

Original Research Article

Deep integration of computer artificial intelligence and natural language processing*Wang sen**Zhengzhou University of Economics and Trade, Anyang, Henan, 455000, China*

Abstract: The development and technological evolution of artificial intelligence (AI) have laid a crucial foundation for natural language processing (NLP) technology. Through innovations in deep learning and large-scale pre-trained models, the language understanding and generation capabilities of AI have significantly improved. This paper analyzes in detail the core NLP technologies, such as speech recognition, word embeddings, semantic analysis, and the applications of generative models. By integrating deep learning with NLP, models have demonstrated exceptional performance in tasks like speech recognition and text generation, further promoting the application of multimodal learning in NLP. Multimodal learning, by combining text, images, and audio, enhances the system's understanding and generalization capabilities.

Keywords: Computer; Artificial intelligence; Natural language

1. Introduction

The development of artificial intelligence can be traced back to the 1950s when scientists began to envision machines with thinking abilities similar to humans. Early AI research aimed to simulate basic logical reasoning and mathematical operations in computers, laying the foundation for future development. In the 1980s, the emergence of expert systems gradually applied AI to specific fields, but progress stalled due to limited computational power and data. At the beginning of the 21st century, breakthroughs in machine learning, particularly deep learning, led to the resurgence of AI, achieving significant progress in areas like image and speech recognition. In recent years, with considerable advancements in computational power and data resources, AI has entered a phase of large-scale applications, ranging from intelligent assistants and autonomous driving to medical imaging analysis, with an ever-expanding scope of technologies and application scenarios. The significance of NLP lies in bridging the gap between machine and human language, allowing information technology to penetrate more deeply into social life, fulfilling the vision of AI serving humanity.

2. Overview of computer artificial intelligence

Computer AI is a profound and extensive field of research driven by humanity's pursuit to mimic and surpass human intelligence. The foundational theories of AI are rooted in computer science, mathematics, statistics, and neuroscience, and its core idea is to simulate and extend human intelligent behavior using computers. AI aims to enable machines to understand, reason, learn, and make decisions by mimicking human thinking to solve complex problems. Over time, AI research has evolved from symbolic logic and rule-based systems to complex machine learning and deep learning models, experiencing numerous technological and methodological breakthroughs.

Machine learning, a significant branch of AI, focuses on data-driven approaches that allow machines to learn from experience. By finding patterns and rules in historical data, the system can then predict or solve new

problems. With the advent of big data and increased computational power, deep learning has emerged as one of the most representative techniques in machine learning. Inspired by the structure and function of the human brain, deep learning uses artificial neural networks to extract features through multiple layers of abstraction, efficiently processing complex data such as images, speech, and natural language. It has shown exceptional performance in handling unstructured data, advancing AI's perceptual and cognitive reasoning abilities.

Among the key technologies in AI, machine learning, NLP, computer vision, and reinforcement learning are the most representative. Machine learning offers powerful prediction and classification capabilities, enabling intelligent systems to optimize their performance based on large-scale data. NLP allows machines to understand, generate, and interact with human language for efficient communication. Computer vision provides machines with the ability to “see,” enabling recognition, analysis, and interpretation of visual information, such as images and videos. Reinforcement learning focuses on optimizing decision-making by interacting with the environment and learning the best strategies through trial and error. These technologies work in concert to push AI to higher levels.

The applications of AI are widespread and have gradually penetrated every aspect of society. In healthcare, AI assists doctors in diagnosis by analyzing medical data and images, providing personalized treatment plans for patients. In the financial sector, AI is used for automated trading, risk assessment, and fraud detection, improving efficiency and security for financial institutions. In the field of autonomous driving, computer vision based on deep learning enables vehicles to perceive road conditions, recognize obstacles, and make safe driving decisions. In addition, applications in smart homes, voice assistants, education, and industrial automation have brought AI increasingly closer to people's lives. These advances in technology have not only improved productivity but also profoundly changed how society functions and people experience their daily lives^[1].

3. Core technologies of natural language processing

The core technologies of NLP cover several domains, and their continuous development has greatly enhanced computers' ability to understand and generate human language. Among these are speech recognition and semantic analysis, word embedding and vectorization models, sentiment analysis, and generative models, which are crucial for the advancement of NLP.

Speech recognition is a key component of NLP, involving the conversion of human speech signals into text. This process requires capturing speech features while effectively handling factors such as different dialects, speech speed, and environmental noise. Recent advancements in deep learning-based speech recognition models, particularly Long Short-Term Memory (LSTM) networks and Convolutional Neural Networks (CNNs), have significantly improved recognition accuracy, particularly for continuous speech signals. Once speech is converted into text, computers proceed with semantic analysis to understand the underlying meaning. Semantic analysis involves understanding language from the lexical, sentence, and paragraph levels by constructing semantic networks and using dependency syntax analysis, allowing deeper comprehension of user needs.

Word embedding and vectorization models are also crucial parts of NLP, providing a way for computers to understand and process language. Language is inherently complex and multidimensional, which makes it challenging for traditional machines to comprehend its semantics. Word embedding solves this issue by mapping words into low-dimensional vectors, preserving semantic relationships between words while clustering similar words in mathematical space. Models like Word2Vec and GloVe use large corpora to learn contextual

relationships between words, transforming them into vector representations. These vectors not only help in simple lexical matching but also use mathematical tools like cosine similarity to compare different words or phrases, enabling machines to understand and generate natural language on a deeper level.

Sentiment analysis and generative models are playing increasingly important roles in NLP, especially in fields like social media and customer service. Sentiment analysis involves analyzing text to identify the emotions and attitudes expressed, providing insight into the emotional inclination of the user. With deep learning networks and Recurrent Neural Networks (RNNs), sentiment analysis captures subtle emotional changes in text, providing crucial information for market research and user feedback analysis. Generative models, on the other hand, allow computers to imitate human language behavior, generating natural language. Pre-trained generative models based on deep learning, such as the GPT series, have shown powerful capabilities in text generation, learning language rules from large amounts of text corpus, and generating coherent, logically consistent text. These models have vast applications, ranging from automated news writing to intelligent customer service^[2].

4. Deep integration of computer AI and NLP methods

4.1. NLP optimization based on deep learning

Deep learning's application in NLP is pushing language technologies to new heights. By leveraging the powerful features of deep neural networks, NLP has achieved significant optimizations in tasks such as speech recognition and text generation. The core of deep learning lies in its ability to autonomously learn and extract features from massive data without manually specifying every linguistic rule, which is well-suited for handling the complexity and diversity of natural language.

Common methods in deep learning, such as Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Transformer models based on attention mechanisms, provide multiple optimization approaches for NLP. RNNs and Long Short-Term Memory networks (LSTMs) excel in sequential tasks by capturing temporal relationships and contextual associations in language, improving text comprehension. Meanwhile, the introduction of the Transformer architecture revolutionized NLP with its multi-head attention mechanism, allowing models to capture long-distance dependencies in parallel, greatly enhancing comprehension and generation of complex sentences. Transformer not only addresses RNN's limitations in retaining long-sequence information but also speeds up training, becoming a core technology in modern NLP.

In addition, large-scale pre-trained models further optimize NLP performance. The introduction of models like BERT and GPT has brought natural language understanding and generation to unprecedented levels. BERT achieves deep comprehension by using bidirectional encoding, accurately capturing word meanings in different contexts, while GPT excels in language generation, producing high-quality writing and dialogues. These models' pre-training processes use vast amounts of unlabeled text data, allowing quick adaptation during task-specific fine-tuning, significantly reducing dependence on annotated data and enhancing generalization capabilities^[3].

4.2. Application of large-scale pre-trained models

The application of large-scale pre-trained models represents an important direction in the deep integration of AI and NLP. Models such as BERT (Bidirectional Encoder Representations from Transformers) and GPT (Generative Pre-trained Transformer), pre-trained on large-scale corpora, have significantly enhanced language understanding and generation, advancing NLP tasks considerably. These models' advantage lies in their ability to

learn deeper linguistic features and contextual associations, thanks to deep learning on massive data, effectively capturing complex relationships and meanings within language. By using self-supervised learning, these models learn from language features without relying on labeled data, thereby improving generalization and adaptability.

BERT, based on a bidirectional Transformer structure, encodes sentences from both left-to-right and right-to-left simultaneously, fully utilizing the contextual information in sentences. BERT has excelled in various NLP tasks, including question-answering systems, text classification, and named entity recognition, thanks to its rich understanding of linguistic semantics and sentence structure. In comparison, the GPT series focuses more on text generation capabilities. GPT's unidirectional Transformer architecture, predicting the next word in sequence, gives it an advantage in generating coherent, natural text. GPT's core idea involves using pre-training to predict the next word, then fine-tuning to adapt to specific tasks. This generative model excels in applications like dialogue systems, content creation, and machine translation. GPT-3, with its massive parameter count and complex training, can generate text that is almost indistinguishable from human writing, making it widely used in intelligent writing, content creation, and automated customer service.

The widespread use of pre-trained models has also redefined the development process and approach. In traditional NLP systems, developers typically designed specific feature extractors and model architectures for each task. Pre-trained models have significantly simplified this process, allowing developers to adapt to different tasks with minimal fine-tuning, making NLP applications more efficient and accessible. Additionally, these models' strong transfer learning capabilities enable them to achieve good performance even on small datasets, reducing the need for high-quality annotated data^[4].

5. Conclusion

The deep integration of computer AI and NLP has greatly enhanced AI's understanding and generation capabilities. Deep learning has played a key role in NLP, optimizing tasks such as speech recognition, semantic analysis, and the application of generative models, bringing computers closer to the human level in language comprehension and expression. Large-scale pre-trained models like BERT and GPT have revolutionized NLP, allowing models to efficiently and intelligently handle complex tasks in language understanding and generation. Additionally, multimodal learning, by integrating text, images, and audio, has expanded NLP's application scenarios, improving machines' perception and interaction capabilities. Despite challenges, the integration of AI and NLP will continue to advance, bringing more intelligent solutions to everyday life as technology progresses.

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