

# ChatGPT for Computational Social Systems: From Conversational Applications to Human-Oriented Operating Systems

**W**ELCOME to the second issue of the IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS (TCSS) of 2023. According to the latest update of CiteScore-Tracker from Elsevier Scopus released on February 5, 2023, the CiteScore of TCSS has reached a historical high of 9.6. Many thanks to all for your great effort and support.

After the usual introduction of our 32 regular articles, we would like to discuss the topic of ChatGPT for computational social systems (CSS). Although ChatGPT has introduced the stronger intelligence to develop and revolutionize CSS in various aspects, it also poses new challenges concerning internet security, human ethics, social responsibility, and ecological sustainability. The parallel intelligence and the emerging technologies, including decentralized autonomous organizations and operations, decentralized science, and scenarios engineering, can provide good solutions to address these challenges as well as realize social intelligence. Furthermore, to enhance the performance of ChatGPT in CSS, the currently well-known conversational applications based on ChatGPT must be evolved into human-oriented operating systems.

## I. SCANNING THE ISSUE

1. “Geometric Renormalization Reveals the Self-Similarity of Weighted Networks” by *Dan Chen, Housheng Su, and Zhigang Zeng*

By extending the geometric renormalization (GR) framework to the weighted network, this article proves that it can maintain the topological characteristics of the initial network within an appropriate iterative range. This article also studies the topological properties of five weighted human connected group networks with different resolutions, and the results show that the topological characteristics of these networks show similar behaviors. In addition, the results also show that the GR transformation of the weighted network can also produce a multiscale-weighted human-connected group network that is highly consistent with the empirical data. Finally, the rationality of the framework is verified.

2. “Mitigating Influence of Disinformation Propagation Using Uncertainty-Based Opinion Interactions” by *Zhen Guo, Jin-Hee Cho, and Chang-Tien Lu*

This article proposes an opinion framework of game theory, which can formulate dynamic opinions through a belief model called subjective logic, and provide opinion updates of five

types of user interaction on the online social network platform. Allowing users to make rational decisions when updating their opinions. This article develops two opinion models, in which users update their opinions according to the perceived uncertainty or homogeneity of their opinions. The models can demonstrate how these two types of users can prevent false information. Finally, the rationality of the framework is verified by a large number of simulation experiments.

3. “An Improved Differential Evolution Framework Using Network Topology Information for Critical Nodes Detection” by *Shanqing Yu, Yongqi Wang, Jiexiang Li, Xu Fang, Jinyin Chen, Ziwang Zheng, and Chenbo Fu*

This article proposes a topology-based differential evolution framework topology-combined differential evolution for critical nodes detection, which designs individual genotypes through node degree, and designs appropriate mutation operators and selection operators to effectively use topological network information, thus improving the performance of evolutionary algorithms. Experiments on synthetic and real networks show that it is feasible to improve the search efficiency of the algorithm by fusing network topology information. The research highlights the importance of the underlying network topology information.

4. “A Self-Fusion Network Based on Contrastive Learning for Group Emotion Recognition” by *Xingzhi Wang, Dong Zhang, Hong-Zhou Tan, and Dah-Jye Lee*

This article proposes an effective group emotion recognition (GER) model, which aims to recognize group emotions using the information of faces, scenes, and objects in the image. The framework consists of three networks, FacesNet, SceneNet, and ObjectsNet. FacesNet combines individual facial features to generate more discriminative features. SceneNet captures multiscale scene features to make use of emotional clues in the scene. ObjectsNet is used to classify the semantic features of objects. The output linear integration of these three networks is taken as the final output of the unique framework of GER. Finally, its effectiveness is verified.

5. “Investigations in Emotion Aware Multimodal Gender Prediction Systems From Social Media Data” by *Chanchal Suman, Rohit Chaudhari, Sriparna Saha, Sudhir Kumar, and Pushpak Bhattacharyya*

This article studies the effect of using emotional information in a multimodal framework, which uses social media input composed of text and images to complete gender prediction tasks. First, the necessity of using multimodal information (text + image) is determined by showing the performance

improvement corresponding to plain text. The second is to establish the usefulness of emotion as a feature in helping gender prediction tasks. Finally, several multitask models using emotion, text, and image features are developed and their behaviors are compared.

6. “A Binary-Search-Based Locality-Sensitive Hashing Method for Cross-Site User Identification” by *Wenqiang He, Yongjun Li, Yinyin Zhang, and Xiangyu Li*

In this article, a binary-search-based locality-sensitive hashing (BLSH) method is designed to solve the problem of huge computation in cross-site user identification. BLSH is developed into a mature hierarchically attentioned binary-search-based locality-sensitive hashing (HA-BLSH), and the hierarchical design of discrete attention is adopted to improve efficiency performance. A large number of experiments on real datasets show the excellent performance of HA-BLSH, and its important parameters are discussed in detail. In addition, the idea of BLSH coding can be extended to  $n$ -dimensional space, which further improves the applicability of the method and can accommodate more scenes.

7. “Graph-Fraudster: Adversarial Attacks on Graph Neural Network-Based Vertical Federated Learning” by *Jinyin Chen, Guohan Huang, Haibin Zheng, Shanqing Yu, Wenrong Jiang, and Chen Cui*

Combining the privacy disclosure of Graph Neural Network-Based Vertical Federated Learning (GVFL) and the gradient of paired nodes, this article proposes the first novel adversarial attack method against GVFL: Graph-Fraudster. This method utilizes the noise embedded in the global node to generate antagonistic disturbance through privacy disclosure and gradient of paired nodes. A large number of experiments are conducted, and the results show the effectiveness and efficiency of Graph-Fraudster and the vulnerability of GVFL in the defense environment. In addition, some suggestions are put forward for future work to improve the robustness of GVFL.

8. “Disinformation Propagation Trend Analysis and Identification Based on Social Situation Analytics and Multilevel Attention Network” by *Junchang Jing, Fei Li, Bin Song, Zhiyong Zhang, and Kim-Kwang Raymond Choo*

This article proposes a disinformation diffusion trend analysis and identification method based on users dissemination of disinformation content and social contextual information, which uses social situation analytics and a multilevel attention network. Specially, a trend analysis and identification model of disinformation dissemination based on social situation analytics is constructed, which is based on the social users’ propagation sequence and propagation content in social networks. The evaluation shows that the model outperforms other comparison approaches and yields the optimal effect using the Socialsиту metadata collected from online social networks platform.

9. “Gray Uncertain Linguistic Multiattribute Group Decision Making Method Based on GCC-HCD” by *Congjun Rao, Cheng Wang, Zhuo Hu, Xinping Xiao, and Mark Goh*

Considering both subjective and objective uncertainty in the original decision information, this article proposes new concepts of gray uncertain linguistic variable and gray

comprehensive clouds by using the existing uncertain linguistic variable. A method for converting gray uncertain linguistic variables into gray comprehensive clouds is provided; a gray comprehensive clouds-weighted averaging operator and a distance measure between two gray comprehensive clouds are proposed and defined, which aggregate the information with multiple gray comprehensive clouds and form the gray comprehensive cloud-hybrid closeness degree (GCC-HCD). Then, it is applied to rank the alternatives.

10. “Privacy-Preserving Link Prediction in Multiple Private Networks” by *Hai-Feng Zhang, Xiao-Jing Ma, Jing Wang, Xingyi Zhang, Donghui Pan, and Kai Zhong*

This article proposes a secure multiparty computation-link prediction (SMPC-LP) method based on SMPC to integrate the information of multiple private networks by formulating a security protocol, so as to help each private network to better predict missing links in its own network without disclosing its structure to others. The method fuses the information of each private network without disclosing their inputs, and then, the similarity score of each node pair is jointly calculated, achieving enhanced link-prediction performance in each private network. The experimental results show that the SMPC-LP method not only effectively predicts the missing links in each subnetwork but also ensures the privacy of each subnetwork.

11. “Unsupervised Domain Adaptation With Global and Local Graph Neural Networks Under Limited Supervision and Its Application to Disaster Response” by *Samujwal Ghosh, Subhadeep Maji, and Maunendra Sankar Desarkar*

When it comes to identification and categorization of social media posts generated during disasters, this article uses limited labeled data along with abundantly available unlabeled data generated during a source disaster. To handle the challenge that the amount of labeled data available is limited, this article proposes a novel two-part graph neural network (GNN). The model learns domain-agnostic features for tokens using graph convolution networks on token graphs built from labeled and unlabeled data across domains and also preserves local instance-level context using a graph attention network on instance graphs. Experiments show that the method outperforms Bidirectional Encoder Representation From Transformers (BERT) by a significant margin on average across datasets.

12. “Petri-Net-Based Model Checking for Privacy-Critical Multiagent Systems” by *Leifeng He, Guanjun Liu, and Mengchu Zhou*

To deal with the state explosion problem resulted by verification of computation tree logic of knowledge based on knowledge-oriented Petri nets, this article adopts reduced-ordered binary decision diagram technique to encode and store all reachable states but not to encode and store any transition relation or equivalence relation. The related algorithms are designed to compute only those required transition relation and equivalence relation and prove their correctness. A number of experiments are done using a famous benchmark about the privacy problem of the multiagent system: the dining cryptographers protocol, and the results illustrate the advantages of their methods.

13. “Fast Asymmetric and Discrete Cross-Modal Hashing With Semantic Consistency” by *Shaohua Teng, Chengzhen Ning, Wei Zhang, Nai Wu, and Ying Zeng*

To cope with some issues in Hashing, a fast asymmetric and discrete cross-modal hashing (FADCH) method is proposed in this article. Matrix factorization is leveraged to collaboratively construct a common semantic subspace between different modalities, and semantic consistency is preserved by aligning the common semantic subspace with the semantic representation constructed from labels. Then, this article embeds labels into hash codes and keeps the correlation between different modal samples using a pairwise similarity matrix and uses an asymmetric strategy with relaxation to associate hash codes with semantic representation. Finally, a strongly orthogonal constraint is introduced to optimize the hash codes and an effective optimization algorithm is developed to directly generate discrete hash codes while reducing the complexity.

14. “Link Prediction and Unlink Prediction on Dynamic Networks” by *Christina Muro, Boyu Li, and Kun He*

To accurately predict the links and unlinks on the future network, this article proposes an effective algorithm called link prediction and unlink prediction with long-term relation and short-term relation (LULS). LULS initializes and optimizes a global matrix and a sequence of temporary matrices for all the snapshots by using nonnegative matrix factorization based on the topological matrices and calculates the similarity matrix of the future snapshot and predicts the links and unlinks for the future network. The conducted experiments on real-world networks illustrate that LULS outperforms other baselines for both link prediction and unlink prediction tasks.

15. “Multistructure Graph Classification Method With Attention-Based Pooling” by *Yuhua Xu, Junli Wang, Mingjian Guang, Chungang Yan, and Changjun Jiang*

This article proposes a Multistructure graph classification method with Attention mechanism and Convolutional neural network (CNN), called MAC. They propose a novel pooling operator, which adopts multiple strategies to evaluate the importance of nodes. To reduce the loss of graph information, they utilize a hierarchical architecture for MAC to capture multiple different substructures of a graph and 2-D CNN to generate a graph-level representation. The experimental results indicate that the method outperforms a range of state-of-the-art graph classification methods.

16. “Variations of Rotating Savings and Credit Associations for Community Development” by *Andres Felipe Zambrano, Luis Felipe Giraldo, Monica Tatiana Perdomo, Iván Darío Hernández, and Jesús María Godoy*

This article studies the performance of two variations of rotating savings and credit associations (ROSCAs) which can potentially increase the resilience of communities. First, they propose a strategy that saves a percentage of the contributions of each member of the ROSCA to reduce the impact of individuals who stop contributing to the association. Second, they study a decentralized version of the ROSCA in which individuals contribute to more than one association. Through mathematical and simulation analyses, they show how the cooperation strategies impact the resilience of low-income communities.

17. “Context-Driven-Based Community Detection” by *Kamal Taha*

This article proposed a novel methodology implemented in a working system called Context-Driven-Based Community Detection (CDBCD) that is able to detect the most granular cross-communities with multisocial traits from heterogeneous social networks. CDBCD can infer the most granular multitrait cross-communities, to which a context user (i.e., an active user) belongs. They evaluated CDBCD by comparing it with ten methods. The results demonstrated that CDBCD can detect granular cross-communities with marked accuracy. The improvement of CDBCD over the ten methods combined is 23% and 19% in terms of adjusted rand index (ARI) and F1-score, respectively.

18. “Predictive Algorithm for Team Mental Model Convergence” by *Jeffy Jahfar Poozhithara, Deanna M. Kennedy, Spencer Onstot, Agnė Januškevičiūtė, and Marjanthi Cekrezi*

This article introduces mental model shifts as a way of capturing team mental models (TMM) dynamics, specifically the positive or negative advancement to a referent model. They show that tasks can be modeled as vectors using the frequency of attribute patterns and an accuracy of up to 86.21% can be achieved in predicting future communication patterns with data from real-world tasks. Furthermore, they validate the estimation of TMM sharedness, showing that the model results are comparable to the sharedness ratings provided by subject matter experts with an average accuracy of 71.29%. Research and practical implications are discussed.

19. “Real-Time Detection of COVID-19 Events From Twitter: A Spatial-Temporally Bursty-Aware Method” by *Gaolei Fei, Yong Cheng, Wanlun Ma, Chao Chen, Sheng Wen, and Guangmin Hu*

This article proposes a spatial-temporally bursty-aware (STBA) method for real-time detection of COVID-19 events from Twitter. First, STBA identifies a set of keywords that represent COVID-19 events using Ripley’s  $K$  function to reduce the interference of noise tweets on event detection. Second, STBA uses online density-based spatial clustering of applications with noise clustering to aggregate tweets that describe the same event as much as possible. Third, STBA further utilizes the temporal bursty characteristic of event location information in the clusters to identify real-world COVID-19 events. STBA achieved even more improvements compared with GeoBurst+, EvenTweet, and EDMC.

20. “Interval Type-2 Fuzzy Risk Evaluation and Prevention for Parallel Breast Cancer Treatment System” by *Hong Mo, Haihong Hu, Jinhui Hu, Yuanyuan Li, Xiao Wang, and Fei-Yue Wang*

In this article, a new method of the evaluation and the framework of prevention for breast cancer (BC) are proposed by synthesizing interval type-2 fuzzy sets (IT2 FSs), two-level fuzzy comprehensive evaluation, and parallel control (artificial societies, computational experiments, and parallel execution). Twelve risk factors are selected as indicators to evaluate the risk level of BC. Then, the patient indexes are monitored in real time by the parallel mechanism between the actual and the artificial system, to feedback, adjust, and optimize the prevention scheme in time. This parallel BC

prevention process can achieve dynamic closed-loop control effects.

21. “Spatial-Aware Local Community Detection Guided by Dominance Relation” by *Li Ni, Hefei Xu, Yiwen Zhang, and Wenjian Luo*

This article proposes spatial-aware local community detection (SLCD), a method characterized by finding the spatial-aware local community with only local information, and characterized by defining the community based on the difference in terms of the sparseness of edges inside and outside the community. They propose Spatial-aware Local community detection algorithm with Dominance Relation (SLDR) and its efficient greedy algorithm called Spatial-aware Local community detection algorithm with Dominance Relation Greedy algorithm (SLDRG), which aims to detect a spatial-aware local community with only local information. Extensive experiments on synthetic and real-world datasets demonstrate that SLDRG substantially outperforms other methods in both structural cohesiveness and spatial cohesiveness.

22. “Can a Holistic View Facilitate the Development of Intelligent Traditional Chinese Medicine? A Survey” by *Guihua Tian, Kun Qian, Xinyi Li, Mengkai Sun, Hao Jiang, Wanyong Qiu, Xiaoming Xie, Zhonghao Zhao, Liangqing Huang, Siyan Luo, Tianxing Guo, Ran Cai, Zhihua Wang, and Björn W. Schuller*

Intelligent Traditional Chinese Medicine (ITCM) is an emerging interdisciplinary subject. A comprehensive discussion of the benefits from a holistic view, as a crucial philosophy in the theory of TCM, to ITCM is lacking. In this article, they introduce a holistic view and the application of adaptive learning and field theory in ITCM, discussing the ethical issues of ITCM which are taken into account by human-centered TCM and potentials based on affective computing of ITCM. They give some opinions and insights on the challenges and open issues towards the future of ITCM.

23. “Reversible Linguistic Steganography With Bayesian Masked Language Modeling” by *Ching-Chun Chang*

This article proposes a reversible steganographic system for natural language text. They use a pretrained transformer neural network for masked language modeling and embed messages in a reversible manner via predictive word substitution. They derive an adaptive steganographic route by taking account of predictive uncertainty, which is quantified based on a theoretical framework of Bayesian deep learning. The experimental results show that the proposed steganographic system can attain a proper balance between capacity, imperceptibility, and reversibility with close semantic and sentimental similarities between cover and stego texts.

24. “An Autoregressive Graph Convolutional Long Short-Term Memory Hybrid Neural Network for Accurate Prediction of COVID-19 Cases” by *Myrsini Ntemi, Ioannis Sarridis, and Constantine Kotropoulos*

To predict the number of COVID-19 cases the next day for every state in the United States, this article proposed a hybrid model comprised of an autoregressive (AR) filter, a graph convolutional neural network (GCN), in which an adjacency matrix is exploited, and a long short-term memory (LSTM) neural network, coined as AR-GCN-LSTM (AGL). The AR

module has been shown to capture efficiently the linearities and the GCN-Long Short-Term Memory (GCN-LSTM) module to capture the nonlinearities present in the time series. AGL consistently tracks the evolution of COVID-19 cases and it is better than the state-of-the-art methods. By this way, they efficiently capture the latent information about the spread of the virus and improved the prediction performance of the hybrid model, revealing which state truly affects the other ones.

25. “Efficient Driver Anomaly Detection via Conditional Temporal Proposal and Classification Network” by *Lang Su, Chen Sun, Dongpu Cao, and Amir Khajepour*

In consideration of detecting driver inattentive behaviors is crucial for driving safety in a driver monitoring system and recent works about driver distraction detection are always with many defects, a two-phase anomaly proposal and classification framework is proposed in this article. By combining driver anomaly detection and high-level distraction action recognition, they successfully balanced the performance and efficiency in the previous works. In the next place, the framework allocated different modalities and views input to different tasks, by which it shows competitive performance with less computational effort, while keeping high anomaly detection sensitivity and robust performance in classifying common driver distractions.

26. “HackGAN: Harmonious Cross-Network Mapping Using CycleGAN With Wasserstein-Procrustes Learning for Unsupervised Network Alignment” by *Linyao Yang, Xiao Wang, Jun Zhang, Jun Yang, Yancai Xu, Jiachen Hou, Kejun Xin, and Fei-Yue Wang*

This article proposes a novel method named harmonious cross-network mapping using cycle-consistent generative adversarial network (HackGAN) to solve the problem that a few unsupervised network alignment (UNA) methods existing rely on discriminative attributes to capture nodes' similarities and are hard to obtain optimal one-to-one alignments. First, the unsupervised deep graph infomax model preserves useful intra-network global and local structural proximities and based the model distinct network embeddings are learned. In the second place, they propose a cycle-consistent adversarial learning model with the objective of minimizing the Sinkhorn distance between mapped embedding spaces. And after the above steps, HackGAN learned successfully optimized one-to-one mappings between different embedding spaces. In the end, they propose a collective correspondence assignment method, which helps to obtain more accurate and robust predictions by preventing many-to-one alignments caused by the hubness problem.

27. “SEHC: A Benchmark Setup to Identify Online Hate Speech in English” by *Soumitra Ghosh, Asif Ekbal, Pushpak Bhattacharyya, Tista Saha, Alka Kumar, and Shikha Srivastava*

This article creates a multidomain hate speech corpus of English tweets to solve the problem with social media that the existing datasets on hate speech or offensive language identification lack diversity in the dataset's content. They use the existing models and present a stacked-ensemble-based hate speech classifier (SEHC) to identify hate speech by annotating each instance in dataset as hate or nonhate. In the process of

setting SEHC, they investigate some dataset features and used automated classifiers to do a variety of baseline investigations. The tacked ensemble system is good at capturing the variety of existing deep neural models in terms of feature representation for the same input instance, for which the system outperforms the considered state-of-the-art systems.

28. “Popularity-Aware and Diverse Web APIs Recommendation Based on Correlation Graph” by *Shengqi Wu, Shigen Shen, Xiaolong Xu, Ying Chen, Xiaokang Zhou, Dongning Liu, Xiao Xue, and Lianyong Qi*

This article proposes a novel web application programming interfaces (APIs) recommendation method named the popularity-aware and diverse method of Web API compositions’ recommendation (PD-WACR). First, PD-WACR search several candidate API compositions by the Steiner search method. After that, PD-WACR selects the final API compositions with the highest diversity values from them by Simhash and Hamming distances. The experimental results show the advantages and innovations of the PD-WACR.

29. “Are Fake Images Bothering You on Social Network? Let Us Detect Them Using Recurrent Neural Network” by *Pushpendu Kar, Zhengrui Xue, Saeid Pourroostaei Ardakani, and Chiew Foong Kwong*

This article proposes an approach to characterize the propagation patterns of fake images on social media using several user features and tweet features. They construct the propagation pattern of a fake image using a bunch of user features and tweet. The result of the experiment shows that the model already reaches high performance and the detection model has great potential so that can be used in classifying image future.

30. “Hidden Gold for IT Professionals, Educators, and Students: Insights From Stack Overflow Survey” by *Oluwaseun Alexander Dada, George Obaido, Ismaila Temitayo Sanusi, Kehinde Aruleba, and Abdullahi Abubakar Yunusa*

This article identifies and ranks the common skills, specific to 23 different information technology roles to help relevant people be aware what could they do in the future. Furthermore, the article urges people to pay more attention to the skills needed in their fields, which will play a key role in their successful career. The stack overflow developer survey data for the year 2020 are also analyzed. After that, it is concluded that individuals must have the necessary skills in the most commonly used technologies for the role.

31. “Social Knowledge Enhances Collective Safety: Computational Models and Simulations” by *Peng Lu, Yan Li, Feier Wen, and Dianhan Chen*

This article uses an agent-based model to simulate real cases and use counterfactual outcomes to evaluate the beneficial effect of social knowledge, and obtains the optimal solution (with the best matches), which can be supported by their multiscenario simulations and calculations. Then, this matrix is added into simulations to infer social outcomes. Their finding has managerial insights: for civilians, people should be aware of this social knowledge, and they should form small groups before fighting against terrorists; for the society, the set of potential heroes can be enlarged as civilians can be taught by the social knowledge, which is obtained from real case-based simulations. Thus, social safety can be

improved, and the effects can be evaluated by computational methods.

32. “Influence-Based Community Partition With Sandwich Method for Social Networks” by *Qiufen Ni, Jianxiong Guo, Weili Wu, and Huan Wang*

This article considers the community partition problem under the independent cascade model in social networks. They aim at partitioning a given social network into disjoint communities. To address the community partition problem based on the influence maximization, they design several algorithms to solve the problem. They also present a simple greedy algorithm to solve the original objective function and apply the sandwich approximation framework to it. Finally, their algorithms are evaluated on three real datasets, which clearly verify the effectiveness of their method in the community partition problem.

## II. CHATGPT FOR COMPUTATIONAL SOCIAL SYSTEMS: FROM CONVERSATIONAL APPLICATIONS TO HUMAN-ORIENTED OPERATING SYSTEMS

### A. ChatGPT: New Opportunity for CSS

Artificial intelligence (AI) foundation models adopt the approach of combining large computing power and strong algorithms to learn a set of features and rules for accomplishing tasks in multiple scenarios by training on massive unlabeled high-quality datasets. The development of AI foundation models has gone through three stages: pretrained models, large-scale pretrained models, and ultra-large-scale pretrained models, with the number of parameters breaking through from billions to trillions, supporting various tasks across multiple modalities such as images, graphics, texts, speech, etc. These models have strong anti-interference ability and high prediction accuracy, and can automatically and intelligently optimize their parameters, as well as quickly analyze and process massive data. Users only need to provide relevant data for their tasks, and then these tasks can be completed by AI foundation model directly, or through simple fine-tuning. The large-scale and pre-training characteristics of AI foundation models makes them change from “listening and observing” to “thinking and creating,” which are further expected to achieve the function of “reasoning and decision-making.” As such, AI foundation models are regarded as the primary basis and innovation source of applications in almost all industries.

Recently, Chat Generative Pretrained Transformer (ChatGPT), a state-of-the-art generative pre-trained large language model (LLM) developed by OpenAI, has garnered high attention all over the world [1], [2]. It adopts three steps of supervised model training dialog, enhanced training optimization, and model fine-tuning to simulate human learning language and knowledge acquisition. With its language understanding and text-generation capabilities, ChatGPT is trained on massive data to possess almost all-around knowledge. ChatGPT can engage in continuous multiround conversations based on contexts, and has certain writing ability to support various tasks such as art creation, technical transfer, office learning, and logical reasoning. It can even judge whether the user’s speech contains malicious or criminal intent based on a

preset code of ethics and then determine whether to provide an answer. It has even been found that ChatGPT has the empathy of a nine-year-old child [3].

Although the answers given by ChatGPT are not always accurate, direct and complete answers provide users with good experience. It took only two months for its monthly active users to reach 100 million. Now, ChatGPT is regarded as the technological revolution in the AI field, and has attracted the attention of researchers from all over the world. The breakthrough in AI brought by ChatGPT occurs in the domain of human natural language, characterized by ambiguity and high flexibility, other than the well-defined game such as chess. Language is one of the most important human inventions, serving as the cornerstone of abstract reasoning, thought exchange, and cultural transmission. The ability for machines to generate both written and spoken language will prove to be more creative than their ability to generate visual content.

ChatGPT changes the way humans perceive the world and even subvert existing lifestyles, social norms, and political and economic orders. As such, it is considered to have great potential to meet challenges faced by the computational social systems (CSS), which use the intersection of computer science and sociology to study social phenomena. CSS primarily investigate how social behaviors and interactions are influenced by computer systems and networks, as well as how computer systems can be used to simulate, analyze, and optimize social systems. Compared to traditional sociological methods, CSS are more data-driven and quantitatively analyzed, providing a more accurate description and explanation of social phenomena and aiming at offering a new perspective for us to better understand and manage social systems. To deal with the complexities related to humans and their language and behaviors, CSS involves multiple technologies to simulate, predict and optimize social systems, including social computing, machine learning, and big data analysis [4], [5]. However, as the speed and scale of dynamic changes in CSS have reached substantially high level, and the demand for human-machine-object integration in social systems has become stronger, CSS is faced with unprecedented challenges, such as efficiently processing massive data, ensuring data privacy and security, and avoiding model bias. ChatGPT has the ability to provide real-time, effective, and intelligent solutions for these challenges due to its advantages in multimodal data analysis, self-supervised learning, and model architectures with strong generalization capabilities.

### B. Potential Applications

ChatGPT has the capability to understand and respond to varying complex questions and tasks in CSS. Because of the rich functionality, such as natural language processing (NLP), data analysis, translation, and sentiment analysis, as well as superior performance, ChatGPT can be used to perform a variety of tasks, including generating reports, answering questions, and providing recommendations, so as to improve the intelligence and efficiency of decision-making in CSS. Also, due to the high accessibility and user-friendly characteristics, ChatGPT has a lower application barrier, which

makes it easily accessed and used by a wide range of people and organizations, either through direct interactions with it, or using its interface to develop new applications or functions, regardless of their technical expertise or resources. By virtue of these incomparable advantages, ChatGPT has great potential to significantly revolutionize CSS in terms of data processing, NLP, complex network analysis, and sentiment analysis.

1) *Big Data Processing*: ChatGPT has the advantages of quickly processing and analyzing large and complex datasets in CSS, which can help social networks or internet platforms gain deep insights into behaviors and preference of their target audience, and identify the future trends so as to continuously optimize and improve their development strategies.

2) *NLP*: ChatGPT has advanced NLP capabilities thus can bring significant benefits to CSS. It can be used to analyze text-based data, such as social media posts, customer reviews, and customer feedback and opinions, which are in favor to quickly identify key topics, sentiment, and opinions, and better understand humans in social systems. The superior NLP capabilities of ChatGPT also makes it easy to understand and interpret users' needs from their inquiries, and quickly generate accurate answers with human language to respond to them, so as to reduce the response time and also improve the response accuracy and efficiency.

3) *Complex Network Analysis*: CSS uses complex network analysis technologies to understand the relationships between nodes in the complex network, including individuals, organizations, and communities. ChatGPT has great advance in analyzing complex networks such as social community, supply chains, collaboration systems, and so on, since it can be effective in analyzing their structure and evolution, and identifying the relationships and interactions between these nodes. This will help in understanding the patterns of communication and information dissemination in social networks, identifying key players and bottlenecks in these systems, and providing corresponding management and control strategies.

4) *Sentiment Analysis*: CSS heavily relies on sentiment analysis to identify and categorize the opinions, attitudes, and emotions of individuals, organizations, and communities, as well as the overall mood of social networks and online communities. With strong capabilities in sentiment analysis, ChatGPT can be used to analyze the sentiment of social media posts, online reviews, and various types of news or reports, and classify them as positive, negative, or neutral, with different intensity of sentiment. Moreover, it can exert the function on analyzing the trends of sentiment over time and identify these important changes in public opinion, especially the turning point of the public opinion. These contribute to grasp social attitudes and opinions in real time, thereby enhancing the performance of CSS.

ChatGPT has attracted a lot of attention and brought a huge sensation to the academic and industry, which has triggered a wide discussion in on its application fields. Thanks to ChatGPT's powerful NLP capabilities, it can fully understand user needs and make the corresponding response quickly. Besides, through continuous interactions, ChatGPT can learn about users' preferences, habits, emotions, and sentiment, enabling it to provide more personalized and humanized services.

As such, it is regarded to have great potential to improve CSS and can be used in a wide range of purposes, such as customer service, information retrieval, and real-time recommendation. At present, chatbots and virtual assistants are the most typical and well-known application form of ChatGPT in CSS. The integration of such intelligent chatbots on the online platform, including Websites, application services (Apps), and customer service systems, will enhance the customer experience and satisfaction. Moreover, it can also serve as a virtual assistant to help users handle various tasks such as scheduling, writing, and translating. The human-machine interaction facilitated by ChatGPT allows for a more natural and intuitive interaction between humans and machines, making CSS more engaging and sustainable.

### C. Challenges and Limitations

Though ChatGPT brings prosperous applications and various derivatives to CSS, it may cause various problems at the mean time. On the one hand, ChatGPT will pose potential challenges and risks in internet security, human ethics, social responsibility, and ecological sustainability, which need to be carefully addressed to ensure the responsible and sustainable development of CSS. On the other hand, the adoption of ChatGPT to CSS is severely constrained by high cost that resulted from its development mode.

1) *Internet Security*: ChatGPT can be used to develop malicious codes or programs for cyber-criminal activities. Large-scale trained language models in ChatGPT help internet attackers to generate codes that launch offensives against vulnerabilities in applications for data larceny or denial-of-service (DoS) attacks. It can also be used to generate codes that can evade security monitoring, giving rise to difficulties in security detection and attack prevention. There are proofs that cyber criminals show great interest in ChatGPT and are trying to use this new tool to generate malicious codes for information theft, multi-layer encryption tools, dark network market scripts, just to name a few. Although the emerging trial of ChatGPT to the challenge of internet security is only on a small scale and immature, it is undeniable that in the very near future, ChatGPT will completely change the current attack and defense modes, rules and set off a booming revolution.

2) *Human Ethics*: ChatGPT has been used to accomplish draft, polish papers and speeches, summarize literature, identify research gaps, and write codes for sorts of topics. This creates dependencies and invisible prejudices among human beings. Moreover, the acknowledgment of the usage on ChatGPT on paper work has no guarantee, which largely increases the occurrences of plagiarism, and other serious violations of academic ethics [1], not to mention the impact on copyright protection of those auxiliary generated codes, images, and texts, etc.

3) *Social Responsibility*: ChatGPT suffers from data bias. ChatGPT is mainly based on datasets before 2021 for pre-training. These data might be unverified or even fictitious, and cannot be dynamically adjusted. These contaminated training data produce specious information, however, in a convincing and logical manner, which is difficult for common people

to distinguish the true from the false. Therefore, the misuse of ChatGPT has the risk of distorting scientific facts and disseminating wrong information, and even spreading extreme polemical claim for the sake of public opinion control.

4) *Ecological Sustainability*: The decision-making process in ChatGPT is a totally black-box, which leads to large degree of uncertainty and opacity [6], [7]. The kernel algorithms therein are complicated and of high economic values, rendering the potential situation of monopoly in both the technological and commercial level.

Moreover, as the foundation models of ChatGPT become more complex, they may require more computational resources and become less scalable, making it difficult to be applied to large-scale CSS applications. The training and deployment on ChatGPT model require much computing power, except a large number of corpus data with manual labels in the large language models. Therefore, the satisfactory results achieved thereby cost high interaction time and large computing environment. Despite the above factors, ChatGPT also requires server support with large computing power when applying to individual scenario. The cost of these servers is unaffordable for ordinary users. As calculated by scientists, there are more than billions of parameters in ChatGPT model for training and running, and a single reply costs at least a few cents. The high computational cost of running these models may limit their accessibility and affordability for organizations and users in CSS.

### D. The Parallel DAO to Social Intelligence

Aiming to discover patterns from massive amounts of data and analyze, control, and evaluate social systems centered by human, the primary challenge in terms of human language ambiguity should be addressed [8], [9], [10], such as the fact that the same word can have different meanings for different people, and even for the same person in different time or environments, and to establish an accurate model for it. To effectively mine relevant information from complex systems and simulate human language-based description and analysis capabilities, linguistic dynamic systems was proposed by Wang in 1995 [11]. Today, ChatGPT has established an accurate understanding model of human natural language and also realize intelligent language control. It seems that there has been a very good answer to this challenge.

ChatGPT has shown remarkable abilities in NLP tasks, and applying it to CSS will facilitate the complex social communication and further enhance social intelligence [12], [13]. However, as it becomes more and more prevalent in various social systems, the lack of trustworthiness has emerged as the most criticism, which mainly reflects in three aspects including the unreliability in its information production and presentation, the monopoly and opacity in its model development and implementation, and the imprecision in its application to specific social scenarios. As shown in Fig. 1, the successful solution of these problems will be inseparable from the help of parallel intelligence [14], [15] and the emerging technologies, including decentralized autonomous organizations and operations (DAOs) [16], [17], decentralized science (DeSci) [18], and scenarios engineering (SE) [19].

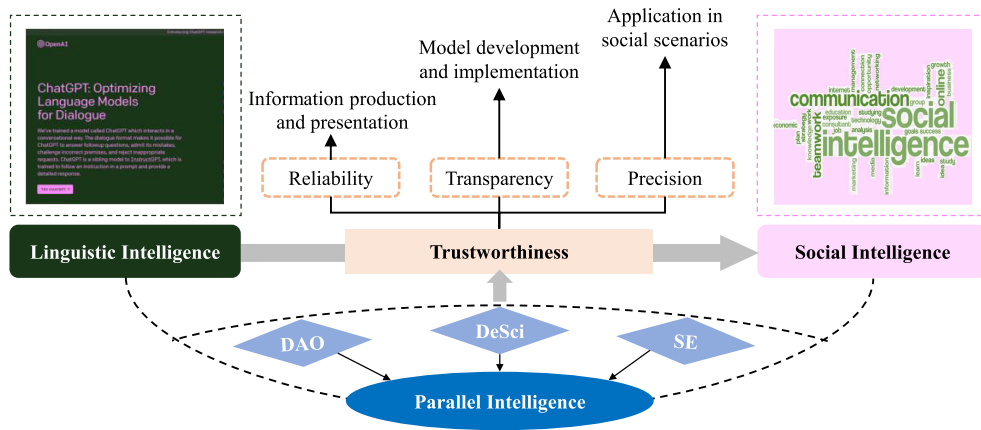


Fig. 1. From linguistic intelligence of ChatGPT to social intelligence of CSS.

First, if the problem of its stubborn tendency to present misinformation confidently and convincingly cannot be properly addressed, the application of ChatGPT into CSS cannot be reliable and may even cause devastating risks. The model training of ChatGPT primarily relies on learning the statistical patterns of language in vast databases of online text, and human labelers also play a critical role in providing additional context and feedback to ensure its accuracy and relevance. Besides, we can also expect ChatGPT to dynamically access external information sources and include references and citations for the information they provide, to conduct the fact-check by themselves to reduce the misinformation. However, these may not be sufficient. On the one hand, the real-world database cannot provide enough training data for the long tail cases and negative samples. Hence, more virtual data are needed to train ChatGPT to help it cope with unprecedented new problems. On the other hand, human users’ auditing and verification are essential to ensure that the presented information is accurate and reliable. Only when humans are truly included into the internal training and learning loop, they can provide useful feedback and oversight to improve the performance of ChatGPT.

This motivates ChatGPT to be developed as the Cyber-Physical-Social Systems (CPSS), where the social resources related to humans and social factors are well integrated with physical resources and cyber resources to form an organic whole [20], [21]. The success of constructing the CPSS infrastructure and enhancing the performance of ChatGPT needs the support of parallel intelligence. Specifically, under the parallel framework, ChatGPT can effectively learn from historical data to establish its artificial system, and then generate their own training data to remedy the data shortage for self-learning and self-improving, and finally establish LLM with precise features and rules in real time within its virtual system and improve LLM through continuous interaction with the actual system.

In turn, ChatGPT also provides support for the realization of parallel intelligence. Under the parallel framework, artificial organizations are constructed in the form of digital twins, software-defined entities, or metaverses, with knowledge robots such like ChatGPT or digital humans as the main participants [22], [23]. They interact with humans in actual

organizations and serve humans in three modes: descriptive robots describe the function and nominal activities, predictive robots predict possible events and outcomes, and prescriptive robots prescribe the best practices and optimal plans or actions. The virtual–real interaction and collaboration between humans, robots, and digital humans will naturally lead to the achievement of parallel intelligence.

Second, due to the huge investment and high difficulty in development and implementation, almost all well-known conversational AI robots are proprietary and dominant products and tools owned by technology giants, and ChatGPT is no exception. Their underlying training datasets and LLM are not publicly available, leading to the opacity in the development and implementation. This further creates the technological monopoly, which is contrary to the spirit of open science and not conducive to improving capabilities of AI robots [24], [25].

To prevent the formation of monopoly and opacity, DAOs and DeSci can be used to facilitate data fusion and model collaboration. They advocate the construction of an open and transparent AI ecosystem with the democratic organizational structure and autonomous operational norms essentially different from traditional ones [26], [27]. This ecosystem is self-organized and has a flexible and extensible structure that can change with tasks, and its operational rules are encoded in smart contracts that can automatically execute, thus cannot be controlled by any party [28]. Besides, the collaboration between all market participants are encouraged through making them be stakeholders that independently and publicly contribute to the technology development [29], e.g., tech companies invest computing and financial resources, academic institutions and researchers provide specialized knowledge and technological achievements, and users give feedback on products. Meanwhile, they will obtain the rights and benefits according to their contributions, e.g., tech companies will benefit from the technological innovation due to the large scale of community involvement of their open-sourced models and corpora, academic institutions and researchers will benefit from the performance improvement of their models in terms of producing more accurate and comprehensive results, and users will benefit from getting individual needs to be better met and service experience to be improved and even obtaining



the monetary remuneration. This will help to eliminate the monopoly and opacity in developing and implementing ChatGPT and shape the transparent and convincing advanced AI technologies and products.

Finally, as a general strong AI, ChatGPT can support a wide range of downstream scenarios, and is competent for various types of complex tasks. When applied to CSS, ChatGPT is faced with the specific problem of specialized domain, and the direct use of the foundation model often has a certain gap with the harsh application requirements of the scenario. Therefore, it is essential to carry out the scenario-oriented fine-tuning in addition to large-scale pretraining, aiming to generate precision knowledge and deep intelligence. The dis-satisfactory performance of ChatGPT in specialized contents, technical topics, or scientific tasks that require in-depth understanding is a good exemplar.

To promote ChatGPT to better serve the applications, the general foundation model should be organically combined with the scenario foundation model and business foundation model, so as to build the scenario-oriented model system. Among them, the general foundation model can form a scalable and general cognition, the scenario foundation model aims to introduce the scenario data and knowledge oriented to the application field, and the business foundation model serves the professional but common businesses and tasks. SE that relies on intelligence and index, calibration and certification, and verification and validation to generate the trustworthy and interpretable AI scenarios can be a feasible technology to support the establishing and training of the scenario and business foundation models [30].

#### *E. Human-Oriented Operating Systems for Smart Operations in CSS*

ChatGPT makes the conversational capabilities of AI become the product of standardization, scale, process and low cost, and further urge the realization of social intelligence in CSS to take a big step forward. However, it is far from enough to only have the foundation model system, the generated scenario-oriented knowledge, and the conversational applications. However, due to the characteristics of multidimensional complexity in CSS, the effective supporting tools and methods should be provided to establish the sustainable ecology for smart operations, so as to make full use of these foundation models, reduce the application difficulty, and serve different types of users. Therefore, the intelligent conversational applications such as ChatGPT are expected to evolve to be the general human-oriented operating systems (HOOS), aiming to enhance the efficiency and effectiveness of managing knowledge works in CSS [31].

ChatGPT and the other AI foundation models will serve as the model base of HOOS to integrate all kinds of data, algorithms, and computing power, with the purpose of supporting the establishment of human-machine interactive platforms comprised of flexible modules for controlling various hardware and software resources. The general intelligence produced by them will help decouple the business logic of HOOS from the underlying complex intelligent technologies, to provide

direct, easy, and user-friendly interfaces for both users and developers. Moreover, by identifying and understanding users' preferences, habits, behaviors, etc., they can better grasp users' intention and respond to their needs quickly and accurately, which contributes to providing the personalized and customized service in HOOS.

HOOS should allow humans to interact with machines in the human-like way, reducing the learning curve and making the interaction more intuitive and the operation more smarter. It should also adapt to the preferences and habits of individuals by agilely configuring and continuously adjusting its functionality and interface to better serve the user's needs. Besides, HOOS based on AI foundation models may also incorporate other advanced technologies to provide the comprehensive functions and services. Furthermore, HOOS should be integrated with not only the real world but also the virtual world to achieve the sustainable development capabilities.

We hope that ChatGPT can reach advanced state of development, so as to transform the social systems and our worlds into "6S" societies with safety, security, sustainability, sensitivity, service, and smartness [15].

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