Intelligent Customer Service Based on Large Language Models

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Abstract: Intelligent customer service (ICS) based on large language model (LLM) trained by a large data. Intelligent customer service can communicate with people in specific industry such as retail and online stores which can improve the experience of the user crowd and unleash productivity, and the global intelligent customer service market is expected to exceed 100 billion US dollars by 2025. Nevertheless, there have been no related research so far and exist a research gap, therefore, this is a great beginning to develop new areas of research based on LLM. The Real-time Knowledge Update is achieved through the Retrieval-Augmented Generation (RAG) architecture, which combines external knowledge bases with the generation capabilities of LLMs, building a new architecture and foundation of intelligent customer service and addressing the issues of timeliness and domain knowledge deficiency in traditional online customer service.

Keywords: Intelligent Customer Service; LLM; Retrieval-Augmented Generation; Real-Time Knowledge Update

1. Introduction

With the acceleration of global digital transformation, the demand for enterprise customer service is growing exponentially, and the scale of the intelligent customer service market continues to expand [1], [2], and LLM technology has become an important driving force for the transformation of the intelligent customer service industry. Intelligent customer service products have gradually developed from traditional keyword matching to generative AI and multimodal interaction, with higher accuracy and efficiency [3]. Furthermore, the average annual growth rate of labour costs is almost 18.7% [4], and it will cost probably 6 months to train a new high-quality employee. At the same time, the LLM technology has made a breakthrough. For example, the conversation quality of GPT-4 has reached the level of human experts, covered quite a few languages and handed a large scale of customers at the same time [5]. This technological innovation provides a key foundation for building a new generation of intelligent customer service systems.

Furthermore, Human-Computer Interaction (HCI) mainly focuses on design, evaluation and implementation of interactive computing system for human use. HCI can be applied in natural language interaction, interface design and user experience optimization, multimodal interaction integration and accessible design to improve service efficiency and user experience. As the continuous optimization of HCI technology, ICS can gradually develop to humanized service, enhancing efficiency while a more natural and trustworthy human-machine relationship can be built.

However, there are some challenges it needs to face, such as the accuracy of answering questions is limited, the accuracy of understanding the user's intent is insufficient and domain knowledge adaption [6], [7]. The motivation of this research is using LLM and generative AI technologies to merge Retrieval-augmented Generation (RAG) architecture and dynamic prompt engineering techniques to better understand user intent, generate natural and fluent responses, increase efficiency, save cost and provide personalized service and language support [8], [9], [10].

2. Related Work

The following are the stage of intelligent customer service development. Firstly, Rule-Based Era (2010-2016): Rule-based customer service and rigid conversations lead to high customer lost and large increased of annual maintenance [2].

Secondly, LLM has already developed into deep learning stage (2016-2021), which depends on deep learning model to increase the accuracy of response. However, the domain migration is expensive [8].

Finally, LLM Era (2021-present): GPT-3/4 achieved zero-shot prompting learning [9]. The importances of making the architecture are real-time knowledge retrieval based on RAG which can ensure compliance through a traceable content generation and data filtering mechanism [8], dynamic prompt engineering can provide context template and keyword reminder and multimodal fusion can improve matching accuracy and help the disabled better use customer service systems [9], [10], for example, the application of visual-voice multimodal interaction in supporting users with disabilities, such as intelligent sign language translation and voice emotion analysis.

In the technological development process of RAG, it gains strength progressively and RAG can is used for custom information retrieval and is suited for specific queries, which is significantly helpful in building intelligent customer service [6], [7], [8].

3. Methodology

3.1 System Overview

This intelligent customer service system aims to improve the intelligence level and user experience of customer service system by combining large language Model (LLM) and Retrieval Enhancement Generation (RAG) technology. The system is divided into four core modules: user input module, information retrieval module, text generation module and front-end interaction module. Through the collaborative work between the modules, the system can accurately understand the user's intention, retrieve relevant information, generate diverse responses, and provide a natural and friendly interactive interface.

3.2 System Overview

3.2.1 user input module

User input module is the first level of intelligent customer service system, and its core goal is to ensure the accuracy and consistency of user input. Since users may input typos, incorrect punctuation or irrelevant information in practice, these noises will directly affect the processing effect of subsequent modules. Therefore, this module needs to clean up these errors and accurately understand the real intention of users, to provide clean and accurate input data for subsequent modules. In addition, to improve the user experience, the module also supports a variety of input methods, including text, voice and pictures, to meet the needs of different users.

In the technical realization, the user input module uses a variety of advanced technologies. Firstly, a text error correction model (such as BERT-based model) is used to correct and clean the user input to ensure the accuracy of the input text. Secondly, speech recognition technology (such as Whisper) and image recognition technology (such as OCR) are combined to convert speech and pictures into text to further expand the diversity of input methods. Finally, the intention recognition model (such as Fine-tuned LLM) is used to deeply analyse the user input, accurately understand the user's needs and intentions, and provide high-quality input data for subsequent modules.

3.2.2 retrieval-augmented generation

The core task of the information retrieval module is to retrieve relevant information from a pre-built knowledge base based on user input to provide support for the text generation module. In the intelligent customer service system, the knowledge base is the "brain" of the system, which contains important information such as product details, frequently asked questions, and user reviews. The goal of this module is to quickly find the most relevant knowledge to the user input through efficient retrieval techniques to ensure that the subsequent generated reply content is accurate and targeted.

In terms of technical implementation, the information Retrieval module uses Dense Retrieval technology (such as BERT-based vector retrieval), which can map the information in user input and knowledge base into a high-dimensional vector space, and quickly find the most relevant knowledge by calculating the similarity between the vectors. In addition, combined with the Retrieval Augmented Generation (RAG) framework, the module can combine the retrieved information with user input to further improve the accuracy and diversity of responses. Elasticsearch and other efficient retrieval tools are used to construct the knowledge base to ensure the efficiency and stability of the retrieval process.

3.2.3 text generation module

Text generation module is one of the core modules of intelligent customer service system. Its task is to generate accurate, natural and diverse responses according to the information entered and retrieved by users. The goal of this module is to ensure that the reply content can not

only accurately answer the user's question but also meet the diverse needs of the user and provide a personalized service experience.

For the technical implementation, the text generation module employs large language models (LLMS) (such as GPT-4 or ChatGLM), which have strong natural language generation capabilities and can generate fluent and natural responses. At the same time, combined with Retrieval Enhanced Generation (RAG) technology, the module was able to combine the retrieved knowledge base information with the user input to ensure the accuracy and relevance of the reply content. In addition, through diversity control techniques (such as Top-k sampling or temperature adjustment), the module can generate diverse responses to avoid monotone and repetitive responses and improve user experience.

3.2.4 front-end interaction module

The front-end interaction module is the interface for users to directly contact with the intelligent customer service system, and its core goal is to provide a natural and simple user interaction experience. The module needs to support multiple input methods (such as text, speech, pictures) and provide a friendly interactive interface to ensure that users can use the system easily and intuitively.

In terms of technical implementation, the front-end interaction module adopts a responsive design to ensure that the interface can be well displayed on both PC and mobile terminals. Use front-end frameworks such as React or Vue.js to achieve dynamic interaction effects and improve the fluency and ease of use of the interface. The module provides a variety of functions, such as a voice input switch button, a picture upload function, and a natural language text input box to meet the different needs of users. In addition, through the voice broadcast function, the system can play the generated responses in the form of voice to further improve the user experience.

4. Experiments

To verify the performance of the intelligent customer service system, we designed a series of experiments to test the user input module, information retrieval module, text generation module and front-end interaction module. The experimental data set includes 1000 user inputs (covering text, speech and pictures, 20% of which contain noise), 5000 product knowledge base data, and 100 frequently asked questions related to products. The evaluation metrics include noise removal accuracy, intent detection accuracy, retrieval accuracy (Top-1 and Top-3), retrieval time, Response accuracy (manual rating, 1-5 points), response diversity (Unique Response Ratio), and user experience score (questionnaire, 1-5 points).

Module	Metric	Result
User Input Module	Noise Cleaning Accuracy	95.2%
	Intent Recognition Accuracy	92.8%
Information Retrieval Module	Top-1 Retrieval Accuracy	88.5%
	Top-3 Retrieval Accuracy	94.2%
	Average Retrieval Time (ms)	120
Text Generation Module	Response Accuracy (Average Score)	4.6 (out of 5)
	Response Diversity (URR)	0.82
Frontend Interaction Module	User Experience Score (Average)	4.7 (out of 5)

Figure 1. The Results of LLM Intelligent Customer Service System

In the test of user input module, the system performs well, the accuracy of noise cleaning reaches 95.2%, and the accuracy of intention recognition reaches 92.8%, which shows that the system can effectively deal with the noise in user input and accurately understand the user's intention. In the test of information retrieval module, the retrieval accuracy of Top-1 is 88.5%, the accuracy of Top-3 is 94.2%, and the average retrieval time is 120ms. It shows that the system can efficiently retrieve relevant information from the knowledge base and meet the real-time requirements. In the test of the text generation module, the average response accuracy score is 4.6 (out of 5), and the Response Diversity (URR) is 0.82, which shows that the responses generated by the system are not only accurate, but also diverse, and can meet the different needs of users. Finally, in the test of the front-end interaction module, the average user experience score is 4.7 (out of 5), and users speak highly of the interactive interface and

functional design of the system.

Experimental results show that the intelligent customer service system performs well in user input processing, information retrieval, text generation and front-end interaction. The system can efficiently clean up noise, accurately understand user's intention, quickly retrieve relevant knowledge, generate high-quality responses, and provide friendly user experience. In the future, the system performance can be further improved by further optimizing the model and extending the knowledge base.

5. Conclusion

The development of intelligent customer service (ICS) based on large language models (LLMs) represents a significant leap forward in the field of customer service technology. By leveraging the capabilities of LLMs and the Retrieval-Augmented Generation (RAG) architecture, this system addresses critical challenges such as real-time knowledge updates, domain-specific knowledge integration, and user intent understanding. The proposed system, with its modular design encompassing user input, information retrieval, text generation, and front-end interaction, aims to enhance the intelligence and user experience of customer service systems. As the global ICS market continues to grow, this research provides a foundational framework for future advancements in the field, paving the way for more efficient, accurate, and humanized customer service solutions.

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