Sora for Computational Social Systems: From Counterfactual Experiments to Artificiofactual Experiments With Parallel Intelligence

WELCOME to the second issue of IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS (TCSS) of 2024. This issue showcases an impressive array of 104 regular papers alongside our Special Issue on Big Data and Computational Social Intelligence for Guaranteed Financial Security, highlighting cutting-edge research aimed at harnessing big data and computational techniques to fortify financial security amidst the digital finance evolution. With a focus on addressing the intricate challenges of financial big data, enhancing the efficacy of artificial intelligence, and covering critical topics from data mining to digital currencies, this issue underscores the vital role of cross-disciplinary efforts in mitigating financial security risks.

After the usual introduction of our 104 regular articles, we would like to discuss the topic of Sora for computational social systems. As a text-to-video generation model, Sora has the potential to significantly impact the research in computational social systems, spanning from social system modeling and experimentation to fundamentally altering how we understand and interact with our physical world. It provides dynamic visual representations for experiments in social systems, allowing for conducting experiments on social systems in a scientific animation form, so as to provide significant insights into understanding the complex social systems. Sora not only enables us to study and understand the real world and its developmental dynamics more intuitively but also fully harnesses the limitless imaginative capacities of both human and artificial intelligence. Utilizing the parallel intelligence theory and Sora-enabled artificiofactual experiments, parallel theaters allow us to design and create the ideal new world we envision, thus propelling us into a new era driven by imaginative intelligence (II).

I. SCANNING THE ISSUE

Li et al. [A1] differentiate the informed nodes from inactive nodes and took them into account to better express the information coverage. A new problem named topic-aware information coverage maximization is formulated, with the task to maximize the sum of the expected number of both active and informed nodes in topic-aware social networks. A preprocessing-based heuristic approach is devised to solve it, and an experimental study is also conducted.

Xiong et al. [A2] propose a semantic-guiding adversarial network for generating human trajectories. Specifically, an attention-based generator is first devised to yield trajectory locations in a sequence-to-sequence manner. Then, a rollout module is designated to complete the unfinished trajectory sequence and transform it into an image that can depict its spatial structure. Finally, a convolutional neural network-based discriminator signifies how "real" the trajectory image looks, and its output is regarded as a reward signal to update the generator by the policy gradient.

Zhu et al. [A3] propose a method of extracting emergency elements (EELs) from emergency plans and constructing a business process model (BPM). First, a nested entity extraction model incorporating adversarial training is proposed to extract EELs from the complex sentences in the emergency plan text. Second, the EELs are combined into emergency task units, and then, the relations between emergency task units are identified to form the emergency task sequence flow. Finally, the emergency disposal workflow model is generated based on the emergency task sequence flow and the BPM method.

Li et al. [A4] propose an enforced block diagonal graph learning for multikernel clustering method. Inspired by symmetric matrix factorization, they first design a one-part block diagonal graph learning scheme to learn multiple block diagonal graphs, by exploring an explicit theoretical connection between the clustering partition of kernel k-means and the excellent block diagonal graph. Then, these block diagonal graphs are stacked into a low-rank tensor for exploiting the high-order structure information hidden in the nonlinear data.

Xue et al. [A5] propose the docking framework between the domain model and the artificial society model. The model docking specification is given from three aspects: the agent model, the environmental model, and the rules model. The effectiveness of the framework is verified by two classic cases: artificial stock market and epidemic prevention and control.

Kamal et al. [A6] develop a deep learning model called BiCapsHate to detect hate speech (HS) in online social media posts. The model consists of five layers of deep neural networks. It starts with an input layer to process the input text and follows on to an embedding layer to embed the text into a numeric representation. A BiCaps layer then learns the sequential and linguistic contextual representations, a dense layer prepares the model for final classification, and finally, the output layer produces the resulting class as either hate or non-HS.

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Zhu et al. [A7] propose a new undersampling scheme, called a clustering-based noisy-sample-removed undersampling scheme (NUS) for imbalanced classification. The majority of class samples are clustered. The distance of the majority class sample from the cluster center that is furthest away is used as the radius to build a hypersphere. The Euclidean distance is determined between the center of a cluster and each minority sample to find whether they are in the hypersphere or not. Afterward, this article excludes noisy samples from the minority class. The noisy samples of majority classes are removed by using the same procedure.

Yang et al. [A8] contribute a new model named collaborative meta-path modeling for explainable recommendation. It models the similarity of user pairs and item pairs through rating information and constructs collaborative meta-paths for explainability. In addition, it designs an attention mechanism to aggregate different paths connecting the target user and the target item. Moreover, the information of the subgraph composed of all paths connecting the target user and the target item is integrated for rating prediction.

Zheng et al. [A9] prompt the concept of a backdoor attack on link prediction and propose Link-Backdoor to reveal the training vulnerability of the existing link prediction methods. The Link-Backdoor combines the fake nodes with the nodes of the target link to form a trigger. Moreover, it optimizes the trigger by the gradient information from the target model. The link prediction model trained on the backdoored dataset will predict the link with a trigger to the target state.

Zhou et al. [A10] propose a fast local search (FLS) approach to solve the k-vertex cut (k-VC) problem, which is an important problem with various real-world applications. It integrates a two-stage vertex exchange strategy based on neighborhood decomposition and cut vertex and iteratively executes operations of addition and removal during the search. To evaluate its generalization ability, they extend it to solve the weighted version of the k-VC problem.

Bhardwaj [A11] deal with the task of hostile post detection in Hindi, aiming to predict whether a social media post is hostile or not. For the hostile posts, one or more fine-grained hostile dimensions will be identified from the following four dimensions: fake, hate, offensive, and defamation. HostileNet, a novel deep learning framework that leverages HindiBERT-based contextual representations and handcrafted features is proposed. A novel mechanism is also proposed to fine-tune HindiBERT's attention vectors.

Guan et al. [A12] present JargonFM, a framework with multiple interpretation modes for jargon understanding in online communities. JargonFM is designed based on the scientific explanation framework and supports three interpretation modes: jargon category prediction based on a jargon classifier, similar word identification based on a jargon synonyms selector, and representative text selection based on an example sentence selector. A jargon interpreter is also implemented to demonstrate the usage and usefulness of the interpretation framework.

Fu et al. [A13] propose the first general framework for account risk rating on Ethereum, which includes a devisable suspiciousness metric to adapt to various illicit fraud detection and a network propagation mechanism to formulate the relations between accounts and transactions. By conducting extensive experiments on a real-world dataset from Ethereum, the universality of the account risk rating framework is shown.

Jia et al. [A14] propose a predictive framework, hierarchical fuzzy C-means (Hierarchical-FCM)-residual networks (ResNets), to capture the hierarchical structure of human mobility for prediction. First, a Hierarchical-FCM clustering algorithm is trained to learn the relationship between proximity and road network hierarchically on large human mobility data. Second, a fusion model is designed to incorporate the knowledge learned from hierarchical clusters into deep ResNets to improve prediction accuracy.

Ahmed et al. [A15] propose the architecture of chatbot by focusing on few-shot learning problem and context management in dialog-based conversations. A novel hybrid intent and slots transformers model is proposed to mitigate the few-shot learning problem with chatbots, and a hybrid interaction strategy for slots mapping and effective conversational context management is introduced to address dialog management.

Elahi et al. [A16] develop a theoretical App acquisition and management model describing different phenomena involved in App acquisition and management in Android smartphones. It systematically discovers and relates different App acquisition and management concepts in 34 subcategories related to user struggles and discovers six problems unaddressed by the literature. Then, general guidelines are provided for users, App stores, developers, and regulators to assist them in enhancing privacy and security protection in the Android ecosystem.

Zhang et al. [A17] depict a common scenario to discuss the educational equality or equity problem. It uses quantitative methods to conduct computational social simulations and obtain the results under equal or equitable conditions via role-base collaboration, environments—classes, agents, roles, groups, and objects, and group role assignment (GRA). The simulation results show that educational equality or equity can be significantly improved by making a reasonable and optimized allocation plan through GRA.

Wang and Wang [A18] use the scale-free network to describe the structure of a society. There are four types of players in their model based on reality: donors, illegal beneficiaries, legal beneficiaries, and inactive people. Then, it gives and explains the benefits of four types of scale-free networks with several innovations. By pair approximation, it introduces the proportion of edges starting from some type of players as the population state. It also defines the equilibrium of the approximate dynamics as the global equilibrium of the population and further defines its stability.

Cai et al. [A19] propose an approach to enhance the quality of the learned deep features through the incorporation of an attention mechanism. Since attention mechanisms are effective in distinguishing similar objects, as they suppress background objects while highlighting target information that is most relevant, a new tracking method with channel and spatial attention termed SiamATTRPN is explored.

Nian et al. [A20] define three ways of dissemination of information in the network of hierarchical structure. Then, the information dissemination model of the hierarchical network

is constructed. Finally, both the simulated data and the real data have concluded that the middle class is the most active in the uniformly distributed hierarchical network, while the lower class is more active in the power-law distributed hierarchical network, which promotes the dissemination of news in the hierarchical network.

Ilias et al. [A21] study the task of depression and stress detection in social media, which injects extra-linguistic information in transformer-based models, namely, bidirectional encoder representations from transformers (BERT) and MentalBERT. The proposed approaches are tested in three public datasets, and the results demonstrate that the integration of linguistic features into transformer-based models presents a surge in performance. Also, the usage of label smoothing contributes to both the improvement of the model's performance and the calibration of the model.

In [A22], mobile data offloading with unmanned aerial vehicle (UAV) trajectory optimization is investigated. To tackle with the delay of requesting data and the immediacy of requested data at the same time, a new metric named delanalty is proposed, jointly considering the delay of user requesting data, the immediacy of requested data file, and the quantity of residual requesting data. A find max delanalty user mechanism is proposed to eliminate the user who has the largest delay time. Furthermore, an actor-critic (AC)-based delanalty trajectory optimization algorithm is proposed to solve UAV's trajectory optimization problem.

Shi et al. [A23] propose a multiknowledge-enhanced summarization (MKES) model for automatically generating meteorological social briefing content, providing a new model for meteorological decision support services. This model consists of a summary generation module and a knowledge enhancement module. Compared with other benchmark models, the MKES model can achieve the best quantitative and qualitative evaluation results. On the basis of the MKES model, a meteorological social briefing generation framework is established to provide decision support services for China Meteorological Administration.

Gong et al. [A24] establish a physiological computational model to analyze the similarities and differences in emotional cognitive characteristics of different cultural groups. An effective adaptive region selection method is proposed to study the relationship between brain regions and emotions, and a multiple-stacked broad learning system (MSBLS) is designed to learn complementary information between electroencephalography and eye movement signals in cross-cultural emotion recognition tasks. The experimental results show the superiority of MSBLS in multitasking.

Jian et al. [A25] propose an edge weighted loss function based on optical flow to train a framework called Flow-Edge-Net, which consists of two symmetric complementary encoder decoder branches. The optical flow branch is used to reflect the motion clues of salient targets, and the edge branch is used to detect the boundary visual features of salient targets. An adaptive weighted feature fusion module is designed to compare and fuse the edge and position information of two networks. The experimental results show the excellent performance of Flow-Edge-Net in significant target localization.

Shen et al. [A26] propose a novel real-time intelligence evaluation framework based on users' psychophysiological data and use this framework to conduct a case study on the psychological and physiological patterns of gifted students. The resting state and auditory stimulation paradigms are designed to obtain electroencephalogram (EEG) data of admitted students, in order to evaluate which EEG patterns can be effectively used to characterize gifted students and distinguish them from ordinary students. The experimental results verified the practicality and effectiveness of the framework.

Wang et al. [A27] propose a new method called common latent embedding space (CLES), which utilizes local and global similarity information to learn a common embedding space. The double graph Laplacian is used as a distance metric to reduce distribution divergence between different domains, and a self-representation strategy is adopted to guide the learning of the common embedding space. The experimental results validated the effectiveness of the proposed CLES method in cross-domain feature recognition.

Zhang [A28] study the community deception problem using Laplace spectral lenses and propose a method called ComDeceptor to hide any set of communities from being detected by community detectors. This method transforms the spectral optimization problem into an edge volume optimization problem and adopts a pruning strategy during the search process to improve search efficiency. The experimental results demonstrate the effectiveness of the ComDeceptor and the superior performance in confusing community structures.

Sridharan et al. [A29] propose a routing technique for wireless sensor networks based on Lie hypergraph cluster to achieve effective data transmission in wireless sensor networks. The sensor nodes are represented as a hypergraph, with each hyperedge treated as a cluster, and the selection of cluster heads is utilized by the minimum hypergraph screenshot. By constructing an upper triangular matrix (UTM) for routing decisions, lie commutators of the UTM Lie algebra identify the best relay nodes for data forwarding. The experimental results show the superiority of the proposed scheme.

Khiabani and Zubiaga [A30] propose a model called cross-target text-net (CT-TN), which utilizes the social nature of tasks to solve the problem of cross-target pose detection in social media. This model aggregates multimodal embeddings of text and network features from data. Several cross-target scenario experiments are conducted on six different source destination target pairs, demonstrating the superiority of CT-TN in the overall effectiveness.

Basak et al. [A31] propose a peak-aligned progress metric and compare it with a more intuitive start-aligned progress metric to calculate the current progress of ongoing humiliation events. These pieces of information are combined with patterns of past humiliation events to recommend victim responses. If the victim chooses the type of response with progress information and recommendations when developing actual

responses, professional image restoration services may be useful to them.

Liu et al. [A32] propose a new centrality model based on node-based semi-local and global structure for semi-local and global centrality (SLGC), which can capture a larger range and richer information to evaluate the criticality of nodes. The first- and second-order generalized energy entropy are constructed to reflect semi-local effects, and a global influence index is constructed based on the clustering coefficient of nodes and the distance between nodes. Then, the total influence of nodes is derived from the above two aspects. The results indicate that the SLGC algorithm has good effectiveness and universality.

Sun et al. [A33] analyze the discussion of public health crises across multiple platforms by developing a generalized regression model, which considers different attributes of social media platforms, including short text, long text, and Eastern or Western orientation. The differences between these platforms are examined based on four factors. The results indicate that short-text platforms are susceptible to information overload, negative emotions, and various modes of dissemination, while long-text platforms are influenced by information concentration, positive motivation, and high-quality content.

Groen et al. [A34] introduce a method for fast parallelization on multicore platforms and discuss the computational complexity of the algorithm and its implementation. They benchmark the parallel code and investigate the performance in a series of optional rule sets, different improvements in spatial representation, and different numbers of agents representing displaced persons. The scalability of different numbers of simulation agents is studied using two supercomputers and a large composite graph.

Zhang et al. [A35] propose a new competitive bidding influence maximization (CBIM) problem, which aims to achieve a win-win situation between the platform and its competitors through multiple rounds of bidding under the premise of fairness. A fairness-aware multiagent CBIM (FMCBIM) framework is proposed to address the CBIM problem. In this framework, a multiagent bidding particle environment is established to capture the interactions between competitors in the dynamic bidding process. The experiments show that the proposed framework has good efficiency and effectiveness.

Chaocheng et al. [A36] propose an evolutionary game model on a square lattice to abstract the intense social competition between internalization, cooperation, and lying flat. A three-way strategy is used to simulate competition: involution, cooperation, and lying flat. It uses hierarchical rules for resource allocation and compares them with value-based rules in the model. The experimental results indicate that factors, such as social resources, inline costs, relative utility of inline strategies, and differences in agency competitiveness, play different but significant roles in social competition.

Jiang et al. [A37] investigate the problem of online task allocation, propose an original time location constraint allocation algorithm, and then optimize it. In order to solve the problem of task loss, an incentive mechanism is designed during the matching process, aiming to appropriately increase the profit of the task and motivate employees to accept the task. In addition, adopting a Q-learning-based prediction algorithm can effectively utilize the budget and improve the success rate of incentives. The effectiveness of the algorithm is verified through experiments.

Ren et al. [A38] construct a graph representation of news articles and use a graph neural network (GNN) to classify fake news. The key idea is to use the co-occurrence information of local words in a sentence to obtain the interaction relationship between sentences and abstract the interaction relationship using a weight matrix represented by a graph. To capture the local structural information between words and quantify the interaction between sentences, a weight matrix calculation method is proposed. The experimental results show the superiority of the proposed method.

Pei et al. [A39] propose few-shot synthetic online transfer learning (FSOTL) to address the issue of poor performance of online transfer learning (OTL) when the target sample is small. FSOTL uses synthetic data to preheat the model online. This not only alleviates the problem of scarce target-domain samples but also enables the model to acquire more knowledge. The experimental results show that the preheating operation of FSOTL helps to improve diagnostic accuracy and achieves the best classification accuracy on different sites.

Chen et al. [A40] propose a new end-to-end framework, ToupleGDD, to solve influence maximization problems by utilizing deep reinforcement learning (RL) technology. Specifically, this framework combines three coupled GNNs for network embedding and a dual deep Q-network for parameter learning. Compared to state-of-the-art sampling-based approximation algorithms, ToupleGDD can avoid expensive diffusion path sampling. The experimental results demonstrate the effectiveness and superiority of the model.

Wu et al. [A41] propose an end-to-end uncertain regression neural network CriticCoder to construct a macroscopic pressure model in water distribution systems with non-negligible uncertain disturbances. CriticCoder divides the normal regression process into two parts, decomposing the output into two parts: observable variables and unobservable variables. Two subnetworks, Coder and Critic, make up of the CritiCoder. By reconstructing the data stream, the encoder is expected to approximate the ideal output from observable variables. The experimental results show the superiority of CriticCoder.

Li and Yao [A42] aim to reveal the neural mechanism changes of the reward process in abstinent heroin addicts (AHAs) with improved mid-term tasks, by combining eventrelated potentials and standardized low-resolution brain electromagnetic tomography analyses. The research results revealed abnormalities in reward-related brain regions of AHAs, which further led to insensitivity to potential punishment and deficits in impulse control. This study helps doctors and therapists understand the psychological mechanisms and addiction processes of drug addicts, thereby better formulating treatment plans.

Chen et al. [A43] propose a news recommendation system based on multiview graph convolutional network (NRMG). It consists of two parts: news representation and user

representation. A content entity collaborative attention network is designed to effectively learn news representation, and a multiview graph convolutional network architecture is designed to learn user representations. This method can effectively capture user interest representations from multiple subspaces. The experimental results indicate that NRMG is superior to existing methods.

Sun et al. [A44] apply the fully connected multilayer brain functional (FCMBF) network framework and the composite FCMBF (CFCMBF) network framework, to analyze the within-frequency coupling and cross-frequency coupling of the sensor layer and source layer EEG signals of relevant subjects. It demonstrates that the topological characteristics of the FCMBF network at the sensor layer of major depressive disorder (MDD) patients are disrupted, and the proposed CFCMBF network may be helpful for clinical auxiliary diagnosis of MDD.

Xi and Singh [A45] examine how well the findings of prior studies generalize to a corpus of over 30 000 narratives of tense social situations submitted to a popular social media forum. It extends and applies natural language processing techniques to understand the effects of descriptions of the people involved in these posts. The findings show that aggregating psychological theories enables understanding real-life moral situations and evidence of bias blame assignment on social media.

Li et al. [A46] propose an innovative method called contrastive sampling-aggregating transformer (CSAT) for community detection in attribute-missing networks. CSAT utilizes a sampling and propagation strategy to obtain different samples and smooth attribute features of the network structure and leverages the transformer architecture to model the pairwise relationships between nodes. Extensive experiments on several benchmark datasets demonstrate the superiority of CSAT in community detection.

Gomez et al. [A47] validate a classification method based on the reconstructive classification to identify two demographic attributes, age and gender, for users of social networks based on the text content they publish. The proposed method uses the reconstructive property of singular value decomposition, and its suitability to work with sparse data, to find a matrix with the main latent components to represent the information of specific gender or age classes. Then, the matrix is used to project and reconstruct new users' information to identify their demographic variables.

Wang et al. [A48] propose a dialog generation model called Speaker-History-Aware Dialogue GEneration (SHADE), which utilizes contrastive learning to model speaking style from historical conversation, resulting in more personalized and distinctive response. The results show that SHADE outperforms other multiturn hierarchical dialog generation models in terms of response consistency, logic, and diversity.

Yin and Zeng [A49] propose an effective defense framework, federated learning data augmentation (FLDA), which defends against data poisoning attacks through local data mix up on the clients. To mitigate the identically distributed (non-IID) effect by exploiting the limited local data, a gradient detection strategy is proposed. The experimental results show that FLDA can effectively reduce the poisoning success rate and improve the global model training accuracy under poisoning attacks for non-IID data. It can also increase the federated learning (FL) accuracy by more than 12% after detecting malicious clients.

Gao et al [A50] explore how social diffusion can be influenced. Through a campaign of Monte Carlo simulations, it finds that diffusion occurs quicker on sparse and highly clustered networks placing the committed minority at nodes with the highest Bonacich centrality with a negative attenuation factor, which seems to be the best approach for facilitating diffusion, and the timing of introducing committed minority has a negligible effect on the diffusion process. Their findings are tested and confirmed on two case studies of real-world networks.

Khoa et al. [A51] show that in the FL environment, the use of compact, lightweight models provides higher efficiency and is suitable for consistent research. They use techniques such as synthetic minority over-sampling techniques to enrich and balance the Harmony dataset and incorporate essential deep learning models into the FL framework. The framework has higher results while remaining highly competitive to other deep learning models with respect to network size, execution time, and stability.

Barrows et al. [A52] investigate the potential to automatically label and detect the polarity (positive, neutral, or negative) of Iranian state-sponsored propaganda Tweets on the Iranian nuclear deal. The SentiWordNet lexicon is used to automatically assign a polarity label and an objectivity score to each tweet. Using the labels, five machine learning algorithms are used to create polarity detection models. The experimental results show that the best-performing models correctly identify polarity in approximately 77% of the tweets.

Li et al. [A53] propose an imperfect vaccination evolutionary game model to explore the effect of epidemic spreading and vaccination equilibrium. They find that the individual social difference in the epidemic spreading layer has a more significant impact on the epidemic threshold than that in the information diffusion layer, and the vaccination equilibrium increases with the social reinforcement strength and primary protective probability. They also discuss the effect of infection cost on vaccination equilibrium.

Che et al. [A54] study the online security traffic patrolling (STP) problem. To achieve omnipresent patrolling and prevent crimes at hot-spot regions, a two-stage offline-online integration STP framework is proposed, where the model-based offline STP coordination policy is designed to guide the online real-time patrolling policy. The experimental results demonstrate that the proposed framework can reduce the driver violation rate, satisfy frequency constraints, and scale well to STP scenarios in a real-time fashion.

Zhong et al. [A55] examine intermittent control of a rumor propagation system with anti-rumor mechanism. The interaction with anti-rumor mechanism is investigated, including the existence and stability of two boundary equilibriums. By identifying threshold parameters, it determines the global exponential stability of the rumor-free equilibrium. To combat rumor spreading, it designs deterministic and stochastic

control strategies with a periodically intermittent control time. Numerical examples validate the theoretical results and evaluate the potential roles of the intermittent control strategies.

Ge et al. [A56] propose an opinion dynamics model based on a moderate opinion guidance strategy. It illustrates the effect of guidance ratio and guidance strength on group consensus level through simulations and assesses the stability of the moderate guidance in multiple networks, comparing it with the traditional degree guidance in various network environments. Results indicate that moderate guidance can not only effectively guide most individuals' opinion to reach a consensus in the short term but also guide those with significant deviations toward the target opinion over the long term.

Varshini et al. [A57] address the overfitting issue by designing a robust distribution generalization of transformer-based generative adversarial network architecture, which can generalize the model for COVID-19 fake news datasets with different distributions without retraining. The experimental findings illustrate that the proposed model outperforms the current state-of-the-art models.

Huang et al. [A58] analyze the shaping of entrepreneurial opportunity (EO) based on the entrepreneurial ecosystem theory. A questionnaire survey is conducted in Guangdong and Wuling Mountains, China, and the fuzzy-set qualitative comparative analysis approach is used to study the factors and causal mechanisms affecting EOs. The findings contribute to the expansion of the entrepreneurial ecosystem theory's application in rural e-commerce entrepreneurship and provide practical implications for the bottom of the pyramid population in effectively obtaining EOs in rural e-commerce.

Lv et al. [A59] define the community-based centrality measure (CBCM) to identify key vertexes in multilayer networks. CBCM utilizes a fourth-order tensor to determine the importance of a vertex in each network layer by combining the following three factors: the PageRank centrality score of the vertex, the community's importance where the vertex is located, and the ability of the vertex within a community to affect vertexes in other communities within two steps. Numerical experiments across various multilayer networks validate the effectiveness and superiority of the proposed methods.

Jin et al. [A60] propose a quaternion deformable local binary pattern (QDLBP)-Net for color facial expression recognition in the wild. First, a pose-correction facial decomposition strategy is proposed to correct the head pose and decompose the facial image into five emotion-related regions. Then, an effective feature descriptor named "QDLBP" is developed, which extracts color quaternion features from each emotional region. Finally, a quaternion classification network is proposed to classify the quaternion features from five emotional regions into seven basic expressions.

Zheng et al. [A61] uncover insights into backdoor attacks based on the differences in the distribution of network motifs. They propose a base motif back-door attack framework against GNNs, named Motif-Backdoor, which uses the distribution difference in the motifs in the dataset to search the trigger structure. Besides, they adopt the graph importance index and the defined subgraph score to find the trigger injection position. Extensive experiments show that Motif-Backdoor achieves the state-of-the-art attack performance.

Li et al. [A62] propose HRS-DMOA, a dynamic multiobjective optimization algorithm (DMOA) based on a designed hierarchical response system. By predefined thresholds, it quantifies the environmental changes as three levels and utilizes different strategies: a Pareto set-based refinement strategy for slight changes, a diversity-based reinitialization method for significant changes, and a transfer-learning-based response for moderate changes. The results demonstrate superior performance compared to four popular baseline DMOAs in terms of both convergence and diversity.

Mai et al. [A63] propose a similarity vector-based text-to-image matching inferring strategy to address limitations in obtaining overall and local matching relation between text and image. They develop a multimodal dynamic graph interaction module, integrating local matching relations and part of speech-based multihead attention within each layer to construct dynamic cross-modal and semantic graphs. Extensive experiments on two benchmark datasets demonstrate the model's competitive performance, achieving state-of-the-art results.

Kazemi et al. [A64] develop a causal RL strategy in a prisoner's dilemma game. An agent is designed to have an explicit causal representation of other agents playing strategies from the Axelrod tournament. The collection of policies is assembled in an ensemble RL to choose the best strategy. The agent is then tested against selected Axelrod tournament strategies as well as an adaptive agent trained using traditional RL. The results show that agents are able to play against all other players and score higher while being adaptive in situations where the strategy of the other players' changes.

Zhou et al. [A65] propose a method for integrating train regulation and train speed profile optimization. Aimed at minimizing energy consumption and delay time, an integrated optimization model is developed, along with a hybrid search algorithm to solve it. The simulation results show the method's effectiveness in real-time adjustments and speed profile recommendations. The well-trained convolutional neural network ensures computational accuracy and efficiency in determining the recommended speed profile during the train regulation process.

Lou and Wang [A66] define the community distribution scheme and propose an efficient generalized community-structure-aware optimization framework (GCF) to enhance subgraph matching efficiency. Three strategies are proposed within GCF to further accelerate the process of subgraph matching. The experimental results on both real-world and synthetic datasets demonstrate GCF's efficiency, significantly reducing time consumption for various subgraph matching algorithms.

Wu et al. [A67] add an attention mechanism to dynamically adjust the user's embedding vector. Based on the attention model, two time-decay functions are considered to emphasize the user's recent preferences. By combining these two time-decay functions with the attention model, they propose

a time-decay adaptive latent factor model for item score prediction. They also apply this model to a dataset integrating Movielens-10M and HetRec2011 and prove that all three new considerations can improve recommendation performance.

Zhao et al. [A68] develop an analytical framework to investigate the spatiotemporal reorganization of dynamic functional brain networks over the adult lifespan. It identifies age-related effects on temporal clustering coefficient and average path length, suggesting ongoing reorganization from maturity to aging. Further analysis reveals that the topological stability of egocentric structures influences information processing in the spatiotemporal domain. Meanwhile, age-related changes in certain functional systems exhibit distinct progressive patterns, potentially indicating compensation mechanisms.

Singhal and Kashef [A69] introduce a weighted stacking ensemble model with sampling to detect fake reviews efficiently, given their impacts on consumer perceptions. They use n-gram models to effectively model the language data for feature retrieval. The experimental results on three customer review datasets show that the proposed model outperforms the conventional machine learning techniques and the state-of-the-art ensemble models.

Jin et al. [A70] propose a convergence analysis method for evolution dynamics in information loss networks, which overcomes the analytical difficulties caused by complex network relationships. Since there is often noise during the transfer of information between players, the convergence of dynamic models in information loss networks is analyzed using the Lyapunov function. Two examples based on the prisoner's dilemma and snowdrift dilemma on networks are proposed to show the effectiveness of the proposed method.

Liao et al. [A71] propose a low-level heuristic rule called reactive assignment strategy. All commuters obey the same strategy to route themselves based on their local observations in a traffic network. Through training based on a designed heuristic template, all commuters will have the ability to find their appropriate paths in real time to maximize the throughput of the traffic network. This decentralized control mechanism can address dynamically arriving commuters more efficiently than centralized control mechanisms.

Niu et al. [A72] present a network embedding approach to retain network structure and attribute information by modeling structural and attribute proximities of the attribute network. They capture higher order matrices using an information diffusion process, and the attribute-based loss functions are optimized as a matrix factorization problem. The final representations are generated through both topology structure and attributes, which make the nodes with more common neighbors and similar attributes closer to the latent vector space.

Liu et al. [A73] propose a multimodal contrastive transformer model for an explainable recommendation, which incorporates multimodal information into the learning process. Meanwhile, they propose a dynamic fusion mechanism during the decoding stage to guide the explanation generation and develop a contrastive objective to generate diverse explainable texts. Comprehensive experiments on two real-world datasets show that the proposed model outperforms comparable explainable recommendation baselines in terms of explanation performance and recommendation performance.

Jin et al. [A74] explain how to extract the influence distance that allows the computation of influence propagation to be transformed into the computation of hop distance. They first propose a novel greedy k-station selection method for single rumor source detection problem in the undirected graph. The rumor source estimator is derived as the Jordan infection center upon the optimal infection path that leads to the selected monitoring stations. Performance validation of the greedy monitor selection method is conducted through comparisons with other methods using synthetic and real-world networks.

Xie et al. [A75] introduce endogenous and exogenous risks to assess the operations efficiency of insurance companies and propose a new evaluation model. This model considers the relative importance of the leader and follower stages in the insurance company's operations, giving precedence to the former. They evaluate the overall efficiency of consecutive periods, overcoming limitations of previous methods focused on single decision-making units. A corresponding input and output index system is built and applied to analyze the operative conditions of listed insurance companies in China.

Hu et al. [A76] study fraud detection in mobile social networks. The cost-sensitive learning is introduced into GNN, and a cost-sensitive GNN is proposed. An RL strategy is designed for node neighborhood sampling, to initially mitigate the data imbalance in node neighborhoods. Then, a cost matrix learning method is designed and combined with GNN, and cost-sensitive embedding is used for downstream fraud detection task.

Cui et al. [A77] propose a novel EEG-based MDD detection framework. A multiview feature extractor is designed to concurrently characterize EEG signals from temporal, spectral, and time–frequency views, and a sparse dynamic graph convolution network is introduced to map the multidomain features into high-level representations. Moreover, a region-attention feature fusion network is proposed.

Chelmis and Rahma [A78] use a one-of-a-kind dataset of administrative records collected by homeless service providers to shed light into the progress of individuals once they enter the homelessness system toward securing stable housing. It confirmed the intuition that some individuals face more challenges than others based on their initial living conditions and initial placement to homelessness services. It also showed that sometimes individuals follow trajectories that take them further away from the target, and in such cases, the likelihood of cycles increases dramatically.

Liang et al. [A79] compress the multiobject tracking model via knowledge distillation, enabling the more lightweight student model to obtain similar performance as the teacher model, to strike a better balance between tracking accuracy and speed. They first propose attention-guided feature distillation, which focuses the student model on the crucial region of the teacher's feature map. Moreover, they propose foreground mask, which leverages the knowledge from the teacher model to filter out the low-quality soft labels from the background, thereby reducing their negative effects for distillation.

Garg et al. [A80] propose OntoDSumm, which can generate a Tweet summary for a disaster with minimal human intervention. A three-phase approach is proposed, which can handle each challenge systematically with high effectiveness and minimal human intervention. The incorporation of domain knowledge through ontology is used for category identification, automatic understanding, and knowledge transfer across different disasters to gauge the importance of a category, and a selection mechanism is designed for disasters, to ensure the high performance of OntoDSumm.

Nunes [A81] carry out the systematic mapping study to provide a comprehensive overview of the impacts that may prevent the effective use of COVID-19 data, critical issues, and gaps in the current academic research. Following the steps of a systematic mapping, they examined 79 studies returned from a search string and eight studies returned from the use of the snowballing technique and selected 37 from related journals and conferences published between 2020 and 2021. The results point to possible problems in the use of COVID-19, preventing its effective use in information systems.

Cui et al. [A82] propose a novel recommendation model based on graph diffusion and Ebbinghaus Curve. To explore the underline reasons for different interactions, they explore an underlying subgraph for each interaction and find important reasoning paths within the subgraph via a well-designed graph diffusion method. To capture users' personalized strategies on long- and short-term tastes, an effective neural network is designed based on the Ebbinghaus Curve to process users' evolving behaviors.

Song et al. [A83] apply the parallel learning framework to tackle data scarcity challenges in the legal domain. The proposed human-oriented artificial-natural parallel system for organized intelligence (HANOI)-Legal has several features. It takes the pretrained foundation model as the artificial system and unified prompt learning as a prescriptive method. The learning process is organized by a distributed operation involving all team members to do labeling concurrently. The experiments verify that the HANOI-Legal is effective for legal tasks even in low-resource scenarios.

Güven et al. [A84] aim to create a system that could classify public accounts on Instagram by analyzing comments, profile pictures, bios, and posts shared by users with business accounts. First, a crawler is developed, and data are collected using this crawler and then anonymized. Next, the collected data are processed using natural language processing techniques for text and image processing methods for images to extract features and create a dataset. The final model has an accuracy rate of 95% on the dataset, allowing for the effective identification of different types of business accounts on Instagram.

Chen et al. [A85] propose a Lightspace-SMOTE upsampling method, which can reduce the feature dimensionality and increase the signal-to-noise ratio of the original data and then upsample it to increase the number of minor class samples. In addition, they propose an efficient ensemble framework that combines Lightspace-SMOTE, focal loss, and LightGBM, which can not only focus more on minor class and the hard-to-class samples but also obtain better performance. The feature importance provided by the model can provide strong support for model interpretability.

He et al. [A86] investigate a framework for predicting the links of different orders in social interaction networks based on edge orbit degrees (EODs). First, a new problem of different-order link prediction is defined to examine the predictability of links generated by different-order interaction patterns. Second, EODs for different-order link prediction are quantified, and the performance of different-order predictors is examined. Finally, a new method fusing multiple EODs (MEODs) is proposed to predict different-order links, and the experiments indicate that the MEOD outperforms state-of-the-art methods.

Wu et al. [A87] design a web-based visualization system named VIEA, which integrates a rich set of views and tailored interactions, enabling users to easily perceive economic features, such as geographical distributions, trade relationships, and pattern comparisons. Case studies and user studies based on real-world datasets have been conducted to demonstrate the effectiveness of their system in the exploration of industrial economics.

Pang et al. [A88] introduce the topic of comment network picturization. As part of the topic-comment network picturization algorithm, they devise Topic2Image, which quantifies the adversarial strength of comment nodes within the topic space and embeds them into 2-D space. To address the challenges encountered in realizing this article's inspiration, they develop two models. The experimental results show that their model outperforms other classical baseline models and the latest baseline models, demonstrating that Topic2Image is feasible and topic image rumor detection is effective.

Qiu et al. [A89] propose a clause-level relational graph attention network with contrastive learning model. The given sentence is segmented into clauses to obtain the relation between two aspects based on clause-level interaction. To integrate multiple-aspect information, a clause-level relational graph, which contains all aspects and inter-aspect relations, is developed. To precisely learn the inter-aspect relations, the supervised contrastive learning strategy is used. The ablation study and case study validate the effectiveness of different components.

Yang et al. [A90] propose a framework for outlier-score outlier removal (FOOR), a new framework for a set of outlier detectors engineered to remove outlier-score outliers from reference scores to improve unsupervised outlier ensemble techniques. The simulated experiments prove that the proposed framework has superior performance when compared to all existing leading techniques on 30 real-world public datasets. FOOR removes outlier-score outliers in existing reference scores, significantly reducing its bias and improving unsupervised ensembles.

Liang et al. [A91] propose a parallel mechanism verification method and execution system, namely, complex adaptive systems for computer-aided dynamic design (casCAD2), which is capable of probing into the laws that govern system evolution within a simulated environment. They serve as a robust tool for verifying the efficacy of decentralized autonomous

organization (DAO) mechanisms and predicting its potential risks. A parallel market-based anchoring mechanism system is also built to demonstrate how it can be used for DAOs' mechanism verification.

Luo and Krishnamurthy [A92] propose a method to detect change points in dynamic social networks using Fréchet statistics. A metric space is defined for graph Laplacians using the log-Euclidean metric, enabling a closed-form formula for Fréchet mean and variance. A framework is presented for change point detection using Fréchet statistics, and it is extended to multiple change points with binary segmentation.

Anshul et al. [A93] propose a multimodal framework to detect depression among social media users. To provide enough context about the user's emotional state, an extrinsic feature is proposed by harnessing the uniform resource locators presented in Tweets and extracting textual content present in images posted in Tweets. Five sets of features belonging to different modalities are also extracted to describe a user. In addition, it introduces a deep learning model, the visual neural network, to generate embeddings of user-posted images, which are used to create the visual feature vector for prediction.

Lou et al. [A94] present a deep click-through prediction model that incorporates a multigranularity interest activation and implicit feature interactions. The model incorporates the nonlinearly extended user representation in the user behavior sequence and uses multiple fully connected layers to obtain the global user interest representation, thereby improving the model's memorization ability for users. Then, a multikernel convolutional network is employed to learn the behavior patterns of the user to solve the problem of pattern diversity and interest mutation noise in behavioral sequences.

Li et al. [A95] introduce Gaussian white noise to simulate the random interference encountered by each subject in the evolutionary game, and the evolutionary stability strategy of the tripartite stochastic evolutionary game under different conditions is discussed. Moreover, the recognition accuracy rate is introduced into the stochastic evolutionary game. They join the government supervision department into the game and realize the supervision mode of social co-governance by using social public opinion to reward and punish the government's reputation.

Zhang et al. [A96] propose a novel method with an online updating mechanism named discriminative joint knowledge transfer. A precise calculation of discriminative information for different emotional states within and across subjects is achieved by leveraging a small number of labeled target-domain samples. Furthermore, to accommodate the time-varying EEG, it extends the passive-aggressive algorithm to enable online adaptation of the emotion recognition model, thereby enhancing its suitability for real-world scenarios.

Wang et al. [A97] propose a personalized recommender based on learnable attribute sampling and heterogeneous GNN to improve the recommender's performance. Based on the user's interactive history with items, the heterogeneous user-item-attribute (UIA) graph is constructed, and attributes of the items are sampled with a learnable neural network to alleviate the issue of irrelevant attributes. By using the pruned UIA, the heterogeneous GNN model is appropriately used to learn representations of users and items.

Xiao et al. [A98] aim to mine the intercity mobility in terms of various metrics of travel trips. It utilizes the tensor decomposition method to conduct an in-depth study on the intercity mobility pattern from the perspective of complexity and multidimensionality. A 4-D tensor is constructed based on private car trajectory and point-of-interest datasets, and the functional similarity and geographic adjacency between regions are defined. An alternating proximal gradient-based method is designed to resolve the core tensor and factor matrix.

Madi and Pirrò [A99] introduce node-centric deception, considering nodes entering and leaving a target community. They theoretically study the effect of node updates by leveraging node safeness as a deception optimization function and present an effective heuristic capable of hiding the target community with minimal node operations, which relies on safeness and considers the insertion and deletion of nodes.

Yang et al. [A100] propose a local structure-based community detection attack heuristic approach (LSHA), where the local structures, including several nodes with dense connections instead of the whole community structures, are considered. In LSHA, a local structure selection strategy is proposed to maximize the attack effect, which selects two local structures for rewiring attack. Furthermore, two metrics, i.e., edge vulnerability and node entropy, are also suggested to select the nodes and edges for attack.

Yang et al. [A101] propose an uncertainty-aware label contrastive and distribution learning (ULCDL) method to estimate patient health questionnaire-8 (PHQ-8) scores, thus detecting depression automatically. ULCDL simulates the ambiguity within PHQ-8 scores by converting single-valued scores into discrete label distributions and learns to predict the score distribution by minimizing the Kullback–Leibler divergence between the score distribution and the discrete label distribution. Moreover, label-based contrastive learning is introduced to learn common features related to depression in multimodal data.

He et al. [A102] propose a label-dependent graph neural network (LDGNN), introducing the Hilbert–Schmidt independence criterion (HSIC) as a regularization to minimize the dependence between input features and noise. HSIC can measure the nonlinear relationship between any two spatial variables and guide GNN to retain more label-dependence information. An expectation–variance separation is designed to centralize nodes and disperse them between classes to further retain label-dependent information.

Tao et al. [A103] investigate a dynamic pricing-based computation offloading solution for multiuser in signal cell network with mobile edge computing (MEC). Through the use of Q-learning algorithm comprehensively considering those sensitive factors, e.g., time cost, energy consumption, and dynamic pricing, the offloading decision at the end-user is achieved with the consideration of time-varying wireless

channel conditions. According to the resources supply and demand relationship, a dynamic pricing algorithm for the MEC server is designed to adjust the pricing strategy to achieve a win-win situation.

Wang et al. [A104] introduce a novel algorithm, named "CrowdDC," which aims to solve the issue of ranking large datasets based on subjective factors using crowdsourced paired comparisons. In traditional paired comparison analysis, dealing with a sizeable dataset can become impractical as the number of comparisons required increases quadratically. To address this problem, CrowdDC is designed as a divide-and-conquer algorithm that partitions the dataset into smaller subsets and compares them independently. The results of these comparisons are then combined to generate an overall ranking.

II. Sora for Computational Social Systems: From Counterfactual Experiments to Artificiofactual Experiments With Parallel Intelligence

Over the last year, we have organized several workshops on artificial intelligence after AlphaGo and ChatGPT, and recently on Sora, a few initial reports and summaries have been completed [1], [2], [3], [4], the following is a summary on impact in computational social systems.

A. Three Levels of Intelligence

In "Tao Te Ching" (or "Dao De Jing" in Chinese), one of the foundational works of ancient Chinese Daoist philosophy, the well-known opening statement "Dao Ke Dao Fei Chang Dao" has rich philosophical insights. Since in Chinese, "Dao" means road or journey, the above statement has traditionally been widely interpreted as "Dao Ke Dao, Fei Chang Dao," which means "The Dao that can be spoken is not the eternal Dao." With the rapid advancements in knowledge and technologies, there has been a more diverse and nuanced understanding. While the traditional emphasis leans toward the ineffability of "Dao," our new interpretations attempt to delve deeper, suggesting that while the essence of "Dao" transcends language, the "Dao" explored through language and practice still points toward that eternal, unchanging truth core, namely "Dao, Ke Dao, and Fei Chang Dao," which means "The Dao, The Speakable Dao, and The Eternal Dao."

In the era of artificial intelligence, our new interpretation can correspond to three levels of intelligence, that is, the Dao corresponds to algorithmic intelligence (AI), the Speakable Dao corresponds to linguistic intelligence (LI), and the Eternal Dao corresponds to II [5], [6]. These three types of intelligence represent different levels and stages in the development of artificial intelligence. AI serves as the foundational level, primarily involving capabilities such as data processing, logical reasoning, and optimization search, while LI, building upon AI, requires systems not only to understand the basic structure of human language but also to grasp context, emotions, and implicit meanings, thus enabling complex dialog and information exchange with humans [7], [8], [9]. II, on the other hand, represents a higher level of artificial intelligence, involving creative thinking, associative reasoning, intuitive judgment, and the ability to explore unknown domains [10], [11].

Just as AlphaGo stands as a milestone in AI and ChatGPT a milestone in LI [12], [13], we consider the emergence of Sora a milestone for II (as shown in Fig. 1) since it successfully bridged the enormous gap from abstract text descriptions to complex video generation, achieving a high-level simulation of human imagination. What impact and significance will Sora bring to the research and development of computational social systems? How will Sora change our social systems? To answer these questions, we first need to understand the characteristics and advantages of Sora and explore its potential for computational social systems.

B. Impacts of Sora

As a groundbreaking large-scale generative model for text-to-video synthesis introduced by OpenAI on February 15, 2024 [14], Sora can create realistic and imaginative scenes from text instructions. It is regarded as a crucial milestone in the development of artificial general intelligence (AGI) and has garnered significant attention from both academia and industry. Sora is uniquely capable of interpreting and emulating the dynamics of the physical world, responding to user-provided textual prompts with vivid and authentic video sequences of high fidelity that seamlessly blend realism with imaginative scenarios. Built upon the foundation of DALL-E and the GPT series models, Sora utilizes the advanced diffusion transformer (DiT) architecture and multimodal learning strategies [15], [16], and it can comprehend the intricate semantics of textual inputs, along with the real-world manifestations of items mentioned in the text. It can generate accurate details of multiple characters, specific actions, objects, or backgrounds in complex scenes, and creatively transform these descriptions into high-quality video content. Fig. 2 provides an instance of the Sora-generated video [17].

Due to the powerful simulation and creative capabilities, Sora is poised to empower the modeling and experimentation of complex social systems, thereby strongly advancing the development of computational social science. First, Sora can provide abundant data resources for social system modeling. Through concise textual inputs, Sora can construct rich video content containing a wide range of social phenomena and behavioral patterns. These videos intricately capture diverse information such as character behaviors, interactive dynamics, and environmental changes, providing unprecedented multidimensional, continuous-temporal data resources for complex social system models. This vivid and detailed dataset can be used not only to delve into the inherent complexity of social systems but also to provide decision-makers with more comprehensive and precise decision-making bases.

Second, Sora has the ability to delve into the potential, elusive, or yet-to-occur but potentially unfolding operating rules and logic of the social system. In the process of generating videos, Sora not only adheres to the rules and logic of the physical world but also employs causal reasoning

Fig. 1. Three levels of intelligence.

and logic construction techniques to create numerous new social behavioral patterns and interaction rules. These newly created rules and logics can be directly applied or heuristically integrated into social system models, enabling them to more intricately simulate the complex dynamics and intricate interactions of the real world. This helps researchers explore various causal relationships and interactions within social systems from new perspectives and gain a more comprehensive understanding of the operational mechanisms of social systems.

Third, Sora offers visualization and more underlying effective interaction tools for experiments. Sora can vividly and dynamically showcase the experimental processes and results of social systems through videos, allowing researchers to observe and understand the operation of complex social systems more vividly. This provides decision-makers with intuitive and compelling decision-making references. In addition, utilizing Sora for cartoon-style social system experiments allows for creative exploration of various hypothetical scenarios. Through visual narrative, it helps researchers understand and predict the evolution paths of social phenomena under different conditions, such as showcasing the expected effects of social policies through realistic videos or simulating the impact of sudden events on community structures and social orders. This significantly enhances the interpretability and predictability of experiments and provides researchers with new exploration tools and powerful research methods.

C. Sora and Parallel Intelligence

Despite significant advancements in the field of video generation, the current Sora model still falls short in fully representing the complexity and diversity of the real world. First, there are limitations in physical accuracy. When attempting to simulate real-world physical phenomena, particularly in continuous dynamic processes involving interdisciplinary interactions such as mechanics and optics across spatial and temporal dimensions, Sora is constrained by the effectiveness of its modeling of deep nonlinear dynamics and stochastic events, making it difficult to accurately reproduce complex physical interactions such as collision effects and light propagation patterns. Second, in the face of the highly dynamic and uncertain nature of the real world, Sora adopts a data-driven learning framework, expanding its understanding of the physical world by leveraging both real video datasets and synthetically generated ones. However, the model's comprehension and replication capabilities inevitably suffer from the limitations of the training data coverage. In particular, when confronted with unforeseen elements of randomness and uncertainty in real-life scenarios, Sora may exhibit inadequate adaptability, struggling to flexibly cope with and accurately simulate these new circumstances. Third, critical challenges are encountered in maintaining logical coherence and reproducing complex scenes. Ensuring inherent consistency in scene transitions and storyline developments during the video content generation process is a key criterion for evaluating generation quality. However, Sora still exhibits deficiencies in this regard, potentially leading to the generation of video segments that contravene real-world logic in their situational construction. Simultaneously, when dealing with vast complex scenes containing numerous characters and dynamically evolving elements, maintaining high-quality and finely detailed visual outputs poses a significant challenge, potentially resulting in phenomena such as blurriness or loss of detail in certain parts of the video.

The parallel intelligence theory based on the artificial societies, computational experiments, and parallel execution (ACP) approach serves as an effective method for addressing the uncertainty, diversity, and complexity inherent in social systems [18], [19], [20], thereby enhancing Sora's video

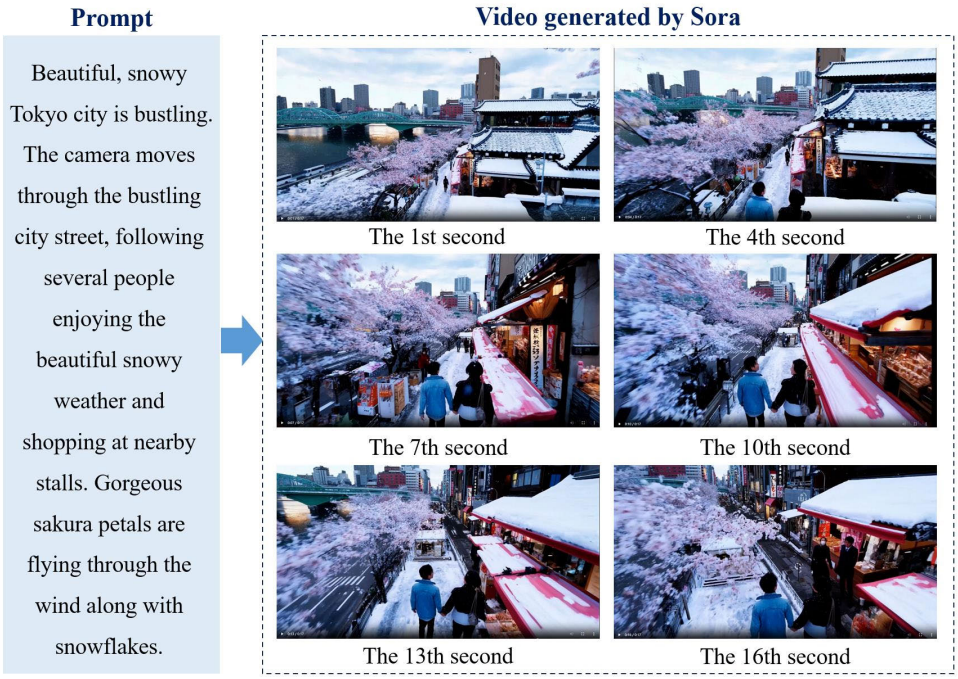

Fig. 2. One instance of Sora's text-to-video synthesis.

generation capabilities. Within the framework of parallel intelligence theory [21], [A83], the artificial systems corresponding to Sora encompass not only various entities and interaction rules in the physical world but also fundamental laws of social operation, logical structures, and social cultural backgrounds. This aims to more accurately simulate and anticipate the diverse manifestations and potential trends of the real world. Within the artificial systems, a series of targeted computational experiments are designed and implemented based on users' textual inputs, exploring various strategy combinations in the text-to-video conversion process. These include different conversion algorithm applications, narrative hierarchical design layouts, artistic presentation of visual styles, and nuanced rendering of emotional content. Through multiple iterations and evaluations, the optimal video with the most artistic and visual impact will be obtained. Through parallel executions and closed-loop feedback between Sora and the artificial systems, the parameters and operational strategies of the artificial systems will be continuously adjusted and improved. This enables the artificial systems to effectively guide real-time performance improvements and innovative enhancements in Sora's actual video generation, thereby effectively enhancing the quality and efficiency of Sora's video generation.

Sora can also support the parallel intelligence theory in two aspects, including artificial society modeling and computational experiments. On the one hand, Sora can use actual data, simulated data, as well as the operating rules and mechanisms of the physical world to generate diverse videos that conform to the logical framework of the physical world. These videos not only cover scenarios that exist in reality but also construct scenarios and causal relationships that are difficult to observe in the real world through various complex logical reasoning and causal relationships. Meanwhile, the data and mechanisms generated by Sora can be further utilized as the database for simulated and computer-generated data, continuously expanding and supplementing the data and mechanisms of artificial societies, enhancing the ability to accurately and comprehensively characterize dynamic changes, complexity, and diversity in the real physical world. On the other hand, the computational experiments can be enhanced by Sora's powerful logical reasoning ability. For a given initial state or target state, or even only a middle-stage state, Sora can creatively generate multiple forward and/or backward extensions of timelines, demonstrating how the social system may develop from this state to multiple different future forms and how it converges from a series of different historical paths to this current state. In addition, based on given initial conditions and expected results, Sora can explore multiple possible evolutionary paths and generate corresponding video demonstrations, intuitively depicting the diverse world evolution processes starting from the same starting point but experiencing different event sequences to reach the same endpoint. These capabilities can effectively enhance the deductive and predictive abilities of computational experiments, allowing for more accurate forecasting and deeper insights into complex systems.

D. From Counterfactual Experiments to Artificiofactual Experiments

Counterfactual experiments are a research method for complex social systems, conducted in a computer simulation environment based on hypothetical conditions to analyze and understand the behavior of complex social systems [22]. Through counterfactual experiments, researchers can explore

situations that cannot be directly observed or implemented in the real world [23]. By conducting deductive analysis of systems under different conditions and events, researchers can infer which factors are the key reasons leading to specific results, thereby evaluating the effectiveness and risks of different decisions and selecting the optimal decision. Counterfactual experiments provide researchers with a tool to explore and analyze complex social systems in a virtual environment, helping to reveal the internal mechanisms of the system and guide practical decision-making while avoiding various limitations and risks that may arise from conducting experiments in the real world. Indeed, computational experiments can be regarded as the algorithmization of counterfactual experiments [24], [25].

With the development of artificial intelligence technologies, AGI technologies represented by ChatGPT and Sora [26] can effectively enhance the capability and effectiveness of computational experiments. Based on this, we integrate AGI technologies into computational experiments and propose a new experimental method called artificiofactual experiments [27], aiming to improve the breadth and coverage of artificial society modeling and the capability and effectiveness of generative deduction using AGI technologies, and provide an intuitive dynamic display of the experiments through the Sora-alike scientific animation forms. Through such scientific animation forms, the accessibility, interactivity, and comprehensibility of the experiments can be enhanced by offering visually engaging representations that vividly illustrate complex concepts and processes, as well as the impact of various fine-tuning strategies, which can help researchers and stakeholders gain deeper insights into the experimental outcomes, fostering better understanding and informed decision-making.

In artificiofactual experiments, AGI-enabled artificial society modeling and generative deduction can greatly enhance the precision, effectiveness, scalability, adaptability, and predictive capabilities of artificial society modeling and computational experiments. In the AGI-enabled artificial society modeling, the data not only include the actual data, the simulated data, and the computer-generated data, but also the artificial intelligence-generated data, and the operating rules and mechanisms not only include the actual rules and mechanisms, the simulated rules and mechanisms, and the computer-generated rules and mechanisms, but also the artificial intelligence-generated rules and mechanisms, where the artificial intelligence-generated data and artificial intelligence-generated mechanisms are the virtual data and virtual mechanisms generated through artificial intelligence technologies such as ChatGPT and Sora. This can provide a large amount of virtual data and virtual mechanisms for constructing artificial societies, not only generating a large number of negative sample cases but also giving birth to a lot of virtual mechanism models originating from the dynamic evolution of complex systems, especially in filling sparse sample spaces, generating missing negative samples, and generating mechanisms that do not conform to or surpass existing scientific principles or are beyond human cognitive ranges. This fundamentally expands the data foundation required for artificial society modeling and the theoretical mechanism support behind it, effectively addressing challenges such as insufficient data samples, scarce negative samples, and complex and diverse mechanisms, thereby greatly enhancing the ability to simulate the complexity, diversity, dynamics, and unpredictability of our social systems.

The AGI-enabled generative deduction incorporates AGI's powerful generation capability into the deduction processes, making the deduction processes more creative, diverse, and flexible, thereby effectively enhancing the efficiency and effectiveness of the deduction processes. Sora, as a representative AGI, has powerful logical reasoning ability, allowing it to design different evolutionary paths forward or backward based on initial or target states and generate corresponding evolution process videos. These evolutionary paths not only include possible evolutionary paths existing in reality but also extreme or rare situations that are difficult to observe in the real world or even the processes that are difficult to occur in the real world. This helps researchers understand the behavior and responses of systems under different pressures, thereby assisting them in understanding how to achieve specific results by adjusting strategies or environmental parameters. The AGI-based generative deduction method has high flexibility and intelligence, not only significantly improving the accuracy and speed of experiments but also allowing researchers to explore deeper issues that traditional methods are difficult to reach, deepen the understanding of the operating mechanism of complex social systems, better predict the future development trends of the real world, and thus provide more accurate and comprehensive theoretical support for decision-making in the real world.

E. The TAO to Imaginative Intelligence

Unlike traditional artificial intelligence systems, which primarily focus on analyzing and learning from existing data, Sora ventures into the uncharted territory of imagination. This involves artificial intelligence not just processing information but also generating new, hypothetical scenarios based on a mix of learned data and creative inference. Sora enables the visualization of concepts that language struggles to articulate accurately, presenting them through video in a tangible form. This breakthrough in cognitive and creative domains transcends the boundaries of human imagination, advancing the LI represented by ChatGPT to the realm of II [13], [28].

II allows experiments in imaginative facts by constructing and exploring scenarios that have not occurred in the real world but are plausible based on existing knowledge. This will enable humans not only to explore the myriad possibilities of the real world but also to create new realms that far exceed our existing cognitive frameworks. Such progress means that we can express our most abstract and complex thoughts and emotions in an unprecedentedly tangible form, enhancing our understanding and problem-solving abilities through visualization. For instance, Sora can simulate the outcomes of novel scientific experiments before they are

physically conducted, predict the impact of untested policies on society, or create new literary and artistic works that reflect complex human emotions and thoughts. This capability is rooted in a sophisticated understanding of both the logical structures that govern the real world and the creative processes that drive human innovation. By blending these elements, Sora can generate predictions, solutions, and creations that extend far beyond the limitations of conventional artificial intelligence, offering unprecedented tools for problem-solving, creativity, and exploration.

Through Sora-enabled artificiofactual experiments, everyone can become a "director" in the decision theater. When Arizona State University developed the Decision Theater Network around 2004, it primarily focused on simulation, modeling, and the visualization of data and information for complex systems. Despite continuous expansion in the technological capabilities and application scope of the decision theater over the subsequent 20 years, its core has always remained focused on advanced data visualization and interactive simulation. The emergence of new technologies, such as the metaverse [29], ChatGPT, and Sora, has propelled the decision theater into a new era, creating a highly intuitive, imaginative, and interactive complex decision support system. However, this still falls short of supporting decisions for complex systems that embody both social and engineering complexities. The challenge of how the imagination in the virtual world can guide the real world to operate and how outcomes from the real world can feedback into virtual experiments remains an issue we face today. To achieve this, it is necessary to construct a parallel theater based on the theory of parallel intelligence [30], [31], fully harnessing the potential of Sora's II in complex decision-making [32], [33].

Considering that centralized organization is not the most prevalent type of organization in human society, the parallel theater should adopt decentralized design principles based on smart contract [34], [35] and DAOs or TRUE autonomous organizations (TAOs) [36], [37], [38]. This approach better simulates and addresses the complexities of the real world, allowing participants to autonomously simulate different decision paths in a leaderless, trustless environment [39], [40], [41]. It explores the potential impacts of various hypothetical scenarios, empowering everyone to become the "director" of their work and lives. The parallel theater makes the decision-making process not only data-driven but also fully considers human rational and emotional constraints, leading to more comprehensive and humanized decisions. From an individual perspective, the parallel theater provides an unprecedented decision support environment, allowing individuals to explore the potential consequences of various life and work decisions within a safe and risk-free virtual space. This experience not only enhances individual decision-making capabilities but also improves their understanding and predictive abilities regarding complex systems. The parallel theater reduces the demands on individual intellect and physical effort, enabling people to invest limited energy, time, and rationality into controlling and directing decisions, whether in routine matters or creative domains [42].

From a societal perspective, the parallel theater, utilizing big models such as ChatGPT and Sora, transforms rich human language into continuous, tangible expressions, blurring human ideas, and cognitive boundaries, followed by alignment and differentiation within social interactions supported by blockchain intelligence [43], [44] and DAOs/TAOs [45], [46], [47]. This process not only fosters the integration of diverse thoughts and cultures but also accelerates the collision of innovative thinking and the generation of new knowledge, encouraging individuals and groups to transcend traditional thinking patterns to explore and construct new cognitive architectures and social structures. On a broader level, the parallel theater becomes a powerful societal experimental field, simulating future societal possibilities through open and inclusive interactions among diverse entities in a virtual environment, providing a potent tool for public policy formulation and societal planning.

The parallel theaters provide us with a feasible and effective way to utilize collective wisdom, as well as boundless imagination of both humans and artificial intelligence, in designing and creating our new worlds. In this process, the boundless imagination will become as crucial as data, serving as indispensable raw materials. Meanwhile, biological humans, robotic humans, and AGI-enabled digital humans will emerge as the primary producers, and the collaboration among these three types of humans will stand as the paramount mode of production. This will lead us into a new era of II.

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APPENDIX: RELATED ARTICLES

[A1] Z. Li, H. Du, and X. Li, "Topic-aware information coverage maximization in social networks," *IEEE Trans. Comput. Social Syst.*, vol. 11, no. 2, pp. 1722–1732, Apr. 2024.

[A2] G. Xiong et al., "TrajSGAN: A semantic-guiding adversarial network for urban trajectory generation," *IEEE Trans. Comput. Social Syst.*, vol. 11, no. 2, pp. 1733–1743, Apr. 2024.

[A3] G. Zhu, R. Yang, E. Q. Wu, and R. Law, "Extraction of emergency elements and business Process model of urban rail transit plans," *IEEE Trans. Comput. Social Syst.*, vol. 11, no. 2, pp. 1744–1752, Apr. 2024.

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