# Guest Editorial Special Issue on Behavioral Modeling, Learning, and Adaptation in Cyber–Physical–Social Intelligence

## I. BACKGROUND AND MOTIVATION

The integration of artificial intelligence (AI) with cyberphysical-social systems (CPSS) creates new research opportunities and challenges with major societal implications. The behavioral and cognitive enhancement of intelligent systems promotes a productive and creative partnership and collaboration between humans and machines. Advancements in these areas enable adaptability, scalability, resiliency, safety, security, and usability that expand the horizons of CPSS.

The goal of this Special Issue is to showcase state-ofthe-art research and applications in all aspects of machine intelligence, human intelligence, and cyber–physical–social intelligence, enabled by complex interactions of cyber, physical, and social spaces. For this Special Issue, 19 papers from 53 submissions have been selected for publication after a thorough peer review according to the standards of the IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS.

## II. A BRIEF SUMMARY OF PAPERS INCLUDED IN THIS SPECIAL ISSUE

In [A1], Theis and Darabi investigate the reachability graphs of underlying Petri net process models for masking the neural network of decay replay mining to increase the quality of next event predictions.

In [A2], Hare and Tang present a survey of research on modeling and adaptivity in serious games in the past ten years and offer perspectives and future research directions in this area.

In [A3], Kafeza et al. use behavioral analytics to model and process customer actions and address one of the most important problems in business, the relationship with the customers and more precisely the identification of loyal customers.

In [A4], Gao et al. propose an attention U-Net based on Bi-ConvLSTM (AUBC-Net) for accurate segmentation of medical images, which deals with the potential association between decoding features and encoding features by bidirectional convolution long short-term memory (LSTM).

In [A5], Xia et al. present a database named annotated facial landmarks for facial palsy (AFLFP) a diverse, and reliable database that contains facial images with 16-class facial expressions of asymmetric facial expressions from 88 subjects.

In [A6], Wang and Wang present a novel stochastic timed Petri net model to address the overcrowding issue in emergency departments (EDs). More specifically, an "observation-response" block is designed to observe the status of ED workflow and adjust resources accordingly. The simulation results verify the flexibility and effectiveness of the method in reducing patients' waiting time.

In [A7], Zhu et al. develop a framework to extract concise and effective decision trees (DT) from pretrained deep reinforcement learning (DRL) policies in traffic signal control tasks. The framework involves three steps. First, a DRL algorithm is used to learn a premium policy for traffic signal control. The policy then guides the data collection, based on which the DTs are derived. The simulation results show that the extracted DTs can generate human-understandable decision processes and provide explicit knowledge from the deep neural networks reference of the DRL.

In [A8], Lv et al. present a comprehensive review of behavioral modeling, learning, and adaptation applications of cyber–physical–social intelligent ecosystems from several domain areas, including intelligent transportation, healthcare, public service, economy, and social networking. The classification and discussions lay out a theoretical basis for future development in smart cities and social systems.

In [A9], Wang utilizes a hierarchical modeling process to present patient flow in a typical emergency department (ED). The focus is on resource requirements, resource sharing, and service duration for effective staffing that matches service demands. A stochastic-Petri-nets-based software tool is developed and proved to be effective in assisting the ED performance evaluation and staffing.

In [A10], Anand and Singh present a novel method for embedding a patient's ID card image with a system-encoded media access control (MAC) address, which uses discrete wavelet transform (DWT) to generate the final mark. It then utilizes redundant discrete wavelet transform (RDWT) and randomized singular value decomposition (RSVD) to embed the generated watermark into computed tomography (CT) scan images of the COVID-19 patient and general images. Extensive tests show that the proposed method outperforms the traditional schemes.

In [A11], Zhang et al. exploit a method for testing the robustness of neural networks (NNs) with nonmonotonic activation functions, called Swish. Specifically, utilizing the linear approximation technique, this approach turns the robustness verification problem into a constraint-solving problem. Furthermore, A prototype tool has been created for testing with open-source NNs. The experimental results show the effectiveness and efficiency of the proposed approach.

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In [A12], Fortino et al. develop a framework for a multiagent social internet of things (SIoT) architecture integrating a reputation system based on a clustering of SOs. Two SOs can interact to complete a transaction when a SO searches for a resource and finds a reliable partner who has that resource. And at the end of the transaction, each of them provides feedback about the partner to the edge server's local reputation system, which updates the SOs' reputation scores. Moreover, each edge server transmits these reputation scores to the cloud, which updates the related reputation values of the SOs based on experiences from all edge domains. This architecture allows a given object going from one edge domain to another to have its reputation value updated, as represented by the value stored in the cloud.

In [A13], Guo et al. devise a mixed integer linear programming mathematical model for U-shaped layout disassembly line balancing problems, in which the balance of workers' fatigue indices is an optimization objective in addition to disassembly profitability. The multiobjective evolutionary algorithm's collaborative resource allocation technique is used to provide an efficient solution to the problem. The linear programming solver CPLEX is used to test the model's accuracy and compare it to the suggested algorithm. Experiments show that the approach performs much better than the CPLEX solver in large-scale applications.

In [A14], Wani et al. design a technique based on artificial intelligence (AI) and deep learning (DL) to identify depressed persons on social media platforms. The model learns a convolutional neural network (CNN) and long shortterm memory (LSTM) models using hybrid feature-based behavioral-biometric signals recorded using Word2Vec, term frequency-inverse document frequency (TF-IDF) models. Significantly, this study's dataset is the first of its kind, containing a range of depressive signals from online social network (OSN) platforms such as Facebook, Twitter, and YouTube.

In [A15], Hameed et al. propose the first contactless British Sign Language (BSL) recognition system using radar and deep learning (DL) algorithms. In particular, the proposed system extracts the 2-D spatiotemporal features from the radar data and applies the state-of-the-art DL models to classify spatiotemporal features from BSL signs to different verbs and emotions, such as Help, Drink, Eat, Happy, Hate, and Sad. The system, built and tested on a largescale benchmark BSL dataset covering 15 different types of BSL signs, demonstrates the highest classification performance with a multiclass accuracy of up to 90.07% at a distance of 141 cm from the subject using the VGG (Visual Geometry Group) Very Deep Convolutional Networks (VGGNet) model.

In [A16], Islam et al. proposed an innovative framework for the human behavior-based personalized meal recommendation and menu planning social system. Specifically, the proposed framework includes a social-affective computing module to recognize the affects of different meals where the person's affect is detected using electroencephalography (EEG) signals. To predict affectivity a hierarchical ensemble method is applied upon multiple feature extraction methods and to generate a food list based on the predicted affectivity, a technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is exploited. The approach was experimentally successfully validated.

In [A17], Guo et al. present an autonomous behavioral decision framework for vehicular agents using cyber–physical–social intelligence. The control unit of a vehicular agent in a vehicular agent network includes a dynamic planning model with multiple objectives and constraints to be properly equipped with social intelligence. An iterative search algorithm and simulation modeling techniques are exploited to implement and execute such agent networks. The proposed method is compared with a universal baseline optimization search algorithm for demonstrating its efficiency.

In [A18], Rehman et al. present a framework named transparent, immutable, and secure vaccine supply chain (TISVSchain) based on (private and/or public) blockchain to handle the issues of counterfeited vaccines and vaccine supply chain problems like transparency, immutability, and traceability. TISVSchain improves the security of the vaccine supply chain by using offline unique account addresses in blockchain-based frameworks and improves the overall performance of the framework by keeping the gas cost low.

In [A19], Ahmed et al. focus on phrases used in personal remarks to solve recognizing grief on social media platforms. Specifically, the proposed research aims to develop generalized attention networks (GATs) that employ masked self-attention layers to overcome the depression text categorization problem. The experimental results show that the emotion lexicon combined with an attention network achieves receiver operating characteristic (ROC)-0.87 while staying interpretable and transparent. The approach was also validated by psychiatrists.

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#### APPENDIX: RELATED ARTICLES

- [A1] J. Theis and H. Darabi, "Improving predictive process monitoring through reachability graph-based masking of neural networks," *IEEE Trans. Computat. Social Syst.*, vol. 10, no. 4, pp. 1927–1938, Aug. 2023.
- [A2] R. Hare and Y. Tang, "Player modeling and adaptation methods within adaptive serious games," *IEEE Trans. Computat. Social Syst.*, vol. 10, no. 4, pp. 1939–1950, Aug. 2023.
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- [A13] X. Guo, T. Wei, J. Wang, S. Liu, S. Qin, and L. Qi, "Multiobjective U-shaped disassembly line balancing problem considering human fatigue index and an efficient solution," *IEEE Trans. Computat. Social Syst.*, vol. 10, no. 4, pp. 2061–2073, Aug. 2023.
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