

# Societies 5.0: A New Paradigm for Computational Social Systems Research

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**W**ELCOME to the first issue of the IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS (TCSS) for 2018, and Happy New Year to everyone. According to the Chinese lunar calendar, this is the year of the Dog, which in Chinese culture represents trust, loyalty, dedication, and energy. As such, I would like to take this opportunity to express my best wishes of a happy, healthy, and high-producing 2018 to each and every one of our readers, reviewers, and editors.

Let us first share some good news. Thanks to your continued support, we were very productive last year, and TCSS has been added to the Emerging Sources Citation Index (ESCI), which is a new edition of the Web of Science and includes important journals not yet selected for the Science Citation Index (SCI). Inclusion in ESCI is widely considered as an important and necessary step for a journal to be further evaluated and included in the SCI database. Therefore, I view this as an important step to our task of rejuvenating TCSS, and also a big milestone in our roadmap to a SCI-indexed top journal in the field.

As we announced in the previous issue, we had planned to move to a bimonthly publication with six issues and a page budget of 1200 in 2018. However, we have been informed that TCSS has already been advertised as four issues this year, as stated in the 2018 IEEE Subscription Price List, so we have to keep the original publication frequency but with the new page budget. As such, we are able to publish 24 papers in this issue.

During the last several months, six special issue proposals have been received and approved by the TCSS editorial board, and we now have altogether five special issues soliciting papers from several interesting and emerging research fields related to computational social systems. The titles of these special issues are listed as follows, and we welcome your submissions to the special issues.

- “Integrating Social Networks With IoT Solutions”  
Submitted by Prof. Jun Zhang from the University of Denver, USA
- “Parallel and Distributed Processing for Computational Social Systems”  
Submitted by Prof. John Korah from Illinois Institute of Technology, USA
- “Augmenting Urban Brain With Visual and Social Intelligence”  
Submitted by Prof. Wei Chen from Zhejiang University, China

- “Blockchain-Based Secure and Trusted Computing for IoT”

Submitted by Prof. Shancang Li from the University of the West of England, UK

- “Computational Social Science for Public Policy and Citizen Wellbeing”

Submitted by Prof. Jonathan Zhu from the City University of Hong Kong, China

## Scanning the Issue

1. A Collaborative Citizen Science Platform for Real-Time Volunteer Computing and Games

*Poonam Yadav, Ioannis Charalampidis, Jeremy Cohen, John Darlington, and Francois Grey*

Considering the potentials of volunteer computing (VC) in undertaking large-scale scientific computing tasks, this paper introduces three tools including the Virtual Atom Smasher (VAS) game, a job distribution middleware named LiveQ, and an online platform CitizenGrid for hosting and providing computation to citizen cyber-science projects, and provides details of their integration process along with further potential usage scenarios for the resulting platform. This integration demonstrates the combining of VC and volunteer thinking to help address the scientific and educational goals of games like VAS.

2. An Adaptive Intelligent Management System of Advertising for Social Networks: A Case Study of Facebook

*Jose Aguilar and Gerardo Garcia*

With the wide use of social networks, social network advertising becomes more and more popular, which makes it a great challenge to optimize the production of advertising on social networks based on the performance of the ads. In this paper, an intelligent system of management of social network advertising based on the performance of the ads is presented, to automatically produce ads based on data mining techniques. The adaptive mechanism of automated production (generation) of online advertising is tested on Facebook, and the results show that the proposed system can carry out automatic modifications and improvements of ads.

3. Social Flocks: Simulating Crowds to Discover the Connection Between Spatial–Temporal Movements of People and Social Structure

*Cheng-Te Li and Shou-De Lin*

Based on the crowd simulation technique, an agent-based framework, Social Flocks, is designed to model the geospatial correlation of social elements. The movements of people are stimulated to tackle two tasks, that is, social networking generation and network community detection; and the social

moving behaviors of agents/nodes are stimulated to study the formation of communities given a social network. Experiments have verified that Social Flocks can serve as a visualization platform for experts to explore the effects over the spatial, temporal, and social contexts. Through demonstrating how the simulation models are exploited to address social network problems, this paper encourages more studies on this direction.

#### 4. Identifying Users With Alternate Behaviors of Lurking and Active Participation In Multilayer Social Networks

*Diego Perna, Roberto Interdonato, and Andrea Tagarelli*

This work leverages the importance of studying the dichotomy between information producers (contributors) and information consumers (lurkers), and their interplay over a multilayer network, in order to effectively analyze such different roles a user may take on different online social networks (OSNs). The novel problem of identification and characterization of opposite behaviors that users may alternately exhibit over multiple layers of a complex network is addressed. Moreover, a ranking method is proposed for alternate lurker-contributor behaviors on a multilayer OSN, named mlALCR. Performance of mlALCR has been assessed quantitatively and qualitatively, and empirical evidence shows the significance and uniqueness of mlALCR mining alternate lurker-contributor behaviors over different layer networks.

#### 5. Social Network Analysis of Cricket Community Using a Composite Distributed Framework: From Implementation Viewpoint

*Sarbani Roy, Paramita Dey, and Debajyoti Kundu*

This work proposes an alternate ranking system based on social network metrics and their evaluation in a composite distributed framework. The main contributions of this paper are twofold: analysis of cricket community from the viewpoint of social network and finding ranking of players and countries based on the properties of graph centrality measures. The paper proposes a comprehensive distributed framework to offer infrastructural support for the large data analysis as well as graph processing. Using a practical case study of social network analysis of cricket community, this paper captures the significance of the alternate ranking in this sport as well as shows effectiveness of the proposed framework in the process of analyzing large network.

#### 6. Forecasting Civil Unrest Using Social Media and Protest Participation Theory

*Congyu Wu and Matthew Gerber*

The ways in which online activism shapes offline behavior during civil uprisings are highlighted. Predictor variables for individuals' protest decisions are derived from the literature on protest participation theory, and then be tested on the case of Twitter and the 2011 Egyptian revolution. Some significant positive correlations between the volume of future-protest descriptions and protest onsets are discovered. Based on the results, predictive models are built and compared with baselines informed by daily event counts. Finally, inspection of the significant variables in the proposed predictive models reveals that an increased military presence may be predictive of protest onsets in major cities.

#### 7. Identification and Analysis of Driver Postures for In-Vehicle Driving Activities and Secondary Tasks Recognition

*Yang Xing, Chen Lv, Zhaozhong Zhang, Huaji Wang, Dongpu Cao, Efsthios Velenis, and Fei-Yue Wang*

The consumer range camera Kinect is used to monitor drivers and identify driving tasks in a real vehicle, and seven common driving tasks are identified in this study. Those tasks are divided into safe, dangerous, and distracting driving. The driver behaviour signals collected from the Kinect consist of a color and depth image of the driver inside the vehicle cabin. Moreover, 3-D head rotation angles and the upper body joint positions are recorded. Then, the importance of these features to behavior recognition is evaluated, and a Feedforward Neural Network is used to identify the seven tasks. Finally, the model performance is evaluated with different features. Final detection result showed an average of greater than 80% accuracy, and the tasks detector is proved to be an efficient model that can be implemented for real-time driver distraction and dangerous behavior recognition.

#### 8. Social Relevance Feedback Based on Multimedia Content Power

*Klimis Ntalianis, Anastasios D. Doulamis, Nicolas Tsapatsoulis, and Nikolaos Mastorakis*

A novel social media relevance feedback algorithm based on multimedia content power (MCP) is proposed, which estimates the similarity measure in a recursive manner. To accomplish this, a set of relevant/irrelevant samples provided by the user for adjusting the system's response is used. Especially, the similarity measure is expressed in a parametric form of functional components. The estimation of MCP is innovative as well, which measures the influence of files over social media users. Both of the visual characteristics of multimedia files and their influence to retrieve information are taken into consideration in the algorithm, and the results show that the proposed scheme offers several merits.

#### 9. Sentinel: A Co-Designed Platform for Semantic Enrichment of Social Media Streams

*Alun Preece, Irena Spasić, Kieran Evans, David Rogers, William Webberley, Colin Roberts, and Martin Innes*

A Sentinel platform supporting semantic enrichment of streamed social media data is introduced for the purposes of situational understanding, which was iteratively developed through a series of pilot studies. Based on a knowledge-based approach, the platform can well interpret the processed media under the 5W framework. The conceptual architecture for the platform is also presented, and the design and implementation challenges of the underlying stream-processing system are discussed. The strengths and importance of the co-design approach are highlighted, and the promising areas are indicated for future research.

#### 10. Control of Message Transmission in Delay/Disruption Tolerant Network

*Yahui Wu, Su Deng, and Hongbin Huang*

Two steps (beaconing and forwarding) are included in the store/carry/forward mode of transmission process for messages in Delay/Disruption Tolerant Network (DTN), and both the beaconing control and the forwarding control are important in the controlling process. Considering the two steps at the

same time in DTN, this paper established an optimal control model to deal with the case with multiple destinations. The analysis of the model shows that both the optimal forwarding and beaconing policies conform to the threshold form. Results in a real scenario showed that the optimal policy can improve the performance.

#### 11. Structure of Crowdsourcing Community Networks

*Khobaib Zaamout and Ken Barker*

As an important issue in targeted social networking, crowdsourcing becomes popular and has attracted more and more attention of researchers, which makes it possible to study the emerging communities to standardize and facilitate the crowdsourcing process. This paper studies the structure of a number of crowdsourcing communities and various properties of association and interaction (INTR) networks, and compares them with existing networks such as OSNs and the World Wide Web network. The study reveals that CC networks are smaller and less symmetrical than OSNs, and the degree distributions of CC networks follow power-law distribution. Moreover, members of CC networks tend to connect to others with varying degrees.

#### 12. Temporal Matrix Factorization for Tracking Concept Drift in Individual User Preferences

*Yung-Yin Lo, Wanjiun Liao, Cheng-Shang Chang, and Ying-Chin Lee*

Time-varying issue of individual user preferences is considered, and a temporal matrix factorization approach is developed for this issue. The proposed approach is tested with a synthetic data set and several real data sets, and the experimental results show that the proposed temporal method is able to achieve lower root mean square errors for both the synthetic and real data sets, and for the synthetic data set and the Ciao data set, there are quite a few users with that property and the performance gains for these two data sets are roughly 20% and 5%, respectively.

#### 13. Semi-Supervised Spam Detection in Twitter Stream

*Surendra Sedhai and Aixin Sun*

This paper proposes a Semi-Supervised Spam Detection (S3D) framework for spam detection at tweet-level. The proposed framework consists of two main modules: spam detection module operating in real-time mode, and model update module operating in batch mode. The spam detection module consists of four lightweight detectors, and the information required by it is updated in batch mode based on the tweets that are labeled in the previous time window. Experiments on a large scale dataset are conducted, and the results show that the framework adaptively learns patterns of new spam activities and maintain good accuracy for spam detection in a tweet stream.

#### 14. A General Cognitive Architecture for Agent-Based Modeling in Artificial Societies

*Peijun Ye, Shuai Wang, and Fei-Yue Wang*

Artificial Society is an analytical foundation of various complex eco- and social systems. This paper proposes a general cognitive architecture that attempts to adapt all the aspects of agent's decision making in artificial societies, so that different programs and software can be reorganized and

integrated conveniently. To illustrate its implementation, two simulations—emergent evacuation and population evolution—are conducted. These tests clearly show that the proposed architecture is able to support different agent-based models. Problems that might be encountered, as well as possible strategies, are also proposed in the end.

#### 15. Modeling Social Resilience in Communities

*Eunice E. Santos, Eugene Santos, Jr., John Korah, Jeremy E. Thompson, Yan Zhao, Vairavan Murugappan, and Jacob Russell*

This paper proposed a computational framework for formulating multiple resiliency functions, to deal with the challenges of modeling the social resilience of communities, and validated it by modeling the resilience of a fishing community in Somalia over the period of 1999–2012. Resiliency functions are formulated to computationally model the competing support for the community's traditional occupation of fishing and alternatively for taking up piracy on the high seas. Also, an overall resiliency function is provided by combining individual resiliency functions and risk theory. The proposed framework is that it can provide the ability to use social theories to compose the individual resiliency functions into an umbrella resiliency function, and it can also provide qualitative analysis.

#### 16. Social Influence Makes Self-Interested Crowds Smarter: An Optimal Control Perspective

*Yu Luo, Garud Iyengar, and Venkat Venkatasubramanian*

It is very common to observe crowds of individuals solving similar problems with similar information in a largely independent manner. This paper argued that crowds can become "smarter," which runs counter to the widely accepted claim that the wisdom of crowds deteriorates with social influence. This paper proposed a control-theoretic methodology to compute the degree of social influence, conducted an experiment with human subjects, and the experiment results showed that the crowd self-organized into a near-optimal setting. Moreover, a case study was also provided to show how a crowd of states potentially could collectively learn the level of taxation and expenditure that optimizes economic growth.

#### 17. Automatic Detection of Video Shot Boundary in Social Media Using a Hybrid Approach of HLFPN and Keypoint Matching

*Rong-Kuan Shen, Yi-Nan Lin, Tony Tong-Ying Juang, Victor R. L. Shen, and Soo Yong Lim*

Shot boundary detection (SBD) is an important and fundamental step in video content analysis such as content-based video indexing, browsing, and retrieval. This paper presented a hybrid SBD method by integrating a high-level fuzzy Petri Net (HLFPN) model with keypoint matching. The HLFPN model with histogram difference is executed as a predetection, and the speeded-up robust features algorithm utilizing a top-down design figure out all possible false shots and the gradual transition based on the assumption from the HLFPN model. The proposed approach has the ability to increase the precision of SBD and can be applied in different types of videos.

#### 18. A Model for Decision Making Under the Influence of an Artificial Social Network

*Alex Cassidy, Eric Cawi, and Arye Nehorai*

Decision making and the social processes that influence it are of great importance to many problems. This paper considered how the social processes can influence the decision making of people, and established a model for it using modern information technology and social networks. Specifically, it researched the use of artificial social networks to make influential users that are desirable to society as a whole. The results showed that the proposed methodology has the potential to move the equilibrium of a system to a more desirable state, and the degree of the improvement depends on the mathematics of the decision being made.

#### 19. Efficient Community-Based Data Distribution Over Multicast Trees

*Stavros Souravlas and Angelo Sifaleras*

Community detection is an important issue in designing algorithms for delay-tolerant networks (DTNs). This paper detected communities in weighted networks with irregular topologies. Based on communities, an efficient data distribution algorithm for DTNs is proposed. The distribution strategy is based on the construction of a number of multicast trees, where each tree can be used to select the best relay node for each target to improve multicast efficiency. The proposed strategy provided better delivery ratio compared with other strategies and it reduced latencies when multiple nodes from a community need to multicast to other community members.

#### 20. Parallel Crime Scene Analysis Based on ACP Approach

*Shuai Wang, Xiao Wang, Peijun Ye, Yong Yuan, Shuo Liu, and Fei-Yue Wang*

Crime scene analysis is a retrospective process from traces to psychology and physiology. This paper proposed the parallel crime scene analysis system based on the artificial societies, computational experiments and parallel execution (ACP) approach, which uses artificial (A) crime scene to describe the basic elements, functions and states of the criminals, computational (C) experiments to compute and predict the different forms of crime scene, and parallel (P) execution to guide or control the evolution of the physical crime process in accordance with the results from the artificial crime scene. The ACP approach sheds light on the intelligent management and control for complex crime scene analysis.

#### 21. Temporal Dynamics of Information Diffusion in Twitter: Modeling and Experimentation

*Eleni Stai, Eirini Milaiou, Vasileios Karyotis, and Symeon Papavassiliou*

By exploiting information dissemination and using real data, this paper studied the temporal dynamics of topic-specific information spread in Twitter, assuming that each topic corresponds to a hashtag. An epidemic model for information spread in Twitter is developed and validated using real data for several hashtags chosen so as to cover a variety of characteristics. The evaluation results indicated a satisfactory performance of the proposed epidemic model for all hashtag types examined; while, more importantly, they allow studying the impact of several factors, such as the need of time-varying infection rates depending on the hashtag type.

#### 22. Information Diffusion on Social Media During Natural Disasters

*Rongsheng Dong, Libing Li, Qingpeng Zhang, and Guoyong Cai*

This paper used two earthquakes in China as the social context in Sina Weibo. A formalized Weibo Information Flow model was proposed to represent the information spreading. Then, the information spread from three main perspectives was studied. The result shows: 1) the shadow of the Dunbar's number is evident in the "declared friends = followers" distributions, and the number of each participant's friends/followers show the typical power-law distribution; 2) an individual's number of followers is the most critical factor in user influence and strangers are very important forces for disseminating real-time news; and 3) two types of real INTR networks share the scale-free and small-world property, but with a looser organizational structure.

#### 23. Agent-Based Modeling of Emergency Evacuations Considering Human Panic Behavior

*Ashutosh Trivedi and Shrisha Rao*

This paper presented an agent-based model considering psychological and physical factors that cause panic in life threatening situations. Some simple evacuation scenarios were simulated, and a method of identifying possible bottlenecks and shortcomings in the environments during emergency evacuations was presented, which could also help in evaluation and analysis of different evacuation strategies. To enable such analysis, a rule-based roadmap approach was used. Different strategies were evaluated on parameters such as evacuation time and physical discomfort caused to the agents.

#### 24. Motivational Psychology Driven AC Management Scheme: A Responsive Design Approach

*Wayes Tushar, Chau Yuen, Wen-Tai Li, David B. Smith, Tapan Saha, and Kristin L. Wood*

This paper aimed at designing energy management mechanisms for buildings that encourage users' acceptance of the technology for increased environmental sustainability, particularly focused on the design of an energy management technique for the air-conditioning (AC) systems in residential buildings that considers users' views on how they use such technology. First, some motivational psychology literatures were synthesized. Then, the obtained insights from various motivational models are incorporated into the design of an energy management scheme. Finally, some experiment results were provided to illustrate how the designed energy management mechanism validated the motivational psychology models.

### ***Societies 5.0: A New Paradigm for Computational Social Systems Research***

In 1954, Hsue-shen Tsien published his famous "Engineering Cybernetics" [1] which laid the foundation for today's control engineering and control theory. He started the book with such a brief statement in the preface "The celebrated physicist and mathematician A. M. Ampère coined the word *cybernétique* to mean the science of civil government (Part II of "Essai sur la philosophic des

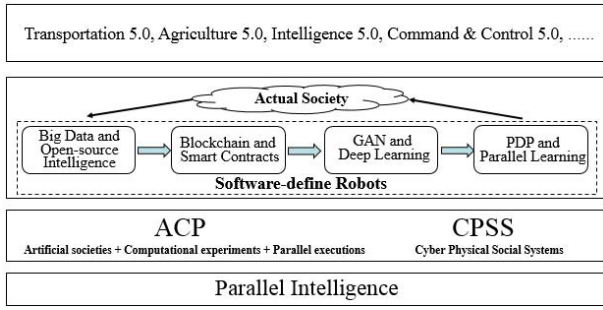


Fig. 1. Research Framework of Societies 5.0.

sciences” 1845, Paris), Ampère’s grandiose scheme of political sciences has not, and perhaps never will, come to fruition.”

The statement is quite true throughout the entire 20th century. But now as the development of information technology promoted the emergence of Big Data technologies, the cloud computing technology provided large calculation force, and the pervasive use of mobile smart devices played important roles in guiding people’s behaviors, the modeling and management of super complex systems such as our society becomes possible. Although the uncertainty, diversity, and complexity of human behavioral characteristics introduced new questions and challenges, we believe that all kinds of complex societal systems can be modeled and studied through the ACP approach [2], and thus proposed the concepts of societies 5.0 in 2015 [3].

After tremendous advancement in mechanization, electrification, information and network technology, modern society has entered a new era of technology development, the parallel age of virtual–real dual intelligence technology. Correspondingly, our society is moving from machine society (Societies 1.0), electric society (Societies 2.0), information society (Societies 3.0), and network society (Societies 4.0) into its fifth paradigm: the parallel society or Societies 5.0, where parallel intelligence will be its defining features.

We can summarize the key idea and research framework of Societies 5.0 in Fig. 1. The fundamental theory of Societies 5.0 research is parallel intelligence, which is a novel methodology that extends the traditional artificial intelligence theories to the emerging cyber-physical-social systems (CPSS) [4]. More specifically, parallel intelligence is particularly effective in dealing with “human-in-the-loop” type issues with both social complexity and engineering complexity, and aims at seeking agile, focused, and convergent solutions to these uncertain, diversified, and complex issues. Parallel intelligence represents the paradigm shift from the traditional research perspective of Newton systems to the self-enforcing and self-fulfilling Merton systems, yielding large numbers of small and specific laws based on big data, rather than big and universal laws based on “small data” [5].

ACP and CPSS are two keys in Societies 5.0 research [6], [7]. In the “A” part of the ACP approach, the real-world societal system will be modelled and analyzed.

We hypothesize that we can also establish one or more artificial societal systems. Based on these co-evolving actual and artificial societal systems, we can design and conduct diversified computational experiments in the “C” part to evaluate and verify specific behavior, mechanisms, and strategies involved in the societal systems. These experiments can be designed as “what-if” type of scenario inference and simulation, based on the predefined “if-then” rules. The optimal solution will emerge in large numbers of computational experiments, and in the “P” part as feedback to actual societal systems. This “A-C-P” step will repeat infinitely, and it will lead the actual societal system eventually approximating its optimal artificial counterparts.

The CPSS approach is particularly suitable to study Societies 5.0 which features uncertainty, diversity, and complexity. In traditional “Newton systems” with little to no need of considering human or social factors, the outputs can be precisely predicted given the inputs. However, in CPSS-oriented “Merton” societal systems, human, information, and machines are equally integral, resulting in a hybrid intelligence society where endogenous and complicated human factors including behavior and mentality will definitely influence the outputs, given the same inputs. As such, rather than simply “command and control,” we need to actively guide the co-evolution of actual–artificial societal systems based on descriptive modeling and predictive experimentations. That is, we need descriptive, predictive, and prescriptive, intelligence, which is the key idea in CPSS approach representing descriptive intelligence, predictive intelligence, and prescriptive intelligence, respectively.

The key techniques of Societies 5.0 follow the idea of knowledge automation [8], [9], which is a direction for further development of Artificial Intelligence technology and a general framework for dealing with management and control of CPSS type societal systems. A series of techniques are integrated into one or more software-defined robots in order to fulfill the typical work-flow of processing societal knowledge. For instance, big data analytics and open-source intelligence can be used to collect and preprocess social signals [10]; the emerging blockchain and smart contracts can be used in modeling and validating societal systems [11]–[15]; Generative Adversarial Networks and deep learning can be used in computational experiments and the result analysis [16], [17]. Finally, Parallel Dynamic Programming (PDP) and parallel learning can be used in knowledge implementation and feedback [18], [19]. Due to page limit, we omit the details and interested readers can refer to the references.

Societies 5.0 is a novel paradigm in studying computational social systems, and has been applied in Qingdao Academy of Intelligent Industries as a pilot project to study various aspects of the parallel societies with success, such as Transportation 5.0, Agriculture 5.0, Intelligence 5.0, Command and Control 5.0, and so on. We hope Societies 5.0 will play an important role in future research of computational social systems, and warmly welcome interested researchers to cooperate in this emerging field to move us forward to the coming parallel societies.

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He joined the University of Arizona, Tucson, AZ, USA, in 1990, where he became a Professor and the Director of the Robotics and Automation Laboratory and the Program in Advanced Research for Complex Systems. In 1999, he founded the Intelligent Control and Systems Engineering Center, Institute of Automation, Chinese Academy of Sciences (CAS), Beijing, China, under the support of the Outstanding Overseas Chinese Talents Program from the State Planning Council and "100 Talent Program" from CAS. In 2002, he joined the Laboratory of Complex Systems and Intelligence Science, CAS, as the Director, where he was the Vice President for Research, Education, and Academic Exchanges with the Institute of Automation from 2006 to 2010. In 2011, he was the State Specially Appointed Expert and the Director of the State Key Laboratory for Management and Control of Complex Systems, Beijing. His current research interests include methods and applications for parallel systems,

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