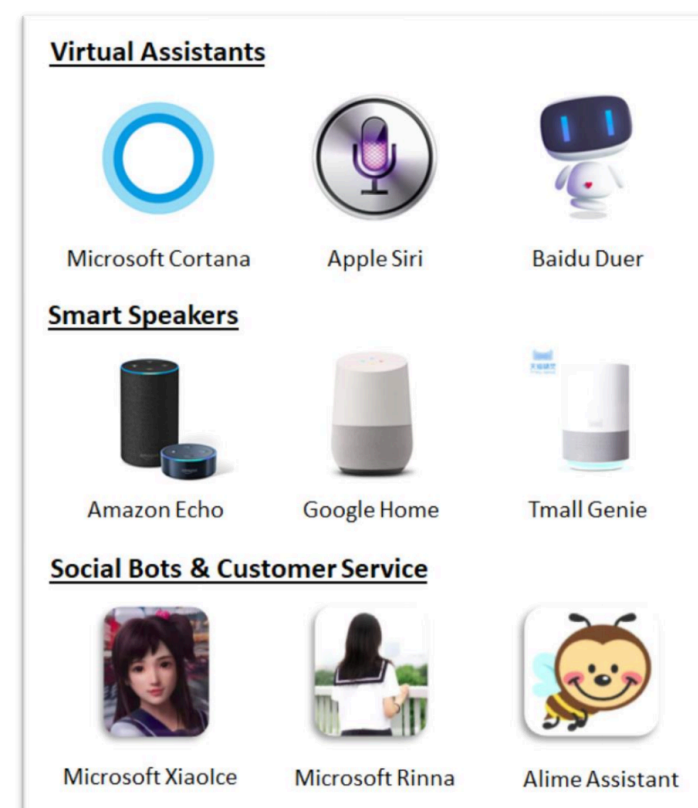
ConvAI2: Overview of the competition

There are currently few datasets appropriate for training and evaluating models for non-goal-oriented dialogue systems (chatbots); and equally problematic, there is currently no standard procedure for evaluating such models beyond the classic Turing test.

The aim of our competition is therefore to establish a concrete scenario for testing chatbots that aim to engage humans, and become a standard evaluation tool in order to make such systems directly comparable.

Navigation:
ConvAI2: Overview of the competition
Prize
News
Current Leaderboard
PersonaChat ConvAI2 Dataset
Evaluation

Industry



Virtual Assistants

- Microsoft Cortana
- Apple Siri
- Baidu Duer

Smart Speakers

- Amazon Echo
- Google Home
- Tmall Genie

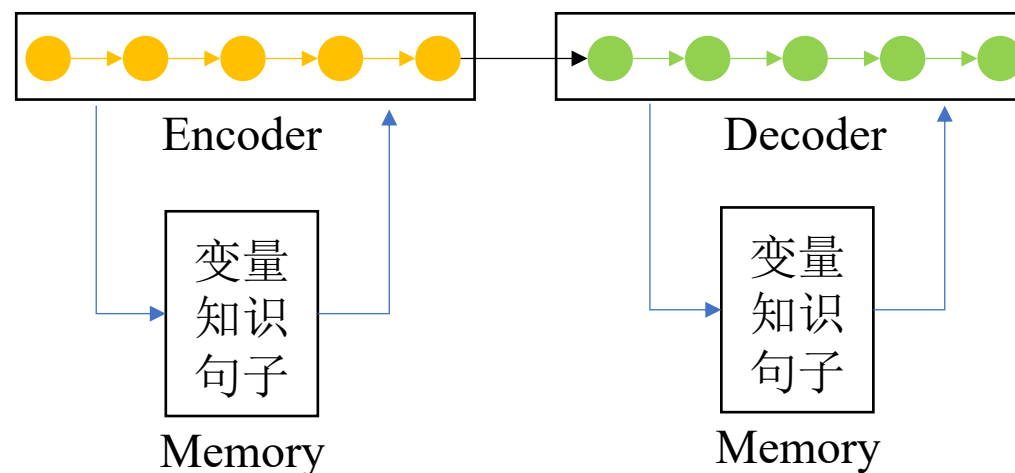
Social Bots & Customer Service

- Microsoft Xiaolce
- Microsoft Rinna
- Alime Assistant

From <http://www.ruiyan.me/pubs/tutorial-emnlp18.pdf>

Chitchat

- Given context, generate or retrieve a response.
- Generally generated by **Seq2seq** based models (with memory) or retrieved by various matching networks.



Motivation

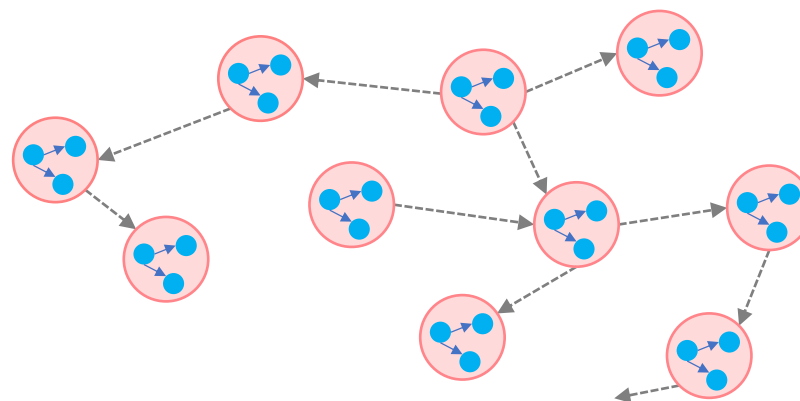
- How about talking to real user?

Start	80后 对此 肯定 不会 陌生,当年 骗 父母 买来 练打字 的 举手!
User	举手,我就 买 过 这样 的,我 觉得 挺不错 的
Bot	我家 的 是 买 过,不过 现在 还在 用 这个 东东.老爸 给 了 一台 电脑!举手.
User	是啊,我 也 要 举手,那 时候 我 也 给 我 家 的 老 人 家 买 过 这 个
Bot	我家 的 是 开着 卖,叫 你 买 个 给 我 们 玩.哈哈 哈!恭 喜 发 财 了 啊.
User	好 啊,恭 喜 发 财,过 年 一 起 来 打 牌 啊
Bot	好 可 爱 的 小 刺 猬,可 爱 死 了.
User	是 啊,很 可 爱 的 刺 猬,就 是 刺 太 多 了

- No effective mechanisms to manage chatting goals, and tend to produce less coherent and engaging dialogs.

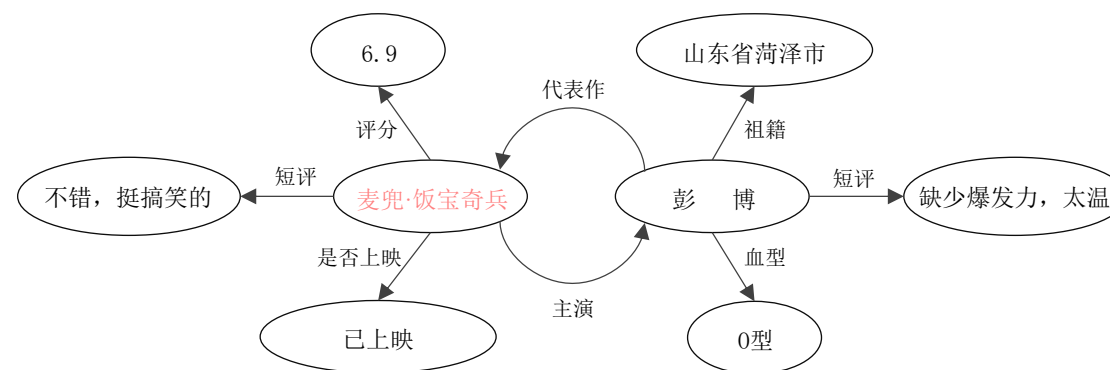
Motivation

- We introduce goal management into chitchat, to foster a more coherent and engaging multi-turn dialog.



Approach

- Goal (limited to this paper): chatting around a topic
 - Topic: a vertex in the KG
 - topic facet: an aspect of the given topic
 - 麦兜·饭宝奇兵 主演 彭博



Approach

- We divide the task of multi-turn chitchat generation into two sub-tasks
 - Goal (chatting around a topic) sequence planning
 - Goal completion by topic elaboration
- And present a three-layer KG Grounded Hierarchical RL model
 - Upper-layer learns to plan topic (vertex) sequence over a KG
 - Middle-layer and Lower-layer work together to conduct topic elaboration
 - Middle-layer learns to select a neighboring vertex around the goal vertex as a topic facet
 - Lower-layer produces a multi-turn dialog based on topic and topic facet

Approach

Goal Planning

Topic Elaboration

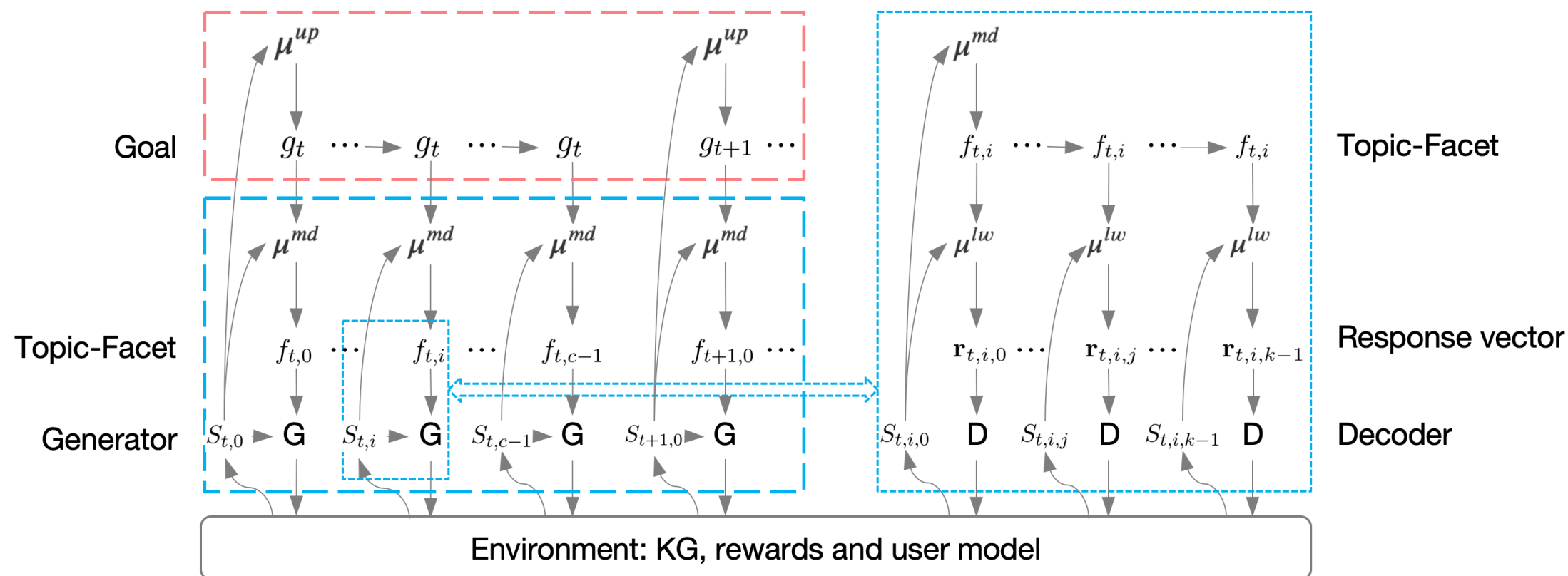
↓
Upper-layer

↓
Middle-layer

↓
Lower-layer

Goals	Topic Facets	Utterances
<Between Calmness and Enthusiasm>	Start_of_Session	<p>M: Do you like love movies?</p> <p>U: Yes, I often watch love movies recently.</p> <p>M: Then you can go to see the movie <Between Calmness and Enthusiasm>(2001). It's a love movie.</p> <p>U: I've seen this movie. There are many cheaters in it. Another movie with the same rating is <The World Is Not Enough>(1999).</p>
<The World Is Not Enough>	<p>Starring, Robert Carlyle</p> <p>Starring, Pierce Brosnan</p>	<p>M: Robert Carlyle starred in this movie, whose constellation is Aries.</p> <p>U: Yes, he starred. His ancestral home is Glasgow, Scotland.</p> <p>M: The film is starred by Pierce Brosnan, who was born in May 1953. Do you know who it is?</p> <p>U: Of course. He starred with Robert Carlyle and won the 24th Saturn Award for Best Actor.</p>

Approach



Rewards

- For Upper-layer
 - Coherence of the goal sequence: Average cosine distance with TransE
 - User interest consistency: Bot should follow new topic mentioned by users
 - Diversity: Balance between changing the goal too frequently and always sticking to the same goal
 - Sustainability: Give priority to vertices with lots of related knowledge, PageRank
 - Goal-completion information from the middle layer
- For Middle-layer
 - Topic-facet coherence
- For Lower-layer
 - Utterance relevance, Utterance informativeness, Topic-facet completion

Experiment

- Dataset: DuConv(publicly available knowledge-driven dialog dataset)
 - Consists of 30k dialogs with 120k dialogue turns
 - Provides a KG in the domain of movies and celebrities
 - 91k films and 51k film stars, and about 3.6 million knowledge triplets
- Models
 - CCM (Zhou et al. 2018), a state-of-the-art KG based conversation model
 - CCM+LaRL (Zhao, Xie, and Eskenazi 2019), a latent variable based RL model
 - KnowHRL, our model
 - KnowHRL-liteReward: only use utterance relevance and informativeness as rewards.
- User simulator: multi-mapping based generation model (Chen et al. 2019)

Evaluation

- Evaluation Metrics at Session Level
 - Coherence: Intra-topic coherence, Inter-topic coherence
 - Engagement: User-interest consistency (Cons.)
 - Distinct
 - Knowledge accuracy (K.A.)
- Evaluation at Turn Level
 - Setting: Randomly sample 200 dialogs with user simulator or human.
 - Metrics: Appropriateness, Informativeness

Evaluation at Session Level

Setting: Randomly sample 100 dialogs with with user simulator or human, in which, on average, each dialog consists of 14 utterances.

Model	Intra.	Inter.	Dist-2	K.A.	Cons.
CCM	0.67	0.32	0.27	0.14	0.06
CCM+LaRL	0.94	0.44	0.32	0.17	0.09
KnowHRL	1.42	1.39	0.39	0.88	0.89
-liteReward	1.13	0.41	0.35	0.81	0.07

Table 2: Results of session-level evaluations on dialogs with user simulator. KnowHRL outperforms all the baselines significantly (sign test, p-value < 0.01) in terms of all the metrics.

Model	Intra.	Inter.	Dist-2	K.A.	Cons.
CCM	0.72	0.40	0.29	0.13	0.09
CCM+LaRL	0.98	0.52	0.33	0.19	0.17
KnowHRL	1.40	1.45	0.41	0.90	0.93
-liteReward	1.16	0.46	0.38	0.84	0.13

Table 3: Results of session-level evaluations on dialogs with human. KnowHRL outperforms all the baselines significantly (sign test, p-value < 0.01) in terms of all the metrics.

Findings:

- With the help of KG, and our strategy of divide-and-conquer, we obtain explainable dialog states and actions for KnowHRL.
- Thus, it is convenient to design goal related rewards to optimize the planning of goals and topic facets;
- These goals and topic facets can be used to guide response generation for better coherence and informativeness.

Evaluation at Turn Level

Setting: Randomly sample 200 dialogs with user simulator or human.

Models	Simulator		Human	
	Appr.	Infor.	Appr.	Info.
CCM	0.74	0.81	0.79	0.84
CCM+LaRL	0.77	0.78	0.81	0.81
KnowHRL	0.87	0.91	0.89	0.94
-liteReward	0.82	0.83	0.85	0.87

Table 4: Turn-level results on dialogs with user simulator and dialogs with human.

Findings: KnowHRL outperforms baselines in terms of turn-level response appropriateness and informativeness when chatting with user simulator and human.

B: 你喜欢看日本电影么 [Do you like watching Japanese movies?]

U: 喜欢啊，你推荐几个看看呢 [Yes, could you recommend some movies?]

B: 给你推荐一部电影叫《龙猫》，是一部日本电影，你可以去看看 [My Neighbor Totoro, it's a Japanese movie. You can have a try.]

U: 好呀，有空就去看看，这个电影的口碑不错 [I'll try it whenever I have time, this movie has a good reputation.]

B: 我还知道一部日本电影，是押井守导演的，我觉得也不错。 [I know another Japanese movie that is directed by Mamoru Oshii, which is a good movie.]

U: 你说的是哪部呀，说说看呢，我看下我听说过没 [Which one? Maybe I have heard of it.]

B: 《攻壳机动队2》，我觉得挺好看的，你可以看看 [Ghost in the Shell 2, I enjoy it, you can have a try.]

U: 哦，这部电影我看过，5年前上映的，很不错呢 [I've seen this movie, it is a good movie that released five years ago.]

B: 这部电影的主演是大冢明夫，他是射手座的呢！ [The film is starred by Akio Tsuka who is a Sagittarius!]

U: 我知道有一位跟他同年出生的明星，叫阿丽森·詹尼 [I remember another star who was born in the same year, named Allison Janney.]

B: 这是《我，花样女王》的主演吧，你知道她是什么星座吗？ [She starred the I, Tonya, Do you know what constellation she is?]

U: 这个我倒是不清楚了，告诉我吧 [I don't know about that. Tell me, please.]

B: 是天蝎座，祖籍美国俄亥俄州 [Scorpio, and her ancestral home is Ohio, USA.]

U: 我记错了，原来是美国人啊！ [I'm mistaken. It turned out to be an American.]

-
- B: 你有没有关注中国辽宁沈阳的明星吗? [Did you take note of stars who come from Shenyang, Liaoning, China?]
- U: 哈哈, 我关注了一些, 你想说的是哪个呀 [Haha, I paid attention to some of them. Which star do you mean?]
- B: 是啊, 她叫屈菁菁, 她的代表作《别有动机》, 你可以去了解一下他的作品 [Her name is Qu Jingjing, and her represent work is *Ulterior Motive*. You can learn more about her works.]
- U: 恩恩, 我知道她呀, 是一个气质美女 [En, I know her. She's a temperamental beauty.]
- B: 她还出演过《黄金时代》呢, 是中央戏剧学院毕业的, 你知道么 [She has been in *The Golden Era*, and do you know that she graduated from Central Academy of Drama.]
-
- U: 知道呀, 我还知道跟她同一个院校毕业的一位演员叫龚蓓苾 [Yes, I also know Gong Beiyun, an actor who graduated from the same college as her.]
- B: 嗯, 人也长的不错。 [Well, she's also good-looking.]
- U: 是的, 很漂亮, 也很有气质, 是金牛座的 [Yes, She's beautiful and temperamental, and she is Taurus.]
- B: 她的老公伍仕贤也是一个很有实力的人, 演技有个性的制作人呢! [Her husband, Wu Shixian, is also a very talented person. He is a producer with individuality in acting.]
- U: 恩恩, 对的呢, 龚蓓苾和伍仕贤在演艺圈是一对令人羡慕的夫妻呢 [Right. they are enviable couples in the Performing Arts circle.]
-
- B: 他还出演过一部电影, 你知道吗? [He's also been in a movie, you know?]
- U: 这我倒是真不知道了, 你说说看呢 [You fall me, tell me please.]
- B: 《将爱情进行到底》, 是一部爱情片, 我觉得他还可以, 推荐你去看看 [*Eternal Moment*, it's a a love movie which I recommend you to have a try.]
- U: 这部片子我听说过呀, 看的人很多, 口碑还行 [I've heard about this film. There are a lot of people watched it, and the reputation is not bad.]
-

Conclusion

- We propose a Knowledge graph grounded Hierarchical RL based conversational model (KnowHRL) to demonstrate how **hierarchical goal planning and elaboration over a KG** can facilitate chatting topic management and further response generation **for chitchat**.
- Results show that KnowHRL outperforms baselines in terms of dialog coherence, user interest consistency, and knowledge accuracy.
- In the future, we would like to investigate how to enrich the content of KG to cover more chatting goals.