Behavioral Information Feedback With Large Language Models for Mental Disorders: Perspectives and Insights

WE are pleased to present the third edition of the IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS (TCSS) for 2024. This edition includes a robust collection of 104 regular papers and features a Special Issue on Knowledge-Infused Learning for Computational Social Systems. This special issue delves into the sophisticated integration of advanced technologies and knowledge-based methodologies within the analysis of computational social systems. Spanning 12 articles, the issue addresses a wide spectrum of topics, from big data management to refining machine learning models with domain-specific insights. It encompasses areas such as energy management in sensor networks, acoustic analysis of heartbeats, detection of fraudulent activities in online ratings, and the management of rumors on social networks, exemplifying the significant role that knowledge-infused learning plays in enhancing technological applications and fostering innovation in social computational systems.

After the usual introduction of our 104 regular articles, we would like to discuss the topic of behavioral information feedback (BIF) with large language models (LLMs) for mental disorders. BIF with LLMs for mental disorders is vital due to its potential to transform mental health care by enhancing accessibility, cost-effectiveness, and personalization of treatment. LLMs equipped with BIF can provide continuous, real-time therapeutic interactions, and early intervention, which are critical in managing mental health effectively. This technology enables tailored therapy based on individual behavioral cues captured through multimodal data, thus bridging significant gaps in traditional psychotherapy. Moreover, it opens new avenues for research in technology-enhanced mental health interventions, advancing both affective computing and computational psychopathology and making mental health services more effective and widely accessible.

I. SCANNING THE ISSUE

Existing group recommendation models suffer severer data sparsity problems. Article [A1] proposes a member-augmented multi-interest model with knowledge graph embeddings to overcome the aforementioned drawbacks. The proposed model applies the member augmentation technique to precisely predict a group's opinion on items. In addition, multi-interest framework to model the change of diverse user preferences is leveraged. The framework can know which interests of the user will affect the decision of the group, and interests will vary with different group members.

Current studies seldom consider the withholding strategy's impact on delay propagation. Inspired by this, article [A2] proposes a novel bi-directional delay propagation model combined with the trains' operation trajectory and stations' withholding strategy. Moreover, the operation constraint, station capacity constraint, and interlocking constraint are also considered. Then, the primary delay under section disruption and section temporary speed limit are derived based on the location of the disturbance, duration time of the disturbance, and the operation strategy. Then, a max-plus algebra-based delay propagation model is established to compute the corresponding secondary delays. Also, the All Pair Critical Path algorithm is modified to incorporate the station capacity constraint in the searching process.

Robust models cannot identify the target nodes of the adversarial attacks, and thus it is unable to pinpoint the weak spots and analyze the causes or the targets of the attacks. Article [A3] studies the important research problem to detect the target nodes of graph adversarial attacks under the black-box detection scenario. This is the first work that aims at detecting the target nodes of graph adversarial attacks under the black-box detector scenario. Two detection models is proposed, named Det-H and Det-RL, which employ different techniques that effectively detect the target nodes under the black-box detection scenario against various graph adversarial attacks. Two novel surrogate attackers are further proposed that are able to generate effective attack examples and camouflage their attack traces for training robust detectors.

Current methods suffer from the inability to consider the topology of the graph data and inadequate use of unlabeled data. To address these issues, article [A4] proposes federated graph augmentation (Fed GA) by combining graph neural network models to utilize similar topological existing in different client graphs and augment the client data. Furthermore, Fed GA-L based on Fed GA is developed, which integrates pseudo-labeling and label-injection to improve the utilization of unlabeled data. Fed GA-L allows pseudo-labels to be used as additional information to enhance data augmentation and further improve the accuracy of node classification. The effectiveness of Fed GA and Fed GA-L through experiments on multiple datasets is evaluated.

Current research isolates these two mechanisms, with further division of indirect reciprocity into positive and negative based on the direction of daily interactions. To capture the coevolution of direct and indirect reciprocates, this work [A5] has developed a simple yet comprehensive model, allowing individuals to choose among these reciprocates arbitrarily. A comprehensive equilibrium analysis discovers that the analogous strategy of negative indirect reciprocity, called negative scoring (NSCO), has a stronger control property than the well-known reciprocity strategies. Utilizing evolutionary simulations, it is found that direction can indeed promote the emergence of indirect reciprocity.

The dissemination of positive and negative information interacts with each other, making network dissemination analysis and utility optimization more challenging. To this end, a negative–neutral–positive–susceptible (NNPS) model and a max–min ant system algorithm with a repetitive influence reduction strategy (MMAS-RIR) are developed. First, an NNPS model with a novel heterogeneous influence indicator is constructed to simulate the interactive dissemination of positive and negative information. The influence of each user's neighbors on each user is treated differently, producing heterogeneous state transition probabilities for users. Second, article [A6] formulates the control of information dissemination as an optimization problem with a designed control scheme. The disruption strategy and counterbalance strategy are automatically implemented on the selected users according to their states in the control scheme. Third, a MMAS-RIR algorithm for the formulated problem is specially developed, where the repetitive influence reduction strategy is used to reduce the influence repeated range of the connected users. Moreover, to improve the exploitation, an adaptive local search is added in MMAS-RIR.

The clustering performance degenerates dramatically if the views are corrupted by noise. To overcome this limitation, a robust multi-view clustering approach based on weighted low-rank tensor approximation and noise separation is proposed in [A7]. The proposed model improves the performance through a low-rank approximation function and weighted singular values. The weighted low-rank tensor approximation method considers both prior knowledge and the physical meanings associated with different singular values, leading to superior performance in capturing high-order correlations. Additionally, to eliminate mixed noise, a novel Cauchy norm is developed to handle outliers, and Frobisher norms are used to handle random corruptions and slight perturbations, respectively. A high-efficiency optimization algorithm based on the alternating direction method of multipliers is designed to address the challenging proposed model.

Article [A8] proposes a machine learning based approach to solve a graph optimization problem, named network intervention with limited degradation, which aims at adding new edges to augment the graph to minimize the local clustering coefficient of a target node. Article [A8] proposes a new framework, named network intervention with self-supervision, which employs reinforcement learning and self-supervised learning to effectively solve the problem. Two new effective pretext tasks in self-supervised learning, Distances-target prediction task and local clustering coefficient increment prediction task are proposed to improve the model performance. In addition, two new embedding approaches, neighborhood embedding and constraint property embedding are also proposed, to capture the structural information of the graph.

In [A9], three policy-making rationales (called "controllers") are evaluated: a flattening-the-curve controller that maximizes allowable transmission rate while ensuring hospital capacity is not exceeded, a time-limited-intervention controller to minimize the number of infectious people with policies of fixed durations, and a minimizing-health-and-economic-costs-with -reinforcement-learning controller to minimize weighted public health and economic costs. Each controller is applied in six scenarios where there is no underreporting, underreporting without correcting it, and underreporting with corrections. It is found that both the recommended policies by a controller and the resulting disease trajectories would be different under different scenarios, in which direction underreporting affects policies and disease trajectories depending on three factors: time elapsed since start of pandemic, local hospital capacity, and disease severity.

Article [A10] focuses on examining the structural, relational, and cognitive aspects of social capital in relation to the difficulties in digital education in tertiary institutions. The research uses a quantitative approach, and the data were collected through an online survey of students in nonstate universities in Sri Lanka. Structural equation modeling was used to analyze the data, and the results showed that the three dimensions of poor social capital have a negative impact on digital education in tertiary institutions. This study also used multigroup moderation analysis to examine the effect of gender and location.

Article [A11] proposed a hybrid graph-based framework, namely, SINCERE, to build compact sarcasm detection models with sentiment and emotion analysis by leveraging only a small amount of prior data. To automatically extract patterns from a small dataset collected by distant supervision, a graph is first constructed. This approach is used to discover latent representations of vertices in a network, as the basis for a language model. They demonstrate that simple classifiers built from the model can detect sarcasm and generalize better than the state-of-the-art approach.

In [A12], political slants in news and their influence on readers by analyzing election-related news and readers' reactions to the news on Twitter are investigated. Each publisher's political slant based on the favorability of its news toward the two major parties' presidential candidates is computed. The difference in news coverage of the two candidates between the left-leaning (LEFT) and right-leaning (RIGHT) news publishers is statistically significant. The effect size is larger for the news on Twitter than for headlines. And, news on Twitter expresses stronger sentiments than the headlines. Moral foundations in readers' reactions to LEFT and RIGHT differ statistically significantly, though the effects are small. Further, these shifts in moral foundations differ across social and political issues. User engagement on Twitter is higher for RIGHT than for LEFT.

Article [A13] presents efforts to address cyberbullying detection in a code-mixed context, emphasizing the importance of explain ability. The contributions of this study can be categorized into two main aspects: Firstly, a cyberbullying corpus

named Bully Explain is created in a code-mixed language. Secondly, a unified generation framework, BullyGen, is proposed. This study demonstrates how to redefine multi-task challenges as a text-to-text generation problem, allowing the utilization of extensive pre-trained sequence-to-sequence models in scenarios with limited linguistic resources. Experimental results validate the effectiveness of the proposed model.

Article [A14] creatively proposes to study and explore the double-edged sword effect of negative emotions to improve the efficiency of crowd evacuation. To this end, the NegEmotion model was first constructed, which considers the positive impact of negative emotions on crowd evacuation. Then, based on the NegEmotion model, an optimization problem for emotion regulation was proposed, and heuristic algorithms were used to solve the optimal emotion regulation strategy. Finally, the effectiveness of the model was verified through simulation of crowd evacuation. The experimental results indicate that this method can effectively improve the efficiency of crowd evacuation.

Article [A15] proposes a new task to study the social emotions of popular online topics and collects a large amount of Chinese data from Weibo. The new dataset contains over 20 000 trend themes and collects tags, posts, comments, and related metadata, making it a valuable language resource. In addition, by utilizing useful contextual information provided by tags, posts, and comments, this article also proposes a hashtag- and topic-enhanced attention model (HTEAM) to enhance the performance of social emotion prediction. The experimental results indicate that HTEAM outperforms the baseline.

The TruthSeeker dataset was selected in [A16]. This article uses multiple levels of validation to ensure accurate benchmark datasets. Then, many machine learning and deep learning algorithms were created and implemented to test the accuracy of true and false tweet detection. In addition, the article also introduces three auxiliary social media ratings: bot, credibility, and influence ratings to better understand the patterns and characteristics of Twitter users towards fake/true tweets. The article also utilizes clustering-based event detection to analyze the relationship between topics and tweets.

Article [A17] proposes a new autoregressive conditional jump intensity—generalized autoregressive conditional heteroskedasticity Markov chain model. This model considers the asymmetric effects of positive and negative shocks on jump volatility and is used to study the asymmetric jump behavior in the stock market. This article uses a multi temporal linkage model to analyze the dynamic dependence of jump risk between mainland China and Hong Kong stock markets, and constructs dynamic hedging portfolios for spot and futures markets. The results indicate that the model proposed in this article has the best fitting effect on the Chinese stock market.

Article [A18] provides an overview of current Internet of Things systems and discusses the most advanced intrusion detection systems (IDSs) currently available. This article proposes an attack model for modeling possible attacks. In addition, as the focus of this article is to provide explanations for IDS prediction, authors first conducted a comprehensive study on commonly used interpretation methods and their advantages and disadvantages. This article proposes a metric and metric classification method for explanatory evaluation. Finally, a high-level architecture for the proposed system is presented, which includes workflows and components for explaining security and privacy aspects.

Article [A19] introduces a new reference digital twin architecture and applies it to real-world scenarios to evaluate and adjust the bipartite graph matching methods presented in the article. The purpose of this work is to promote fairness, equality, and the realization of needs. The experimental results show that the method proposed in this paper outperforms the baseline method in terms of overall fairness. In addition, authors envision extending the principles of fairness, equality, and demand to load balancing environments, including task offloading, infrastructure as a service, software as a service, and other related fields.

Article [A20] explains the significant differences in user characteristics between true news retweeters and fake news retweeters, and proposes a new fake news detection model based on forwarding user embedding. The model adopts an attention mechanism to learn user representations in the user forwarding relationship graph, aggregates the representations of reposters to represent the tweet, and then uses the representation of the tweet for fake news detection. The experimental results show that the method proposed in this paper performs well and achieves better results than other advanced methods.

Article [A21] proposes a new community detection method based on deep clustering, called deep semi-supervisor community detection (DSSC). A new learning objective has been designed, which uses a semi-autoencoder with a pairwise constraint matrix defined based on point-wise mutual information at the representation layer to accurately learn features, and uses hyperparameters to define pairwise constraint matrices. The results indicate that the proposed method DSSC outperforms the most advanced community detection methods in existing complex networks.

Article [A22] introduces a new paradigm for using generative artificial intelligence (GAI) for economic and financial research to better understand the constantly evolving economic and financial systems. This paradigm includes research objectives, scientific data and methods, and models, characterized by the integration of GAI features from economic and financial research. One of the most important impacts of GAI on economic and financial research is how it will expand the scope of its research subjects. The new research paradigm of GAI proposed in this article can provide important insights for a comprehensive understanding of innovation and transformation in this field.

The authors in [A23] investigated how users may share access to their smartphone resources. They ran an experiment in which participants would bid to share three different resources (camera, microphone, and GPS) with two battery depletion conditions. Through two case studies (collaborative sensing and collaborative AI), they derived design implications for incentive mechanisms in collaborative resource sharing systems. The results offer insights into the factors affecting user's willingness to participate in a sharing economy for sensing resources, taking into consideration the potential implications from the use of the sensor itself instead of focusing solely on the data they capture.

To address how such reputation-based voluntary participation influences the evolution of fairness, article [A24] introduces

indirect reciprocity with voluntary participation into the dictator game. They respectively consider good dictators or recipients can voluntarily participate in games when the opponents are assessed as bad. They theoretically calculate the fairness level under all social norms of third-order information. The results demonstrate that recipients' voluntary participation is more effective in promoting the emergence of fairness behavior.

Article [A25] proposes a heterogeneous graph attention network (H-GAT) model that incorporates an attention mechanism based on ablation experiments in heterogeneous graphs to analyze the patterns and correlations within the surfing behavior data of students. The proposed H-GAT model exhibits excellent performance, with nearly 80% accuracy and recall. This work offers a potential approach to detect depression on college campuses using nonintrusive methods, which could ultimately contribute to early warnings for both individuals experiencing depression and higher education institutions.

Article [A26] proposes a model for platform ecosystem evolution with four dynamics: 1) dynamics between ISPs (services) and platforms; 2) dynamics between users and platforms; 3) dynamics among services; and 4) dynamics between services and demands. They design six evaluation indexes such as demand matching rate, service diversity, and market concentration to evaluate the efficiency of the platform market. The experimental results show that reducing the cost-of-service release can increase the amount of demand and the diversity of services, and the monopoly of digital platforms is a natural trend to improve the efficiency of supply and demand.

Article [A27] proposes a novel framework for detecting fake news, which leverages graph neural network to jointly model the content, emotional information and propagation structure of news conversations. Also, in order to use emotion to amplify the spread of fake news, they propose an edgeaware method to enhance the news graph representation. The experimental results indicate that model achieves state-of-theart performance on various fake news detection tasks.

Article [A28] proposes a federated matrix factorization based on secret sharing to protect users' privacy. The parameters are randomly divided into pieces, the secret sharing technology is used to transmit private information between user–user and user–server. This article introduces the user–item interaction value, which is transmitted to the server with gradient information. The experimental comparison with the existing work and the analysis of computation time show that the proposed method can ensure the accuracy of model privacy recommendations without introducing additional encryption operations.

Article [A29] proposes an adaptive sampling and aggregation-based graph neural network (ASA-GNN) that learns discriminative representations to improve the performance of transaction fraud detection. They use cosine similarity and edge weights to adaptively select neighbors with similar behavior patterns for target nodes and then find multi-hop neighbors for fraudulent nodes. A neighbor diversity metric is designed by calculating the entropy of neighbors to tackle the camouflage issue of fraudsters and explicitly alleviate the over-smoothing phenomena. Extensive experiments on three real financial datasets demonstrate that ASA-GNN outperforms state-of-the-art ones.

Article [A30] briefs on standard preprocessing techniques and various word embeddings for data preparation. It then delves into a taxonomy to provide a comprehensive summary of deep learning-based approaches. In addition, the work compiles popular benchmark datasets and highlights evaluation metrics employed for performance measures and the resources available in the public domain to aid-sentiment analysis (SA) tasks. Furthermore, the survey discusses domain-specific practical applications of SA tasks. Finally, the study concludes with various research challenges and outlines future outlooks for further investigation.

Article [A31] proposes a formal user behavior modeling and analysis approach. First, aiming at identifying the behavior patterns of user activity sequence, they present a user activity transition system model based on stochastic Petri net. Then, the average number of tokens in each place, the probability density function of the tokens, the token flow rate of transitions, and the time spent in each state are analyzed by isomorphic it into a Markov chain, respectively. The experimental results demonstrate that the proposed approach can help us to understand the rules of users' first activity and activity preferences.

In [A32], the proposed method is built-upon the existing approach, distributed graph statistical distance, to enhance the scalability on large graphs. The key innovation of the work lies in the proposition of a batching mechanism for client-server message passing. They present a sampling approach for computing pairwise distances between the nodes to compute the desired graph embedding and systematically explore six distinct variations of a distributed graph embeddings and subsequently subject them to comprehensive evaluation. The extensive evaluations on over 20 graph datasets and ten baseline methods demonstrate improved running time and comparative classification accuracy compared to state-of-the-art embedding techniques.

In [A33], the authors propose an explainable complaint cause identification approach with a dyadic attention mechanism at the sentence and word levels, enabling it to give varying amounts of emphasis to more and less important information. As the first subtask, the model simultaneously trains complaint detection, sentiment detection, and emotion recognition tasks. Afterwards, they identify the complaint's cause and its severity level. To do this, the causal span annotations for complaint tweets are added to an existing financial complaints corpus.

Article [A34] proposes a teacher-guided peer learning approach that employs a continuous action iterated dilemma (CAID) model based on an incremental network. First, authors propose an incremental network generation algorithm that generates an effective communication network. Second, considering the multiple unknown nonlinear environmental impacts, they design a student dynamic model based on CAID with multiple layers of nonlinearity. Finally, based on the incremental network and student dynamic model, they design the Lyapunov function to prove the convergence of the proposed model.

In [35], the authors extended the classic Friedkin–Johnsen opinion dynamics model to hypergraphs, considering the higher order interactions. They resolved this kind of linear dynamics problem by pairwise network representation. They provided an explanation of the equilibrium expressed opinion in terms

of spanning converging forests. They proved that higher order interactions have a nonnegligible influence on opinion dynamics. Moreover, they proposed a fast algorithm by sampling spanning converging forest to approximately solve the problem concerned in linear time.

Article [A36] develops an opinion dynamics model of the evolution of credit scores of enterprises in a social network. Firstly, the leader and follower enterprises are identified. Then, the cooperated utility between any two enterprises is calculated. Some desirable properties of the proposed opinion dynamics model are theoretically stated and proved. Finally, a numerical example is provided to illustrate the feasibility of the proposed opinion dynamics model, while a simulation analysis to investigate the joint influences of the connection probabilities and the network structure on the evolution of credit scores of enterprises is reported.

In [A37], the authors construct a four-party evolutionary game model. The computing tasks are conducted on edge servers. They analyze the stability of the strategic equilibrium in mobile crowdsourcing using replicator dynamics methods. The optimal payoff strategies of the participants in different initial states are obtained. To prevent cheating and false-reporting problems, reward and punishment strategies are provided. Finally, the stability of the equilibrium of the four-party evolutionary game system is verified by simulation experiments, and an incentive strategy is designed to motivate all parties to choose the trust strategies.

In [A38], a novel model is presented for predicting civil unrest events. The model is anticipated to comprehend people's emotions/sentiments as well as the significance of contextual information and the importance of features of civil unrest events. The result shows that the proposed model performs well as it improves the accuracy by 3% to 15% over state of art methods with the farmer's protest dataset. The model is civil unrest event independent and only requires the related corpus and bag-of-word for a specific civil unrest event.

Article [A39] introduces the prospect theory to unify star ratings and text reviews of products and then takes two heterogeneous information as the basis for product designers analyzing competitiveness. First, authors propose a unification model to express different grades of star ratings and text reviews as a unified evaluation system according to value consistency. Then, they use evidential reasoning theory to aggregate unified product evaluation results. Finally, comprehensive comparisons of products are carried out based on the characteristics of dominance relations of products.

Article [A40] proposes a novel planning method to address the issue about transportation. First, a spatiotemporal clustering algorithm is proposed to generate joint stations based on the passenger travel demand. Second, the method models the multiline customized bus optimization problem as a Markov decision process and uses a multiagent deep reinforcement learning algorithm to ensure effective training and response to incomplete information scenarios. Finally, the rationality of the proposed planning method is verified in a case study of customized bus area in Chongqing, China.

In [A41], the authors propose AI-URG, a novel account identity-based uncertain graph with multifactor identity modeling for online service fraud detection. They embed account representation that preserves the uncertain graph's possible world semantics and use the domain knowledge that accounts of family members also from small communities to filter these benign groups and detect malicious communities. The ablation study demonstrates how each component contributes to the effectiveness. The comparison results on two datasets show that AI-URG outperforms the alternatives. The experimental results can provide valuable insights into online service fraud detection.

Article [A42] presents a data-driven approach to measure cognitive differences, authors also explore the cognitive differences between news media and the followers, and the evolution of topics over time. Their findings reveal those discussions about "balloons" on social media in China and the United States display certain differences in terms of sentiment. In addition, they assess the impact of this event on U.S.–China relationship, particularly in trade. They use this event as a case study to demonstrate that ChatGPT-like models may have limited capabilities for such kind of specialized analysis.

In [A43], the authors quantify the power of Big Tech by analyzing their acquisitions, market capitalization, and number of monthly active users. Moreover, they utilize the synthetic control method to estimate the effect of public scandals on the stock price of two Big Tech companies, and find that they had no lasting effect. They also analyze the number of tweets mentioning these scandals, and find that they quickly fade from the spotlight. To explore the public sentiment, they survey 5300 participants across 25 countries, and got many significant findings.

In [A44], the authors propose and implement a hybrid (differential privacy and k-anonymity) anonymization scheme that produces supreme-quality anonymized data that offers knowledge similar to real data without compromising privacy. Specifically, they implement a pair of algorithms that divide the dataset into privacy-violating and non-privacy-violating partitions. Afterward, in a non-privacy-violating partition, a relaxed privacy budget ε is applied to numerical attributes, but most of the categorical attributes are retained (as is) for informative analysis. In privacy-violating partitions, fewer changes are applied to the data by using a reasonable value for ε and by exploiting the diversity in sensitive information.

In [A45], the authors present a hierarchical separation and classification network (HSCN) for discovering dynamic, continuous, and macro- and microlevel variations in facial expressions of affective states. In the HSCN, they first invoke an unsupervised cosine similarity-based separation method on continuous facial expression data to extract twenty-one dynamic facial expression classes from the seven common discrete affective states. The between-clusters separation is then optimized for discovering the macrolevel changes resulting from facial muscle activations.

In order to establish long-term green supply relationships between multi-stakeholders, the authors in [A46] hereby introduce data regulators and propose an evolutionary game model

to observe the cooperation tendency of multi-stakeholders (data providers, users, and regulators). Besides, a replicator dynamic system is built to study evolutionary stable strategies of multi-stakeholders. Furthermore, they explore the influence of the cost of data users to acquire data, the value of open data, the reward (penalty) from the regulators, and the data mining capability of data users to group strategies and uncover some regular patterns.

In [A47], the authors propose a decentralized autonomous car cluster dynamic evolution model. First, they define a decentralized cluster structure. Then, they analyze the cluster evolution behavior and propose a maintenance method. Next, they define eight vehicle states and their transitions. Finally, they introduce the cluster dynamic evolution model and the collaboration model. The results of extensive simulation experiments show that their method can effectively maintain the consistency of cluster consensus and improve the stability of the cluster structure compared with the centralized cluster maintenance method.

Article [A48] introduces a novel task allocation algorithm based on spatiotemporal attention network (STATA). First, all historical tasks performed by workers are aggregated to obtain the correlation of all historical tasks. Then, the most plausible candidate tasks are recalled from the weighted representation for allocation. STATA utilizes the spatiotemporal attention mechanism to capture the relationship between these factors, ultimately improving the accuracy of task allocation. Extensive experiments demonstrate that the STATA model exhibits superior performance in terms of task allocation accuracy and practical application capabilities.

In [A49], the authors propose a mutual information-based method to quantitatively measure node behavior synchronization. Further, they propose a link prediction algorithm that combines local structural similarity with node behavior synchronization. Experimental results on real-life networks show that the proposed method is competitive in accuracy compared to methods relying solely on network structure or exploiting information about node behavior. In addition, the analysis of the prediction performance with different combination ratios reveals the role of node behavior synchronization in different types of real networks.

Article [A50] proposes a multiattribute environments-classes, agents, roles, groups, and objects (E-CARGO) task assignment model based on adaptive heterogeneous residual networks (AHRNets). The AHRNet is integrated into deep reinforcement learning, dynamically adjust task assignment decisions and learn the relationship between workers with different attributes and task requirements. Multi-attribute E-CARGO uses group task assignment policy to obtain the ideal worker-task assignment relationship. a large number of numerical results show that this method can achieve better results than the reference scheme.

Article [A51] proposes a multi-population synergistic gene screening algorithm based on the parallelism of evolutionary algorithm (EA) and combined with Ensemble learning for identifying low-quality genes and removing them as a way of pruning the solution space of the algorithm and improving the search efficiency. The algorithm encodes all nodes in the graph as the gene pool of EA and treats a single population as a weak learner to screen the dominant genes in the gene pool and achieve fast pruning of EA's solution space by integrating the dominant individuals in multiple populations.

Article [A52] quantifies the relationship between the scientists' interactive activities and their influences with different patterns in the AMiner dataset. The results show that elite scientists have higher individual and interaction influences than ordinary scientists in all patterns found in the study, with permutation tests verifying the significance of the new findings. Overall, this article provides a feasible approach to addressing the scientific influence issue and deepening the quantitative understanding of the mutual influence of multiple scientific activities in science and society.

In [A53], the authors propose a novel approach to facial emoji generation, which can control the emotional degree of generated emojis for more complex and detailed usage on online conversations. In this way, their approach aims to map fine-grained emotions to expressive emojis. Both quantitative and qualitative evaluation demonstrate that their approach can successfully generate high quality emoji-like images by representing a wide range of emotions. It is said that this is the first approach to use the deep generative model from the standpoint of the emoji's emotional role, which can further promote more interactive and effective online communication.

Article [A54] develops a knowledge graph-based risk management framework to improve the resilience of Supply Chains (SCs). Specifically, the construction of the SC knowledge graph (SC-KG) framework, including the implementation steps, is presented. Furthermore, the SC-KG is well constructed to build a scenario-based supply chain risk management framework under consideration of the severity of disruptions. Finally, a practical SC-KG containing over 2.5 million entities and 11 types of relationships has been developed and its basic functions have been implemented, which contributes to improving the quality of SC management.

In [A55], the authors propose a risk assessment-based privacy-preserving model for social networks, which is based on graphical evolutionary game theory and infectious disease dissemination dynamics model. In their scheme, a privacy risk assessment model is constructed to evaluate the importance degree of users' privacy information and measure the leakage risk of users' privacy information. Second, due to the heterogeneity of social networks, a graphical evolutionary game model of user privacy information forwarding behaviors is built to quantify and measure the strategy (or behavior) changes of different social users. Further, they construct a privacy-preserving information dissemination model, which is based on infectious disease dissemination model combined with graphical evolutionary game theory.

In [A56], the authors propose a novel approach that leverages human-firearm interaction information, which provides valuable clues for localizing firearm carriers. Their approach incorporates an attention mechanism that effectively distinguishes humans and firearms from the background by focusing on relevant areas. Additionally, they introduce a saliency-driven

locality-preserving constraint to learn essential features while preserving foreground information in the input image. By combining these components, their approach achieves exceptional results on a newly proposed dataset.

In [A57], a new method to free graph augmentations is provided building a novel fuzzy view and two crisp views of the original graph. As all the views are transformed from the original graph, they are semantically similar and naturally considered to possess high-quality positive samples. In this way, the data amount is compensated to a degree without changing the raw node attributes or graph topology. Additionally, to ensure the diversity of the positives, asymmetric renormalization and noise perturbation are adopted. Experiments toward node-level tasks on several real-world datasets demonstrate the competition against several state-of-the-art models.

In [A58], the authors study the dense subgraph augmentation problem in multilayer graphs. Specifically, they propose the notion of (k, L)-core to model the dense subgraphs in multilayer graphs and propose a new research problem, budgeted maximal (k, L)-core augmentation (BMA) problem, which adds at most b edges in the multilayer graphs to maximize the size of (k, L)-core. They prove the NP-hardness of the general BMA problem when $k \geq 2$ and devise a polynomial-time algorithm to find the optimal solution for a special case of BMA, i.e., (2, 1)-BMA. They then devise an effective algorithm, named search for optimum and reorder adaptively, with various performance-improving strategies to tackle the general BMA problem.

Article [A59] proposes a novel approach for Multimodal named entity recognition called a gated disentangled network with cross-modality consensus fusion to address the above challenges. Specifically, to eliminate cross-modality variation, they propose a cross-modality consensus fusion module that generates a consensus representation by learning inter and intramodality interactions with a designed commonality constraint. They then introduce a gated disentanglement module to separate modality-relevant features from support and auxiliary modalities, which further filters out extraneous information while retaining the uniqueness of unimodal features.

In [A60], in order to overcome the limitations of traditional self-supervised contrastive learning in the use of contrastive samples and further explore the value of interaction information, authors propose dual-supervised contrastive learning for bundle recommendation model. Specifically, they use interaction information to construct a supervised contrastive paradigm, which explicitly models the proximity of users and bundles in different views. In addition, they use cooccurrence graphs to mine more high-quality positive samples, further strengthening the supervised contrastive learning. Finally, the two contrastive learning are jointly executed across different views. Extensive experiments on three public datasets demonstrate the effectiveness of their model.

In [A61], the authors suggest a novel solution, evolutionary clustering for ontology matching, to explore correlations between Social Web of Things (S-WoT) data using clustering and evolutionary computation methodologies. The evolutionary clustering for ontology matching approach uses a variety of clustering techniques to aggregate S-WoT data's strongly related ontologies into comparable categories. The principle is to match concepts of similar groups rather than full concepts of two ontologies, which necessitates splitting examples of each ontology into similar groups. They design two clustering algorithms for ontology matching using conventional methods, as well as sophisticated clustering techniques. Moreover, they develop an intelligent matching algorithm that uses evolutionary computation to quickly converge to (or ideally identify) optimal matches.

In [A62], the authors propose the concept of parallel printed circuit board inspection in cyber–physical–social systems. Based on artificial systems, computational experiments, and parallel execution theory with automatic parameter identification and refinement, they perform descriptive intelligence to build an artificial imaging system, obtain knowledge about the mapping relationships of parameter settings and imaging results, and realize automatic parameter identification given image input; conduct predictive intelligence to obtain image quality assessment results and maximize quality score for refinement strategies; and carry out prescriptive intelligence to guide parameter refinement for better imaging.

In [A63], the authors propose TEGDetector, a dynamic graph classifier that learns the evolving behavior features from transaction evolution graphs. First, they cast the transaction series into multiple time slices, capturing the target address's transaction behaviors in different periods. Then, they provide a fast nonparametric phishing detector to narrow down the search space of suspicious addresses. Finally, TEGDetector considers both the spatial and temporal evolutions toward a complete characterization of the evolving transaction behaviors. Moreover, TEGDetector utilizes adaptively learned time coefficient to pay distinct attention to different periods, which provides several novel insights.

In [A64], the authors develop ZEro-Trust Audit with strategic Recommendation, a zero-trust audit and recommendation framework, to provide a quantitative approach to model insiders' incentives and design customized recommendation policies to improve their compliance. They formulate primal and dual convex programs to compute the optimal bespoke recommendation policies. They create the theoretical underpinning for understanding trust, compliance, and satisfaction, after classifying insiders as malicious, self-interested or amenable, they establish bespoke information disclosure principles for these insiders of different incentive categories. They identify the policy separability principle and the set convexity, which enable finite-step algorithms to efficiently learn the completely trustworthy policy set when insiders' incentives are unknown.

In [A65], the authors propose a knowledge-associated embedding for the memory-aware knowledge tracing (KT) framework. Specifically, they first construct a question-skill bipartite graph with attribute features. A knowledge-associated embedding module is proposed to capture the distinctiveness of multiskills via the process of knowledge propagation and knowledge aggregation based on predefined knowledge-paths. Then, to simulate the memory recall phenomenon of the learners in

KT, they design a memory-aware module for long short-term memory (MA-LSTM) networks. A temporal attention layer in MA-LSTM is proposed to learn the forgetting mechanism of the human brain. Finally, they introduce a learning-gain layer to obtain learners' benefits after each exercise.

Article [A66] has proposed a clustering-based summary generation approach that takes multi-viewed representations of data and utilizes a new variant of generative adversarial network (GAN) named triple-GAN to perform clustering. Triple-GAN consists of three networks, a generator, a discriminator, and a separator. Maintaining equilibrium among these networks requires proper parameter tuning which makes training of GAN difficult. In the literature, GAN-based techniques have been extensively applied to image datasets. The proposed method has explored the usage of GAN for text data in an unsupervised manner and the analysis of the training of GAN has also been reported. The developed method opens up a new direction in utilizing GAN for solving clustering problem of text data.

Article [A67] investigates how interacting agents arrive to a consensus or a polarized state. The authors study the opinion formation process under the effect of a global steering mechanism (GSM), which aggregates the opinion-driven stochastic agent states at the network level and feeds back to them a form of global information. A new two-layer agent-based opinion formation model is also proposed, called GSM-DeGroot that captures the coupled dynamics between agent-to-agent local interactions and the GSM's steering effect. Contrary to the standard DeGroot model, this model allows polarization to emerge by letting agents react to the global information in a stubborn differential way. Moreover, the introduced stochastic agent states produce event stream dynamics that can fit to real event data. This article explores numerically the model dynamics to find regimes of qualitatively different behavior.

Article [A68] proposes a multilayer network-based information–behavior–disease coupling (IBDN) transmission model for the process of information diffusion–behavior change–disease transmission. The IBDN model considers various factors such as psychological drivers of information dissemination, the impact of herd mentality on behavioral transmission, the disease transmission dynamics of the current COVID-19 Omicron mutant strain and relevant countermeasures, and the interconnections between information, behavior, and disease transmission. Research has demonstrated that the extent to which individuals are influenced by information is associated with age.

Due to the rapid expansion of the Internet of Vehicles, service providers deploy roadside units (RSUs), and base stations (BSs) close to vehicles. Unfortunately, the open nature of RSU BSs makes them vulnerable to malicious attackers. Article [A69] proposes a security trust degree incentive-based evaluation mechanism that calculates the security trust degree of vehicle users to RSU BSs through the continuous interaction between them in order to effectively address the aforementioned issues. Additionally, taking into account the competitive nature of task computation offloading between vehicle users and BSs, a stable matching algorithm is used to match each vehicle user with the most appropriate BS so that they can work together to prevent competition in task offloading and improve task offloading efficiency.

In [A70], the authors propose a summary-enhanced hierarchical framework, which leverages summary information to enhance financial report sentiment analysis. Their framework incorporates financial bidirectional and auto-regressive transformer (FinBART), equipped with extended position encoding to summarize lengthy report articles and capture long-range interactions. To mitigate information loss, they initially divide each report into segments and then propose the hierarchical analyst sentiment representation network, which utilizes financial bidirectional encoder representation from transformer (FinBERT), bidirectional long short-term memory attention, and dendrite network to fuse information in the generated summary and report segments. Notably, FinBART and FinBERT are pretrained on large-scale financial corpora to effectively understand professional expressions.

Article [A71] proposes a generative model called masked Bayesian nonnegative matrix factorization for detecting core-periphery structures. The article proposes a method to infer model parameters and use this method to prove the convergence of variables. In addition to the capabilities of traditional methods, it can also provide soft partitioning and core scores, and can identify overlapping core periphery pairs. The experimental results validated the effectiveness of this method and indicated that it outperforms traditional methods in different scenarios.

In [A72], the authors propose a diversified graph neural networks-based recommendation systems diversified graph recommendation with contrastive learning. Specifically, they design three key components in their model: 1) the user–item interaction with category-related sampling enhances the interaction of unpopular items; 2) contrastive learning between users and categories shortens the distance of representations between users and their un-interacted categories; and 3) contrastive learning between items and categories diverge the distance of representations between items and their corresponding categories. By applying these three modules, they build a multitask training framework to achieve a balance between accuracy and diversity.

Article [A73] divides interpersonal interaction into two dimensions: psychological and behavioral, and proposes an emergency communication model based on the coevolution of communication strategy and communication behavior. This model is based on the propagation mechanism of emergencies and utilizes relevant social networks to simulate the propagation trend of emergencies. In addition, a method was proposed to predict the occurrence time point from four indicators. The empirical verification and analysis confirm the rationality, progressiveness and effectiveness of the proposed method in solving research objectives.

In [A74], the authors explore a hierarchical transformer (HIT)-based architecture to learn the semantics of code-mixed languages. HIT consists of multiheaded self-attention and outer product attention components to simultaneously comprehend the semantic and syntactic structures of code-mixed texts. They evaluate the proposed method across six Indian languages (Bengali, Gujarati, Hindi, Tamil, Telugu, and Malayalam) and

Spanish for nine tasks on 17 datasets. The HIT model outperforms state-of-the-art code-mixed representation learning and multilingual language models on 13 datasets across eight tasks. They further demonstrate the generalizability of the HIT architecture using masked language modeling-based pretraining, zero-shot learning, and transfer learning approaches.

In [A75], the authors propose DeepINT, an interpreter for anomaly detection in industrial control systems (ICS). In DeepINT, they adopt a search optimization algorithm to find the reference and capture feature importance by the back-propagation gradient to improve interpretation performance and reliability. In addition, they construct a finite difference-based interaction detection, which tests the interaction of different device components, in order to address the problem that actuators in ICS are not easily interpreted, meanwhile improving the comprehensiveness and accuracy of the interpretation results.

In [A76], the authors propose a novel graph-diffusion-based domain-invariant representation learning model for the cross-domain facial expression recognition scenario where there exist distribution shifts between various domains. Specifically, a low-dimensional space mapping strategy is first adopted to diminish the domain mismatch. Then, by skillfully combining the local graph embedding and affinity graph diffusion, the local geometric structures can be effectively modeled and the deeper higher-order relationships of samples from various domains can be captured. In addition, in order to better guide the transfer process and learn a more discriminative and invariant representation, they take into account the label consistency.

In [A77], a novel recommendation system, G-TransRec, is proposed to predict customers' next items of interest with the potential purchase time by exploiting a user temporal interaction sequence. Moreover, by integrating the graph embedding technique, authors include the global user information to explore more collaborative knowledge for effective recommendations. Several experiments were conducted on two real datasets to demonstrate the performance and superiority of the proposed model compared with the state-of-the-art methods on several evaluation metrics.

Article [A78] introduces a novel DiEvD-SF framework, which uses continual machine learning (CML) with selective forgetting. Twitter (currently "X") is used as a real-time and dynamic data source for validation. DiEvD-SF considers the temporal nature of disruptive events (DEs) and "selectively forgets" outdated DEs through machine unlearning. To the best of their knowledge, this article is the first to apply CML with selective forgetting to discard outdated DEs and to continue learning about the new DEs.

Article [A79] has shown that a one step ahead optimal control approach with a sequential, parallel, or asynchronous game-playing procedure leads to easily computable and effective controls for players who influence the opinions of agents connected by a weighted directed graph. To implement the proposed control, each player needs only global agent state information, which, together with rational behavior, is a standard assumption in all existing methods, but requires no information on the policies of other players.

In [A80], the authors propose employing hypergraph convolutional networks for group recommendation. Specifically, their design aims to achieve excellent group preferences by establishing a high-order preference extraction view represented by the hypergraph, a consistent preference extraction view represented by the overlap graph, and a conventional preference extraction view represented by the bipartite graph. The linkages between the three various views are then established by using cross-view contrastive learning, and the information between different views can be complementary, thereby improving each other.

Article [A81] proposes an agent network computation-based evolutionary game model (ANC-EGM). This model consists of two parts: the definition of language attractiveness and the language competition game. The former defines an individual's willingness to use a language, while the latter simulates the language competition game between two types of individuals at the micro level, following the gender struggle. The experimental results of ANC-EGM indicate that language reputation is a key factor guiding the evolution of language systems, and the difficulty of language learning and people's tolerance for foreign languages also have a corresponding impact on language competition.

In [A82], the authors aim to fill this important research gap by reviewing the related literature. They first conducted a brief overview of blockchain technology and auction theory, and then systematically discussed the research progress on the existing blockchain research based on auction theory as well as auction research enabled by blockchain. Toward the end, they presented several open research issues and directions, aiming to provide useful guidance and reference for future research efforts.

In [A83], the authors propose a perturbed graph contrastive learning with negative propagation (PCNP) for recommendation, which introduces negative interest to assist interest modeling in a contrastive learning (CL) architecture. An auxiliary channel of negative interest learning generates a contrastive graph by negative sampling and propagates complementary embeddings of users and items to encode negative signals. The proposed PCNP contrasts positive and negative embeddings to promote interest modeling for recommendation. Extensive experiments demonstrate the capability of PCNP using two-level CL to alleviate interaction sparsity and bias issues for recommendation.

In [A84], the authors propose a susceptible-infectious-quarantine-recovered-susceptible model with quarantines and study its evolution on simplicial complexes. In the model, a fraction of infected individuals is subject to quarantine, but individuals leaving quarantine may still be contagious. Using mean-field methods, they derive the propagation threshold and the steady state infection densities as well as conditions for their stability. Numerical simulations moreover show that longer quarantine times and higher quarantine ratios tend to disrupt discontinuous phase transition and bistable phenomena that are commonly due to group interactions.

In [A85], the blockchain-driven contact tracing framework features an Rivest-Shamir-Adleman encryption-based transaction verification method, achieving over 96% accuracy in

contact case recording, even with a 60% probability of individuals failing to verify contact information. Furthermore, they propose a lightweight reputation corrected delegated proof of stake consensus mechanism, coupled with an incentive model, to ensure timely reporting of contact cases while maintaining blockchain decentralization. Additionally, a novel simulation environment for contact tracing is developed, accounting for three distinct contact scenarios with varied population density.

Article [A86] tries to extend the application of trajectories auto-collected by wireless sensing devices and simulate the epidemic spread in a trajectory data-driven manner. They find the following. 1) Among the three examined nonpharmacological interventions, community containment is more effective than keeping social distance, which can lower the deaths to nearly 1/9 compared to no action, while travel restrictions play limited roles. 2) There is a strong positive correlation between population densities and mortality. 3) The timing of community containment triggered by confirmed diagnoses is proportional to the number of deaths, thus early containment will significantly decrease mortality.

Article [A87] proposes the temporal-tightly graph convolutional network (TT-GCN) to extract temporal features. TT-GCN comprises three significant mechanisms: the causal temporal convolution network (casual-TCN), the walking direction recognition auxiliary task, and the feature mapping layer. To obtain tight temporal dependencies and enhance the relevance among gait periods, the causal-TCN is introduced. Based on the assumption of emotional consistency in the walking directions, the auxiliary task is proposed to enhance the ability of fine-grained feature extraction. Through the feature mapping layer, affective features can be mapped into the appropriate representation and fused with deep learning features.

Article [A88] utilizes the research method of spread dynamics to investigate the influence of the control role of announcements in social networks on the spreading process. This article distinguishes two spreading phases using the authentication intervention as a boundary: the unconfirmed spreading phase and the confirmed spreading phase. True information and false information spreading dynamics model is developed to analyze the changes in spreading effects due to different validation results. The impact of the intervention time on the overall spread process is analyzed by combining important control factors such as response cost and time sensitivity.

In [A89], the authors propose a novel framework named phishing detection on Ethereum via augmentation ego graph based on graph neural network. First, they obtain account labels and transaction records and extract ego-graphs centered on labeled accounts. Then they propose a feature augmentation strategy to augment the node features, so that these features of each ego-graph can be learned. Finally, they present a new graph-level representation, sorting the updated node features in descending order and then taking the mean value of the top n to obtain the graph representation.

In [A90], the authors propose a novel Crossing-modal hashing method, namely robust asymmetric cross-modal hashing retrieval with dual semantic enhancement (RADSE). RADSE consists of three parts: 1) cross-modal data alignment that applies kernel mapping and establishes a unified linear representation in the neighborhood to capture the nonlinear relationships between cross-modal data; 2) relaxed label semantic learning for robust ness that uses a relaxation strategy to expand label distinctiveness, and leverages $\ell_{2,1}$norm to enhance the robustness of the model against noise and outliers; and 3) dual semantic enhancement learning that learns more interrelationships between samples under the label semantic guidance to ensure the mutual enhancement of semantic information.

Article [A91] proposed a methodology for understanding and predicting hate-mongering behaviors on social media. The initial focus is on distinguishing users spreading hateful content from those who do not. Using a curated dataset, authors conducted a large-scale study examining online activities of both groups. To understand triggers for hate-motivated behavior, psycholinguistic and behavioral characteristics are extracted from users' posts (linguistic features, readability, communication style, and posting trends). Additionally, a predictive model was developed to anticipate whether a user is likely to publish hateful content based on past online behavior.

In [A92], a privacy-preserving cooperation framework is proposed to deal with privacy inference threats from third parties in online social networks (OSNs). Authors indicated that privacy inference threats to OSN users come not only from the data that they themselves share with third parties but also from the privacy decision made by other users. In the design of the privacy-preserving cooperation framework, the dynamics of user behavior regarding cooperation with regard to privacy protection were first analyzed based on the evolutionary game theory. Then, the conditions of the existence of evolutionary stable state and the rational of incentive budget of cooperation requesters were also analyzed.

In [A93], the authors have proposed a deep-learning-based multitask model to solve the three correlated tasks, viz. humor, valence, and arousal simultaneously, where humor recognition is treated as the primary task, and valence and arousal are considered secondary tasks. They hypothesize that humor is closely related to the valence and arousal dimensions of sentiment. They make the first attempt to release a new meme dataset for humor recognition in Hindi and propose a multitask deep learning framework to simultaneously solve three problems: humor recognition (the primary task) and valence and arousal classification (the two secondary tasks) for Internet memes.

In [A94], the authors leverage hyperbolic dynamic neural networks for knowledge-aware recommendation (KHDNN). Furthermore, they design a fresh aggregation strategy based on relations to propagate and capture higher-order collaborative signals as well as knowledge associations. Meanwhile, they extract semantic information via a bilateral memory network to fuse item collaborative signals and knowledge associations. Empirical results from four datasets show that KHDNN surpasses cutting-edge baseline methods. Additionally, they demonstrate that the KHDNN can perform knowledge-aware recommendations with complex relations.

In [A95], the authors propose a new paradigm to generative text steganography that takes advantage of certain social media through apparently normal behaviors from the sender.

They make use of the live commenting feature provided by public video sharing platforms, which allow viewers to make comments on video scenes that will fly on screens when the scenes are shown. They show that this feature can be used to construct a generative steganographic system. The sender generates at random a number of distracting words and a certain invertible matrix called W-d matrix based on the total number of message words and distracting words. The sender then transforms a sequence of indexes of these words to a sequence, selects one or more videos with a sufficiently large number of total frames, and generates a comment on each frame in the sequence. To generate comments on frames that conform to comments made by viewers, they devise a neural ResNet-LSTM model to generate a comment for an input image based on its content.

Article [A96] presents a differential game approach to the opinion formation problem in social networks to investigate the evolution of opinions as a result of a Nash equilibrium. The opinion of each individual is described by a differential equation. The objective of each individual is to seek optimal strategies for its own opinion evolution by minimizing an individual cost function. Two differential game problems emerge, one for a population that is not stubborn and another for a population that is stubborn. The open-loop Nash equilibrium actions and their associated opinion trajectories are derived for both differential games using Pontryagin's principle.

Article [A97] proposes a multi-objective evolutionary framework that can search for high-quality guidance signage placement strategies automatically. In the proposed method, an agent-based crowd simulation model is proposed to simulate the wayfinding behaviors of pedestrians in public places. Furthermore, a new safety metric is proposed to quantitatively evaluate the quality of guidance signage placement strategies. On this basis, an indicator-based multi-objective evolutionary algorithm is utilized to search for optimal guidance signage placement strategies that have tradeoffs between crowd safety and pedestrians' travel time.

In [A98], an improved Temporal link prediction model has been introduced using graph embedding with self-clustering (GEMSEC) graph embedding and graph convolutional networks(GCNs). Authors adopted the GEMSEC node embedding to generate the initial feature vectors for each node of the network. The necessary changes are made in the GCN architecture to iteratively process these feature vectors for the dataset's timestamps, which enables better capture of the opinion changes over time and neighborhood information of the users in the network. Then, using the node features vectors and the existence or absence of the edges between nodes as labels, they produced a well-labeled and well-balanced dataset.

Article [A99] proposes a new transformer-based framework named dualpath TokenLearner (dual-TL), which utilizes the concept of learnable tokens to integrate both spatial and temporal informative contexts from the global perspective of the video. It consists of two learnable tokens, spatial TokenLearner and TokenLearner (T-TL) that retain informative spatial and temporal contexts, respectively. The proposed dual-TL uses S-TL to explore associations in different facial regions of interests (ROIs), which promises the remote photoplethysmography prediction far away from noisy ROI disturbances. And a temporal T-TL is designed to infer the quasi-periodic pattern of heartbeats, which eliminates temporal disturbances such as head movements.

Article [A100] highlights the significant risk of mental health consequences, particularly among the youth, during the COVID-19 outbreak. They emphasize the importance of closely monitoring the mental well-being of individuals placed in house quarantine due to lockdown measures. Notably, their findings indicate a shift in the prevalence of mental health conditions, with the youth experiencing a negative impact from the pandemic in Bangladesh, where adult mental health conditions were previously less prevalent. The observed mental health outcomes, including anxiety, depression, physical problems, and stress disorders, underscore the strong impact of the pandemic on individuals' psychological well-being.

Article [A101] proposes a driving behavior prediction model using a wide-deep framework that combines gradient boosting decision tree (GBDT), convolutional neural network (CNN), and long short-term memory network (LSTM) algorithm to fully mine driving behavior characteristics while improve interpretability of the CNN-LSTM model. The GBDT algorithm can quantitatively describe the interaction between the autonomous vehicle and its surrounding vehicles during the driving process, obtaining a series of driving behavior rules, and integrating the driving behavior rule features into the CNN-LSTM neural network.

In [A102], an information cocoon model named BPIC is proposed to model the generation process of information cocoons. The patterns of evolution of the mean and variance of population information values are obtained by analyzing the distribution functions of information values in interest and disinterest information circles. In this process, the measurement of information cocoons across the population is based on Shannon's information entropy, taking into account neighborhood information.

In [A103], the authors have employed the $\mathrm{SE}I_3R_2D_2V$ model for the analysis. This analysis underscores the importance of considering and optimizing the contact dynamics to manage and mitigate the transmission dynamics of COVID-19 disease successfully. They conducted stability analysis for infection-free equilibrium (X') and endemic equilibrium (X^*). Additionally, they conducted a sensitivity analysis of R_t to identify the key factors that significantly affect its value. The stability analysis of the SEIRDV model provides compelling evidence regarding the critical role of the contact rate parameter α_t in effectively controlling the spread of infection.

A new crowd evacuation navigation approach based on multi-source knowledge is proposed in [A104]. First, authors collect relevant data on crowd evacuation establish a crowd evacuation knowledge graph to organize and store this data. Second, the explicit knowledge of scene structure and crowd movements is represented based on the crowd evacuation knowledge graph. Then, a deep-learning-based tacit knowledge model is designed to extract the tacit knowledge of different groups

and scene entities. Finally, a new crowd evacuation navigation approach based on wireless sensor network and related knowledge representations is designed to plan evacuation paths for evacuees.

II. BIF With Large Language Models for Mental Disorders: Perspectives and Insights

Is it possible for artificial intelligence (AI) to become psychotherapists? Human psychotherapists perceive the emotional and cognitive states of their clients through their keen eyes and hearing, engaging in personalized, structured conversations to achieve therapeutic goals. Emotional intelligence provides AI with the ability to perceive and express emotions, including emotional recognition and expression through facial expressions [1], voice [2], eye movements [3], and body language [4]. Researchers of LLMs [5] have begun to explore their ability to think and ask questions, rather than merely responding with knowledge from their database. Thus, LLMs are a step closer to one of the features of cognitive behavioral therapy (CBT)—"Socratic questioning." However, asking questions is not enough. Observing words and expressions to achieve real-time and effective communication is also a foundation for conducting psychological interventions. This requires the multimodal emotional processing capabilities of LLMs, meaning that AI can judge whether a client is in an abnormal emotional based on their multimodal behavioral information, and can also adjust its output strategy based on changes in their emotional status and cognitive load. We refer to such a closed-loop process as BIF. When artificial intelligence agents possess rich emotional perception capabilities, structured dialogue abilities, and a mechanism for BIF, we believe we can affirmatively answer the opening question.

The assessment and treatment of mental disorders has been one of the research hotspots in affective computing in recent years. Depression, as one of the mental disorders, has seriously affected people's daily lives, and the increase in incidence in recent years has brought related burdens to society [6]. Psychological and pharmacological treatments are equally effective in the short term, but psychotherapy is more effective in the long term [7]. Early detection and treatment are particularly important for the alleviation and recovery of depression [8], due to the high cost of psychological intervention, attempts to introduce AI technology into the detection and treatment of mental disorders can show good advantages compared to human approaches [3]. However, it is difficult for existing studies to construct models for accurate detection and efficient treatment of mental disorders in real-life scenarios, which may be related to the complexity of the causes of mental disorders and real-life environments. Besides, the expensive cost of psychotherapy deters many patients. LLMs with BIF would be the possible approach to the above difficulties. We firstly explore why BIF urgently needs to be constructed and improved for mental disorders diagnosis and treatment, and secondly give the future opportunities and challenges.

A. Multimodal Large Language Models (MLLMs) for Mental Disorders

LLMs are neural network models capable of processing and generating large-scale natural language text. They possess the ability to understand and generate language through vast pretraining data and complex neural network structures. Building upon this, MLLMs combine language with other media such as image, audio, and video to achieve more comprehensive data integration and understanding capabilities. They can handle multiple types of inputs simultaneously, thus gaining richer semantic and contextual information to achieve stronger interaction capabilities [9].

Compared to traditional LLMs, the greatest feature of MLLMs lies in their ability to accept multimodal data beyond just text, extracting complementary information from different modalities, and get the joint representation. The multimodal data integration provides MLLMs with a broader space for in-context learning (ICL), known as multimodal in-context learning (M-ICL), enabling MLLMs to possess stronger learning and generalization capabilities in complex real-world scenarios [10]. These features bring new capabilities to MLLMs, such as text content generation based on text prompts with other modalities, such as image [11], video [12], and audio [13]. Besides input, some models support output in different modalities, such as NExT-GPT [14], which can accept input in any modality and provide feedback in any modality. Research has attempted to expand MLLMs to more fields and use cases, such as medical image understanding [15] and document parsing [16], as well as assisting in real-world interactions, such as embodied agents [17] and GUI agents [18].

The potential of MLLMs in real-world interactions opens up possibilities for using MLLMs to assist in interview-based treatment of affective disorders. MLLMs can learn multimodal contextual information by integrating user behavior feedback data such as facial expressions, eye movements, and speech, and can provide explainable diagnostic and intervention insights for affective disorders based on professional diagnostic knowledge. Some research has already been conducted on mental diagnosis and intervention based on LLMs. Integrating acoustic speech markers into textual information has improved LLMs' understanding of human language patterns, revealing individual underlying psychological states and disorders better, and providing references for depression diagnosis [19]. By integrating multimedia data from social platforms and professional diagnostic standards, MLLMs can offer diagnostic bases and personalized suggestions based on natural language conversations [20]. A study involving LLM-driven social companion robots found that conducting 15-day CBT resulted in performance similar to traditional worksheet theory [21]. Research on the LLM-driven chatbot CareCall suggests that it alleviates public health workloads and helps reduce feelings of loneliness and emotional burden [22]. By combining pretrained LLMs with real-world professional Q&A from psychologists and extensively crawled psychology articles, the Psy-LLM framework was proposed, providing instant responses and mindfulness activities for psychological consultations to alleviate patient stress

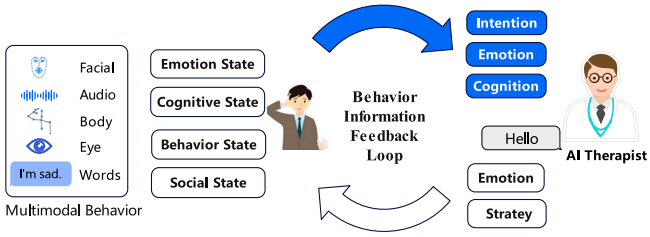

Fig. 1. BIF loop conducted by AI agent.

[23]. These studies fully demonstrate the potential of MLLMs in diagnosing and intervening in affective disorders.

B. BIF With LLMs

Accurate and objective mental disorders assessment play a key role in assisting the diagnosis and treatment process mainly using both physiological and behavioral data. The computational psychophysiology and field theory are proposed to reveal the pathological mechanism of mental disorders and provide more personalized and precise diagnosis methods [24]. Compared to physiological data, the acquisition of behavioral data does not require specialized equipment, is not limited by the environment, and is closer to real-world scenarios. Multimodal behavioral data collected [25] through ubiquitous devices such as cameras and microphones in a conversation provides sufficient information for depression assessment [26].

With the development of generative artificial intelligence (GAI) technology and multimodal pretrained LLMs, it has become possible to construct models with interaction capabilities through behavioral data to assist in the diagnosis and treatment of mental disorders. Chinese question-and-answer (Q&A) data from realistic scenarios are used in [27] to validate the performance of LLM in depression detection. BIF in mental disorders diagnosis and treatment is achieved by constructing virtual AI agent through GAI technology in the virtual interaction process, and providing auxiliary treatment for individuals identified with mental disorders during the conversation process. The framework of BIF is shown in Fig. 1, which stablishes a closed-loop feedback between the client and the AI therapist. It is worth noting that BIF simulates the conversational process in real-life scenarios.

There is a Chinese idiom, chá yán guān sè, which means to guess the meaning behind someone's words and observe their facial expressions to discern their true intentions. In human communication, 93% of the information is derived from nonverbal behavior, including facial expressions, voice, gestures, and eye movements [28]. These behaviors, combined with spoken and written language, form the multimodal channels of human communication. This multimodal behavioral information can reflect the speaker's emotional, cognitive, behavioral, and social states. Effectively recognizing these states is a prerequisite for effective communication. The rise of affective computing has made significant progress in emotion recognition, including behavioral data and physiological signals. AI therapists communicate with clients by using multimodal emotional and linguistic outputs, based on real-time perception of all-round state. AI therapists adjust their communication strategies and processes according to changes in the clients' state.

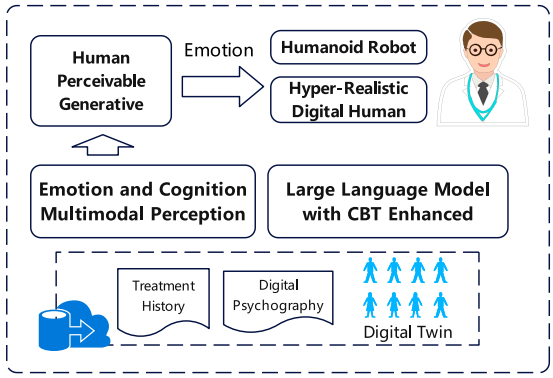

Fig. 2. Structure of AI psychotherapist.

Fig. 2 illustrates the structure of AI psychotherapist. AI psychotherapists are equipped with LLMs that have CBT capabilities, and they maintain digital psychography, which can document the treatment history of clients. AI psychotherapists capture individuals' emotional feedback during conversations, which also provides responses with positive emotional guidance based on the feedback from the conversation. The emotion and information are conveyed through facial expressions, body movements, audio, eye movements, and words. By integrating digital twin simulation technology, AI psychotherapists can achieve better intervention capabilities. The representation of AI psychotherapists can be in the form of friendly humanoid robots envisioned for the future, or as hyper-realistic digital humans and animated characters accessible via mobile devices.

C. Opportunities and Challenges

Witnessing the effectiveness of mental healthcare models in assisting diagnosis and therapy, we believe that with the power of GAI and LLMs, the use of BIF-based mental disorders diagnosis and treatment can make significantly progress in effectively alleviating the abnormal emotional states of clients. We would like to highlight the opportunities and challenges in this field to share our perspectives and insights.

1) Effective feedback mechanism of BIF: In diagnosing and treating mental disorders through BIF, key elements include effective emotional feedback between individuals and AI agents, integrating multimodal behavior data [26], [29], and crafting personalized treatment strategies. Challenges persist in accurately discerning emotional states within real-world settings, hindered by data gaps and external disruptions. The proposed therapy method, leveraging technologies like speech and emotion recognition, alongside gesture tracking, aims to gather comprehensive behavioral data. Yet, aligning these varied data streams proves difficult. The task at hand is to adeptly represent diverse sensory inputs in real-life situations, tailor treatment plans to clients profiles, focusing on their distinct traits, needs, and reactions. Moreover, the efficacy of

BIF hinges on the quality of interaction between clients and AI agents, underscoring the need to advance human-computer interaction techniques to boost user engagement and satisfaction.

2) Accuracy of GAI: Virtual characters play a role as interactive mediators in the diagnosis and treatment of mental disorders. However, the accuracy of GAI in areas such as voice and facial expression generation still needs to be improved, and there is also room for further improvement in the responsiveness and realism of virtual characters. In order to build trust and facilitate effective interactions, virtual characters need to have good interpersonal skills, focusing on appearance, voice, and behavioural characteristics that are crucial for patient acceptance and trust. Future developments should focus on improving these aspects to better support the therapeutic process for patients with mental disorders.
3) Adaptability promotion for multiple devices: Expanding the behavior feedback-based virtual interactive diagnosis and treatment system to various peripheral devices such as wearable devices and robots [30], [31] presents unique challenges in terms of specific adaptability. Since these devices have different functionalities, user interfaces, and data transmission methods, individual adaptation work is required for each device. This necessitates the development of customized software and hardware to ensure seamless integration of the behavior feedback-based diagnosis and treatment system with different types of devices. To address adaptability issues and provide a consistent and reliable behavior feedback-based diagnostic and treatment experience, interdisciplinary collaboration and continuous technological innovation are required.
4) Specialized pretrained language models: Designing and training a language model with the capabilities of a psychotherapist is a challenging task. Due to privacy concerns and other issues, the availability of behavioral data from individuals with mental disorders is very limited. It is crucial to increase the amount of data while utilizing a learnable interface and incorporating instruction-based fine-tuning to train lightweight LLMs that can understand emotional features in behavioral information and generate targeted intervention text. Furthermore, to regulate LLMs outputs and avoid generating harmful content, it is necessary to employ reinforcement learning methods based on human feedback, aligning the model with structured CBT. Therefore, designing and training a language model with the abilities of a psychotherapist is a complex task that requires comprehensive consideration of behavioral data, privacy limitations, and regulatory aspects of model outputs.
5) Real-time monitoring and intervention: By analyzing behavioral data from individuals' daily lives, early signs of mental disorders can be detected as early as possible, enabling early intervention. In the future, it may be necessary to develop portable nonintrusive behavior monitoring technologies that cooperate with virtual interactive systems to assist in improving the effectiveness of intervention measures. This facilitates individuals receiving feedback on their behavioral information in their daily lives and provides personalized interventions and support through mobile applications or smart devices. In addition, ensuring the privacy and security of user data is also an issue that needs to be considered, which requires appropriate security measures during data collection, storage, and transmission to protect patients' privacy.

D. Conclusion

The development of LLMs, GAI, and AGI has laid the foundation for the creation of AI therapists. Psychological interventions based on BIF adopt the natural communication methods of human therapists, enabling AI to perceive the emotions and condition of clients and adjust its responses accordingly to achieve the desired therapeutic outcomes. This approach is expected to be widely anticipated by patients with mental disorders and mental health professionals.

However, there are numerous unresolved issues in the virtual interaction process. It is high time to call for the collective efforts of scientists, psychologists, psychiatrists, and other professionals to refine the mechanisms of BIF and promote its widespread application in conversational settings for mental disorders therapy.

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APPENDIX
RELATED ARTICLES

[A1] S.-J. Lin, C.-T. Chen, and S.-H. Huang, "Member-augmented group recommendation with multi-interest framework and knowledge graph embeddings," *IEEE Trans. Comput. Social Syst.*, vol. 11, no. 3, pp. 3193–3206, Jun. 2024.

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