Large AI Model-Based Semantic Communications

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***Abstract*—Semantic communication (SC) is an emerging intelligent paradigm, offering solutions for various future applications like metaverse, mixed-reality, and the Internet of everything. However, in current SC systems, the construction of the knowledge base (KB) faces several issues, including limited knowledge representation, frequent knowledge updates, and insecure knowledge sharing. Fortunately, the development of the large AI model provides new solutions to overcome above issues. Here, we propose a large AI model-based SC framework (LAM-SC) specifically designed for image data, where we first design the segment anything model (SAM)-based KB (SKB) that can split the original image into different semantic segments by universal semantic knowledge. Then, we present an attention-based semantic integration (ASI) to weigh the semantic segments generated by SKB without human participation and integrate them as the semantic-aware image. Additionally, we propose an adaptive semantic compression (ASC) encoding to remove redundant information in semantic features, thereby reducing communication overhead. Finally, through simulations, we demonstrate the effectiveness of the LAM-SC framework and the significance of the large AI model-based KB development in future SC paradigms.**

***Index Terms*—Semantic communication; large AI models; knowledge base; SAM; semantic compression.**

I. Introduction

Semantic communication (SC), as a new intelligent paradigm, has recently received much attention. It is expected to contribute to various applications such as metaverse, mixed reality (MR), and the Internet of Everything (IoE) [1]. Unlike traditional communication methods, which focused on ensuring the accuracy of transmitted bits or symbols, SC prioritizes delivering the intended meaning with minimal data. Typically, the SC system comprises the following components:

- *Semantic encoder*: The semantic encoder extracts semantic information from the original data and encodes the these features into semantic features, thus understanding the meanings of data and reducing the scale of the transmitted information from the semantic level.
- *Channel encoder*: To ensure data transmitted on the physical channel, the semantic features should be encoded and modulated by the channel encoder to combat channel impairments and improve the robustness.
- *Channel decoder*: The channel decoder is used to demodulate and decode the received signal and obtain the transmitted semantic features before the original data are recovered.
- *Semantic decoder*: The semantic decoder aims to understand the received semantic features, and infer the semantic information and recover the original data from the semantic level.
- *Knowledge base*: SC is a knowledge based system and the knowledge base (KB) is a universal knowledge model which can help the semantic encoder and decoder to understand and infer the semantic information more effectively.

The above components can be implemented by applying deep neural networks (DNNs) which have superior self-learning and feature extraction capabilities. These DNNs can be trained jointly in tandem to maximize expected faithfulness in semantic representation and minimize communications overhead during transmission, and the whole SC system can achieve the global optimality.

Recently, most AI-powered SC system models, including TOSCN [2], DeepSC-ST [3], and DeepJSCC-V [4], centered around designing an efficient communication model. These models heavily rely on the encoder and decoder of SC to extract and interpret semantics. The primary model architectures that facilitate this process includes encoder-decoder (ED) [5], information bottleneck (IB) [6], knowledge graph (KG) [7], and so on. Although these methods are capable of extracting semantic information from unstructured data sources, they may not fully exploit the potential benefits of utilizing KB in their approach.

A. Composition of an Universal KB in SC Systems

In fact, KB is essential for SC to distinguish itself from conventional communication systems by its capacity to understand and infer semantic information. We can build a universal KB by learning a large amount of world knowledge, which forms the core of the SC system. The universal KB consists of prior and background knowledge that can be understood and recognized by users.

1) *Prior knowledge*: SC defines the structure of semantic representation and the relationships between entities

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