# Research on Empathetic Dialogue Generation Based on Emotional Cognition and Empathetic Response

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**Abstract.** Empathetic dialogue aims to improve the machine's "EQ", so that it can complete the recognition and cognition of emotion, the generation of empathy response, and complete the sympathetic dialogue with human beings. With the development of Deep Neural Networks and pre-trained language model, the research of dialogue system has made a great breakthrough. However, there is still a lack of comprehensive research and analysis on empathetic dialogue. Especially from the perspective of the combination of communication elements, semantic understanding and dialogue management to analyze the technology of emotional cognition and empathic response. In this paper, the components of interpersonal communication and human-computer dialogue pipeline architecture are combined to comprehensively analyze the emotional dialogue technology. (1) In order to more intuitively understand the factors that affect emotional cognition in dialogue, this paper analyzes the models and methods of emotional recognition and cognition from the perspective of discourse level, conversation level, speaker level, communication mechanism and other dialogue communication elements. (2) In order to fundamentally understand the role of the three modules in the human-computer dialogue architecture in emotion generation, this paper analyzes the model and method of empathy response generation with the introduction of knowledge, emotion, strategy and other technologies from the perspective of semantic understanding, dialogue management and response generation. (3) We introduced the commonly used experimental models, datasets and evaluation metrics of emotional dialogue technology and analyzed the experimental results. This work can provide some theoretical reference for researchers who study the generation of emotional dialogue.

**Keywords:** Empathetic dialogue generation · Communication components · Emotional perception and cognition · Empathetic response


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## 1 Introduction

Human computer dialogue is a research hot spot in the generation of natural language. It is well known that human to human dialogue is not only the exchange of information, but also the exchange of emotion. At the same time, in the post epidemic era, more and more people are facing emotional problems, which aggravate the psychological problems. So people are eager to have an emotional partner, to be listened to, understood and helped. However, the important difference between humans and machines is that humans have emotions while machines have no emotions, which makes the satisfaction of human-computer dialogue not meet people's needs. Therefore, more and more attention has been paid to the study of emotional dialogue. "Emotional dialogue technology" is simply to endow machines with feelings, which can achieve empathy with human beings. In the process of human-computer dialogue, emotional dialogue technology enables machines to perceive emotions, understand emotions and corresponding emotional expressions. Machines can give caring and compassionate responses by understanding human emotions and situations, thus providing people with immediate emotional support and long-term emotional companionship.

Previous researchers have done a lot of reviews related to dialogue systems, such as Chen Dong et al. [1] published a survey of natural language generation. Wanxiang Che et al. [2] and Hongshan Chen et al. [3] published survey of human-computer dialogue system. Libo Qin et al. [4] published a survey of natural language generation in task oriented dialogue system. Chen Chen et al. [5] and Xin Chen et al. [6] published survey of research on the open-domain dialogue systems. Jianpeng Chen et al. [7] published a survey of human-computer dialogue system based on multiple - round interaction. However, there are few reviews on empathetic dialogue. Yin Zhuang et al. [8] published a survey of affective-based dialogue system. Yanyan Zhang et al. [9] published a survey of emotional dialogue technologies. However, the above research is summarized based on the technology of generation itself. This paper mainly analyzes and summarizes the research of emotional dialogue from the perspective of the five elements of human dialogue and the overall framework of human-computer dialogue. To sum up, the contributions of this paper can be summarized as follows:

(1) We propose to extend the five elements of human dialogue to the five elements of human-computer dialogue, and analyze the emotional recognition and cognition in emotional dialogue from the five elements. The five elements of everyone's dialogue are speaker, listener, context, discourse and communication. First, it focuses on the emotional recognition of discourse level, speaker level and conversation level. Secondly, it analyzes the emotional perception and cognition of dialogue behavior, communication mechanism, emotion and other factors. Finally, the multi-modal emotional perception and cognition are analyzed.

(2) We propose to analyze the generation of empathy response from the perspective of each module of the overall architecture of human-computer dialogue. First of all, the general framework of human-computer dialogue includes three modules: semantic understanding, dialogue management and response generation. Secondly, how to improve the empathy of replies from the aspects of enhancing semantic understanding, adopting dialogue strategies, retrieving replies and generating replies. Finally, in the

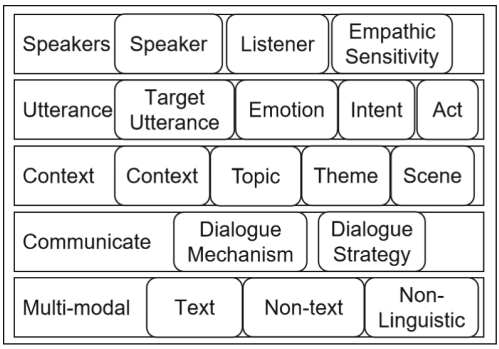


**Fig. 1.** Five elements of dialogue.

"group chat" with more than two participants, the impact of dynamic emotion and static emotional sensitivity on providing empathy response was analyzed.

(3) This paper summarizes the commonly used experimental settings in emotional dialogue, mainly analyzes the main pre-trained model, comparison model, dataset, knowledge base, evaluation indicators and other experimental related settings.

## 2 Emotional Recognition and Cognition

Emotion recognition refers to predicting the emotion of each discourse in the conversation. Emotion recognition in the conversation is increasingly concerned. Only by fully identifying the factors that affect emotion, can we accurately identify the emotional state of the current discourse. Dialogue consists of five parts as shown in Fig. 1: speakers, listener, utterance, context and communication. That is, dialogue refers to the communication between the speaker and the hearer through utterance in a specific context to achieve information, thought and emotional communication. So each component will affect the speaker's mood in the current sentence Based on this, many researchers have done relevant work.

### 2.1 Discourse Level and Speaker Level

Peng Sancheng et al. [10] used Bi-LSTM to extract local features and contextual semantic features of text vector in their research on negative emotion recognition using graph-attention network and width learning network, so as to obtain features of discourse level; RGAT is used to extract long-distance dependencies between speakers, so as to obtain speaker level features. Finally, after connecting the features of discourse level and speaker level, BL is used to classify and output the negative emotions.

### 2.2 Utterance Level and Conversation Level and Emotion Affects Emotion

Weixiao Zhao et al. [11] put forward causal aware interaction network for emotion recognition in conversations, which is the first time to explore the emotional reasons that

affect emotions in emotion recognition, including the influence of the speaker's own emotions on his own words and the influence of the listener's emotions on the speaker's emotions. The work is divided into four parts: get causal clues through COMET, and further explore the source of causes: divide the reasons into self- reasons and others' reasons, then trace the corresponding causal discourse, and finally complete emotion recognition.

### 2.3 Communication Mechanism and Dialogue Behavior and Emotion

Chujie Zheng et al. [12] proposed a multi-factor hierarchical framework for empathetic response generation (CoMAE). This model models the communication mechanism, dialogue behavior and emotion of empathy expression in a hierarchical way. It enhances the deeper understanding of discourse and gets more sympathetic responses.

## 3 Empathetic Response Generation

Nowadays, intelligent voice human-computer dialogue system consists of voice recognition; Natural language understanding; Dialogue management; Natural language generation. In dialogue technology, natural language understanding actually refers to semantic understanding of discourse, while natural language generation refers to empathy response. As illustrated in Fig. 2.

We can get empathy responses from three perspectives: semantic understanding, dialogue management, and response generation. The semantic understanding module can enhance emotional recognition and cognition by using emotional corpus, introducing knowledge base, enhancing the understanding of scenes or topics, and identifying discourse intentions. The dialogue management module improves the attractiveness of the dialogue by tracking the state of emotional dialogue and using emotional dialogue

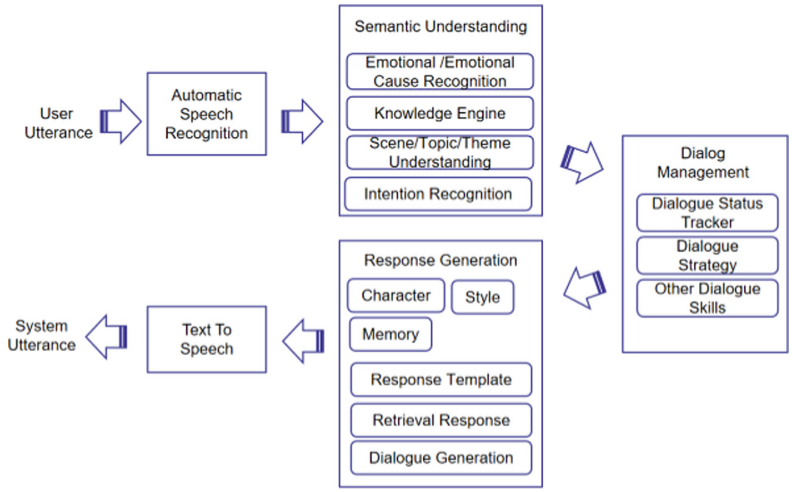


**Fig. 2.** The detailed framework of empathetic dialogue pipeline architecture

strategies. The response module can generate emotional responses through emotional script template, retrieval response technology, and dialogue generation technology to achieve emotional companionship.

### 3.1 Improve Empathy Response by Enhancing Semantic Understanding

This section mainly studies how to improve the quality of empathic response by introducing information such as emotion, knowledge and intention. In the workflow, first, we input the obtained information and conversation history to the Transformer Encode side. Then, we obtain the context information through bi-LSTM. We can also identify the emotional information at the utterance level through the emotional reasoner or classifier, and filter the knowledge through Attention to avoid the conflict between knowledge and emotion. Finally, we input the emotion, intention, knowledge and other contents of the context level to Transformer Decode to improve the quality of empathy response, as shown in Fig. 3. The following is an experimental method to improve empathy response by enhancing semantic understanding.

#### 3.1.1 Improving Empathetic Response Generation by Recognizing Emotion

Emotional cause is an essential factor in empathy response. Identifying emotional causes can help to understand emotions and respond to empathy. Jun Gao et al. [13] first studied the work of emotion causes in the generation of empathy responses, proposed an emotion reasoner to identify the speaker's contextual emotions and the reasons behind emotions, designed a hard and soft gating attention mechanism, input the emotion causes to the response generator, and improved the generation of empathy responses.

#### 3.1.2 Empathetic Dialogue Generation via Sensitive Emotion Recognition

Empathy is a key feature of emotional dialogue, because emotions are dynamic rather than static. Lanrui Wang et al. [14] proposed to use a fine-grained coding strategy to

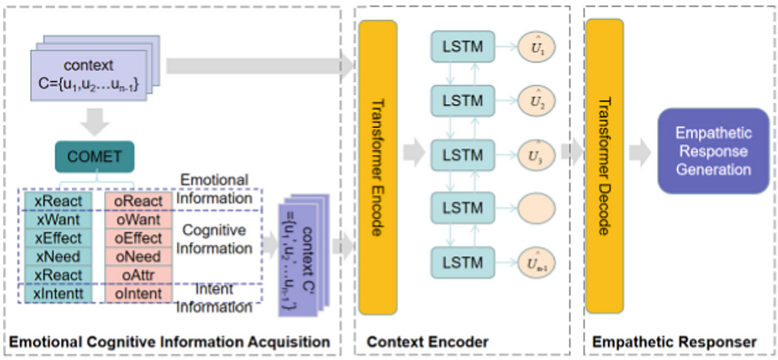


**Fig. 3.** Architecture for improving empathy response based on enhancing semantic understanding. Which consists of emotional cognitive information acquisition module, context encoder, empathetic response generator.

predict the characteristics of emotional intentions in responses. This fine-grained coding strategy is more sensitive to the emotional dynamics (emotional flow) in conversation. In addition, in order to generate more sensitive responses, a serial encoding and emotion-knowledge interaction (SEEK) model is designed to avoid the conflict between the selected knowledge and the predicted emotion, resulting in the generation of responses that do not match the emotion.

#### 3.1.3 Reveal Dialogue Strategies to Regulate Emotions via Taxonomy of Empathetic Questions in Social Dialogs

Effective question-asking is a key component of a successful conversational chat robot. It can help chat robots show empathy and make interaction more attractive by showing concern for the speaker's emotions. However, the current dialogue generation approaches do not model the subtle emotion regulation technology, because it lacks a taxonomy of empathetic questions and their purpose in social chitchat. Ekaterina Svikhnushina et al. [15] put forward a taxonomy of empathetic questions in social dialogs, which divides questions used in social communication into questioning intentions and questioning behaviors. By summarizing the co occurrence of questioning intention and behavior, and its role in emotion regulation, this paper reveals the questioning strategies in dialogue. For example, choose appropriate questioning behavior for a certain purpose; Choose appropriate intentions and corresponding questioning behaviors according to the positive and negative situations of emotions.

#### 3.1.4 Knowledge is the Bridge of Emotional Dialogue

Lack of knowledge will make it difficult for machines to understand the implicit emotions in discourse and learn how to conduct emotional interaction from the limited context history. Qintong Li et al. [16] proposes to introduce external knowledge, including common sense knowledge and emotional vocabulary knowledge, to better understand and express emotions in emotional dialogue.

### 3.2 Improve Empathetic Response by Enhancing Semantic Understanding and Adopting Dialogue Management

The main work of this section is to add dialogue management to improve empathy response. Intuitively, we know that high-quality dialogue requires certain skills, so the quality of empathy response can be improved through the dialogue strategy of emotional support. The dialogue strategy, together with the emotional dialogue history and current discourse integrating knowledge, is used as the input of the decoder to control the generation of dialogue and improve the empathy of the response. As shown in Fig. 4. The following is to enhance the empathy of machine response by enhancing semantic understanding and using dialogue strategies.

#### 3.2.1 Towards Emotional Support Dialog Systems

Emotional support is a key ability in many dialogue scenarios. Siyang Liu et al. [17] defined emotional support tasks, proposed an ESC framework for emotional support,

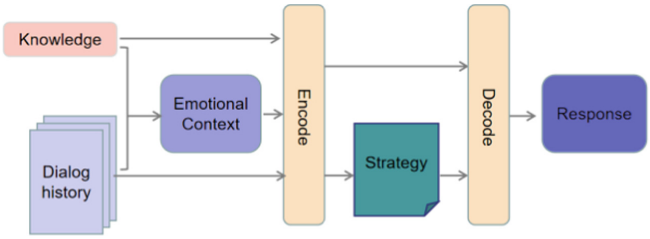


**Fig. 4.** Architecture of empathetic dialogue generation based on knowledge and dialogue strategy.

constructed an ESConv dataset for emotional support empathetic dialogue, and filled in the research on establishing emotional support in the dialogue system. This research is the first to study emotional support from the perspective of introducing dialogue strategies into dialogue management, which is particularly applicable to such scenarios as social interaction (accompanying and encouraging users), mental health support (comforting a depressed caller and helping him find out the problem), and customer service chat (pacifying angry customers and providing solutions). The experimental results are shown in Table 1.

#### 3.2.2 A Mixed Strategy-Aware Model Integrating COMET for Emotional Support Conversation

In emotional dialogue, multiple facilitation strategies are flexibly integrated in response, which will make the dialogue more coherent and users have a stronger willingness to interact. Quan Tu et al. [18] proposed a mixed strategy-aware model integrating COMET for emotional support conversation (MISC). And common sense knowledge is introduced to enhance emotional state.The experimental results are shown in Table 3.

#### 3.2.3 A Multi-factor Hierarchical Framework for Empathetic Response Generation

Chujie Zheng et al. [19] proposed CoMAE model. This model hierarchically models the three key factors of empathy expression, communication mechanism, dialogue behavior and emotion, because each factor is not intuitively independent and should be connected. On the one hand, this approach shows the importance of hierarchical modeling. On the other hand, the hierarchical modeling of communication mechanism, dialogue behavior and emotion, the three key factors will enhance the deeper understanding of discourse and get more sympathetic responses.The experimental results are shown in Table 2.

### 3.3 Improve Empathetic Response by Retrieving and Generating Responses

Spective of response generation itself is mainly based on the generation model. Recently, search based results have also been combined with generation model based results to generate responses. However, there is a problem that the semantics of the search results will have a large gap with the user's query semantics, making the results unsatisfactory. Xikai Liu et al. [20] proposed a long-term and short-term memory network with fusion

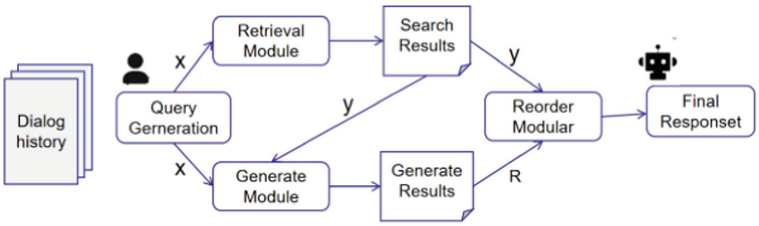


**Fig. 5.** Architecture of dialog generation model based on retrieval results fusion mechanism

mechanism, which combines the retrieval results with the dialogue text within the model to better integrate the retrieved information into the generation model. As shown in Fig. 5.

### 3.4 A Multi-party Empathetic Dialogue Generation Based on Static Sensibility and Dynamic Emotion

The previous work is a dialogue study between two participants, without empathy dialogue between multiple speakers. Moreover, emotion and emotional sensibility are usually confused, and most of them only focus on emotional perspective. Lingyu Zhou et al. [21] proposed a new multiparty dialogue generation task, because the personality of people and the emotions and content between speakers will lead to changes in the emotions of some participants in "group chat". Therefore, this paper explores the important role of the combination of static sensibility and dynamic emotion in multi-party empathy dialogue. People with strong empathy sensibility are likely to generate empathy responses in dialogue, while those with low empathy sensitivity are the opposite.

## 4 Experiments

### 4.1 Common Compared Models

- MIME: Another extension of Transformer based model, which considers emotion clustering and emotion simulation. In addition, the model also introduces the randomness of sampling in the training process.
- MK-EDG: a context enhanced empathetic dialogue generator, which uses various types of external knowledge and emotional signal extraction to generate responses.
- BlenderBot Joint is the SOTA model on ESConv dataset. It prepares a special strategy marker before responding to the discourse.
- ChatGPT: On the official website of OpenAI, ChatGPT is described as a language model for optimizing dialogue and the main model of GPT-3.5 architecture. ChatGPT can not only talk smoothly with users, but even write poems, articles and codes. At the same time, it focuses on the training method of moral level, and will "say no" to ill intentioned questions and requests.

### 4.2 Common Datasets and Knowledge Base

- Emphetic Dialogues (ED): Each dialogue is based on a specific situation. The speaker feels the given emotional words, and the listener responds. This new resource includes crowdsourcing one-to-one dialogue, covering most emotion sets in a balanced way.
- Emotion Support Conversation dataset (ESConv): An emotional support session dataset labeled with rich emotional support policy labels.
- The DailyDialog contains two-way conversations about daily life covering topics. This data set has seven emotional labels: anger, disgust, fear, joy, neutrality, sadness and surprise. This dataset has more than 83% of neutral labels.

### 4.3 Common Evaluation Metrics

#### 4.3.1 Manual Evaluation

Manual evaluation requires people to make subjective judgments on the generated responses in terms of logical consistency, emotional rationality, etc.

- Fluency: To what extent does the generated response conform to the grammar? Is the response fluent and easy to understand?
- Coherence: How relevant is the generated response to the context?
- Relevance: Is the generated response suitable for the conversation? Are they discussing the subject?
- Empathy: How much does the generated response know about the speaker's situation and emotional characteristics? Is there enough empathy or advice?

#### 4.3.2 Automatic Evaluation

The metrics of automatic evaluation usually include: Perplexity, BLEUand Distinct-N.

- Perplexity (PPL) is based on the model itself, and the degree of confusion serves as the basis for judging whether the model is good or not. Although the degree of confusion can be better evaluated, it has certain limitations.
- BLEU is most commonly used in the evaluation of machine translation. It evaluates the quality of the model by calculating the co occurrence of words between sentences. Distinct-N is often used in emotional dialogue system, which does not depend on standard response.
- Distinct-N measures the richness of words in generated replies by counting the number of N-grams in generated replies. It can be divided into one tuple (Distinct-1) and two tuples (Distinct-2).
- ROUGE-L is to calculate the length of the longest common subsequence and find the longest common subsequence length between the real response and the generated response

### 4.4 Results and Analysis of Empathy Response Experiment

Through comparative analysis of the three experiments, Table 1 shows the best results on PPL, B-2 and B-L after adding strategies to the support system ESConv, and Table 3 shows that the mixed strategy system has improved in PPL, B-2 and B-L compared

**Table 1.** Automatic evaluation results of emotional support empathetic dialogue

| **Backbones** | **Variants** | **PPL** | **B-2** | **R-L** | **Extrema** |
|---|---|---|---|---|---|
| DialoGPT | Vanilla | 15.51 | 5.13 | 15.26 | 49.80 |
| | Joint | - | 5.00 | 15.09 | 49.97 |
| | Oracle | 15.19 | 5.52 | 15.82 | 50.18 |
| BlenderBot | Vanilla | 16.23 | 5.45 | 15.43 | 50.49 |
| | Joint | - | 5.35 | 15.46 | 50.27 |
| | Oracle | 16.03 | 6.31 | 17.90 | 51.65 |

**Table 2.** Automatic evaluation results of CoMAE model

| | **Models** | **PPL** | **B-2** | **R-L** | **Greedy** |
|---|---|---|---|---|---|
| **Happy** | **Vanilla** | 18.82 | 5.95* | 15.00* | 66.09* |
| | **+ CM** | 18.21 | 6.67* | 17.64* | 66.95* |
| | **+ DA** | 18.01 | 7.18* | 18.09* | 67.35* |
| | **+ EM** | 17.88 | 7.51* | 18.27* | 67.78* |
| | **CM‖DA** | 17.83 | 7.76* | 18.85* | 67.78* |
| | **CM‖EM** | 17.57 | 8.17* | 19.58* | 68.25* |
| | **DA‖EM** | 17.38 | 8.37* | 19.91* | 68.59* |
| | **CM‖DA‖EM** | 17.26 | 9.21 | 20.75 | 68.86 |
| | **CM → DA** | 17.69 | 7.95* | 18.96* | 67.79* |
| | **CM → EM** | 17.45 | 8.04* | 19.49* | 68.08* |
| | **DA → EM** | 17.28 | 8.73* | 20.09* | 68.59* |
| | **CM → DA → EM** | **17.02** | **9.44** | **20.76** | **68.92** |

**Table 3.** Automatic evaluation results of MISC

| **Model** | **ACC** (%)↑ | **PPL**↓ | **D-1**↑ | **D-2**↑ | **B-2**↑ | **B-4**↑ | **R-L**↑ | **M**(%)↑ |
|---|---|---|---|---|---|---|---|---|
| Transformer | - | 89.61 | 1.29 | 6.91 | 6.53 | 1.37 | 15.17 | 10.33 |
| MT Transformer | - | 89.52 | 1.28 | 7.12 | 6.58 | 1.47 | 14.75 | 10.27 |
| MoEL | - | 133.13 | 2.33 | 15.26 | 5.93 | 1.22 | 14.65 | 9.75 |
| MIME | - | 47.51 | 2.11 | 10.94 | 5.23 | 1.17 | 14.74 | 9.49 |
| BlenderBot-Joint | 28.57 | 18.49 | 4.12 | 17.72 | 5.78 | 1.74 | 16.39 | 9.93 |
| MISC | **31.63** | **16.16** | **4.41** | **19.71** | **7.31** | **2.20** | **17.91** | **11.05** |

with the emotional support system of a single strategy. Table 2 Multi-factor modeling of emotional dialogue system takes into account the dialogue mechanism, emotion and dialogue behavior, which has greatly improved in PPL, B-2 and B-L compared with the previous two systems. On the whole, it is effective to improve empathy response by introducing emotion, knowledge and other contents and dialogue strategies.

## 5 Conclusion

This paper takes emotion recognition, cognition and empathy response as the main line of the research on empathy dialogue, and analyzes the generation of empathy dialogue by taking dialogue elements and three modules of human-computer dialogue system as two side lines. On one hand, we propose to analyze emotional cognition from the perspective of the five elements of dialogue: speaker, listener, discourse, context, dialogue mechanism or strategy. On the other hand, we propose to analyze the related work of empathy response generation from the perspective of three modules of human-computer dialogue system: semantic understanding, dialogue management, and corresponding generation mode. Lastly, we summarized the experimental setting and analyzed the main challenges of empathy dialogue and looked forward to the future research direction.

The inadequacy of this paper is that the analysis model and method are not very detailed enough, and the future work will further explore relevant research. In the future, we are going to build a knowledge map based on the theory of humanities, and formulate dialogue strategies based on psychology. It is our direction to make knowledge, emotion, role, style and strategy jointly guide the generation of dialogue, and to study the personality empathy dialogue system. It is hoped that this work can promote the development of empathetic dialogue.

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