Social Computing: From Crowdsourcing to Crowd Intelligence by Cyber Movement Organizations

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WELCOME to the fourth issue of the IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS (TCSS), which includes 16 regular papers and a brief discussion on social computing. We would also like to inform you that IEEE will conduct its regular 5-year review for TCSS at its TAB meeting in November at Boston. Any suggestions for our review report are welcome!

Scanning the Issue

1. Cross-Cultural Studies Using Social Networks Data
Issa Annamoradnejad, MohammadAmin Fazli, Jafar Habibi, and Sadjad Tavakoli

This paper proposes a framework to calculate cultural distance among several countries using the information and cultural features extracted from social networks. The framework estimates the distribution of news-oriented tweets for each nation and computes the cultural distance from these sets of distributions. Based on a sample composed of more than 17 million tweets from late 2017, the proposed framework calculated the cultural distance between 22 countries. Their results show a positive correlation between cultural distances computed by the proposed framework and distances computed by Hofstedes cultural scores and also identified connections between some of the cultural features.

2. Fusing Behavioral Projection Models for Identity Theft Detection in Online Social Networks
Cheng Wang, Bo Yang, Jipeng Cui, and Chaodong Wang

This paper investigates whether there is a complementary effect among different dimensions of records for modeling user's behavioral patterns. They focus on three typical dimensions of behaviors in online social networks (OSNs) and devise the dedicated behavior models based on each dimension of data. By examining all the feasible logical combinations, they find the optimal ones for two real-world data sets: Foursquare and Yelp. They also analyze the potential correlation between customized demand and optimal logical fusion scheme and find that the correlation is independent of the specific data. This study would give the cybersecurity community new insights into the possibility and methodology to achieve a customized identity theft detection in OSNs by integrating multiple behavioral projection models.

3. PSO-ANE: Adaptive Network Embedding With Particle Swarm Optimization
Jinyin Chen, Yangyang Wu, Xuanheng Xu, Haibin Zheng, Zhongyuan Ruan, and Qi Xuan

This paper proposes an adaptive network embedding algorithm with particle swarm optimization (PSO-ANE), which is based on the second-order dynamic random walk and PSO method to learn network representations. A second-order dynamic random walk is designed to search a suitable strategy for each node based on the structure-based transition probability, the centrality-based transition probability, and the static link weights. To reduce the parameter dependence, PSO is adopted for key-parameter optimization to get global steady network embedding. The experiments validate that the proposed method outperforms the existing state-of-the-art techniques on multi-label classification, multiclass classification, and link prediction tasks.

4. A Unified Framework of Epidemic Spreading Prediction by Empirical Mode Decomposition-Based Ensemble Learning Techniques
Yun Feng and Bing-Chuan Wang

This paper proposes a unified susceptible-exposed-infected-susceptible-aware framework to combine the epidemic spreading process with individual's self-query behaviors on the Internet. An epidemic spreading prediction model that contains two phases is established based on the proposed framework. First, it is decomposed through the empirical mode decomposition method to obtain the intrinsic mode functions. Second, the ensemble learning techniques that use the self-query data as an external input are applied to these intrinsic mode functions. An empirical study on the prediction of weekly consultation rates of hand-foot-and-mouth disease in Hong Kong is conducted, and the results show that the proposed method outperforms other learning methods on fluctuating complex epidemic spreading data.

5. Impact of Social Network Structures on Uncertain Opinion Formation
Min Zhan, Haiming Liang, Gang Kou, Yucheng Dong, and Shui Yu

This paper introduces a model for uncertain opinion formation in social networks under bounded confidence to investigate the impact of social network structures on uncertain opinion formation by the simulation experiments analysis. Simulation results show that: 1) larger agents scales will yield the smaller ratios of agents expressing the uncertain

Digital Object Identifier 10.1109/TCSS.2019.2930420

opinions and larger average widths of uncertain opinions; 2) the average stable time starts increasing and then decreases with the increase in the network connected probabilities; and 3) larger network connected probabilities will yield fewer opinion clusters and the smaller average ratios of the extremely small clusters in all clusters. The obtained results are helpful for the government and relevant management departments to understand and manage uncertain public opinion evolution effectively.

6. Editorial Versus Audience Gatekeeping: Analyzing News Selection and Consumption Dynamics in Online News Media
Abhijnan Chakraborty, Saptarshi Ghosh, Niloy Ganguly, and Krishna P. Gummadi

In traditional news media organizations, a small number of expert editors are responsible for selecting news stories that are consumed by all news readers (the audience). However, with the growing popularity of social media as a news consumption medium, a part of the editorial power of selecting news stories has shifted to the audience who select and share the stories that can reach a large number of consumers. In this paper, the authors analyze the data from two popular news media sites, *The New York Times* and *The Guardian*, and characterize the considerable differences in the types of stories selected by the audience and expert news editors. They also find that story selections by audience vary significantly across different social media channels such as Twitter, Facebook, and email. They contextualize the differences utilizing media and communication theory and discuss their implications for news readers and media organizations.

7. Analysis of Hospitalizing Behaviors Based on Big Trajectory Data
Yongdong Wang, Dongwei Xu, Peng Peng, Qi Xuan, and Guijun Zhang

With the improvement of living standards, people pay more attention to health, which is significant to analyze peoples hospitalizing behaviors. The wide use of mobile devices generates a great deal of data, which contains a lot of travel information about residents. Many people would like to see a doctor through calling an online car hailing for its convenience. Thus, based on big trajectory data generated by the online car hailing, the hospitalizing behaviors of residents are analyzed in this paper. The hospitalizing behaviors are analyzed from two aspects. One is performed from the temporal aspect, in which the daily numbers of trips of hospitalizing behaviors under different modes are analyzed. The other one is performed from the spatial aspect, in which the hot hospitals, popularity, and gravity distribution of hospitals are analyzed. Based on the spatial analysis, the network constructed by the hot hospitals is also analyzed. The results show that the hospitalizing behavior analysis can reflect the hospitalizing behaviors in detail, which can make contributions to the decision-making of infrastructure configuration for institutions, such as urban planning departments and hospitals.

8. A Second-Order Diffusion Model for Influence Maximization in Social Networks
Wenyi Tang, Guangchun Luo, Yubao Wu, Ling Tian, Xu Zheng, and Zhipeng Cai

In social networks, several influential individuals can promote an idea or a product to numerous individuals. Thus, it is valuable to solve the influence maximization (IM) problem, which asks for finding the most influential set of individuals in a social network. To estimate the influence of individuals, the existing independent cascade (IC) model simulates the influence diffusion only considering the influences from direct in-neighbors to nodes. This consideration does not hold in real life. In many cases, people are likely influenced by information depending on where it comes from, instead of who gives it. To simulate the influence diffusion more accurate, this paper proposes the second-order IC model, which takes the previous influence into consideration. In addition, the authors design an approximate algorithm and its distributed extension for IM under the second-order IC model. Experimental results show that the proposed second-order IC model outperforms the IC model in terms of simulating influence diffusions. The proposed algorithms are efficient, and the obtained node sets are influential.

9. MPURank: A Social Hotspot Tracking Scheme Based on Tripartite Graph and Multimessages Iterative Driven
Yunpeng Xiao, Haiyang Yu, Qian Li, Ling Liu, Ming Xu, and Hanchun Xiao

This paper proposes a social hotspot tracking scheme termed MPURank, which is based on tripartite graphing and a multimessage-driven iterative method. First, the topic is regarded as a network of simultaneous multimessage dissemination, and retweeting topology graphing is used to determine the propagation path; then, a topic tripartite graph is established to elucidate the interrelationship among the nodes of messages, paths, and users. Second, an iterative scoring algorithm based on hyperlink-induced topic search (HITS) is proposed to rank the key elements based on the tripartite graph. This algorithm circumvents the influence of the multimessage network and propagation path on the evolution of public opinion, overcoming the issues of node attributes and topics, and the influence of multimessage and multipath complexity in source tracing, thus identifying the key elements. Finally, they conducted an experiment based on real world data, which verifies the utility of the algorithm.

10. Assessing Refugees' Integration via Spatio-temporal Similarities of Mobility and Calling Behaviors
Antonio Luca Alfeo, Mario G. C. A. Cimino, Bruno Lepri, Alex Sandy Pentland, and Gigliola Vaglini

This paper proposes a set of metrics aimed at providing insights and assessing the integration of Syrians refugees, by analyzing a real-world call details records (CDRs) data set including calls from refugees and locals in Turkey throughout 2017. Specifically, they exploit the similarity between refugees and locals spatial and temporal behaviors, in terms of communication and mobility in order to assess integration dynamics. They use a novel computational approach to analyze spatio–temporal patterns: Computational Stigmergy, a bioinspired scalar and temporal aggregation of samples. Computational Stigmergy associates each sample to a virtual pheromone deposit (mark). Marks in spatiotemporal proximity are aggregated into functional structures called trails, which summarize the spatiotemporal patterns in data and allows computing the

similarity between different patterns. Their results show that collective mobility and behavioral similarity with locals have great potential as measures of integration.

11. New Blockchain-Based Architecture for Service Interoperations in Internet of Things

Wattana Viriyasitavat, Li Da Xu, Zhuming Bi, and Assadaporn Sapsomboon

The Blockchain technology (BCT) and relevant smart contracts have been introduced recently to provide the trusts of data and process executions, and the authors argue that BCT would be the vital mechanism that leads to the successes of the Internet of Things (IoT) services, but only BCT is not enough to overcome all of challenges. This paper discusses the interoperability of IoT services and the challenges and proposes an architecture solution by integrating BCT, service-oriented architecture (SoA), and enablers of key performance indicators (KPIs) and service selections. The proposed architecture aims to solve both interoperability and trust issues for IoT services. The feasibility of the proposed method is validated by the examples of smart contract implementations.

12. MultiSpectralNet: Spectral Clustering Using Deep Neural Network for Multi-View Data

Shuning Huang, Kaoru Ota, Mianxiong Dong, and Fanzhang Li

This paper proposes MultiSpectralNet (MvSN), a deep learning approach to spectral multi-view clustering, provides mapping multi-view data points to their fusion eigenvectors, and can obtain a more accurate data structure by correcting the misleading information in the single views to a certain extent by feedback in the network training process. In addition, the proposed model can cluster large multi-view data sets and provide cluster prediction for out-of-sample-extension. The authors test unsupervised clustering accuracy (ACC) and normalized mutual information (NMI) of their method in clustering several artificial and real-world data sets, and the experimental results show that their method outperforms conventional compared state-of-the-art works.

13. Tweet Summarization of News Articles: An Objective Ordering-Based Perspective

Roshni Chakraborty, Maitry Bhavsar, Sourav Kumar Dandapat, and Joydeep Chandra

Existing methods primarily attempt to identify a set of relevant tweets from which the summary tweets are selected that maintains the diversity and coverage requirements. However, the noise and the nontemporal behavior of the article-specific tweets make the identification of such relevant tweets extremely difficult, resulting in poor summary quality. Through empirical investigations, this paper shows that initially identifying the diverse opinions can lead to better identification of the relevant tweets, i.e., following a specific ordering of the objectives can lead to improved summary. The authors propose a tweet summarization technique that follows such a specific ordering. The validation of the proposed approach for 800 news articles with 2.1 billion related tweets shows that the proposed approach produces 11.6%–34.8% improvement in summary quality as compared to the existing state-of-the-art techniques.

14. Interactional Moral Systems: A Model of Social Mechanisms for the Moral Regulation of Exchange Processes in Agent Societies

Antônio Carlos da Rocha Costa and Helder Manuel Ferreira Coelho

This paper first introduces the concepts of moral agent, moral system of agent society and, in particular, the central concept of moral agent sensible to moral sanction. Next, it introduces the concepts of moral gain and moral loss in social exchanges, and of reputation-based persistence of exchange processes. Following, the authors elaborate the notion of negotiated moral regulation of reputation-based persistent exchange processes. Finally, they combine those concepts in the notion of a reputation-based mechanism for the negotiation-driven moral regulation of exchange processes of agents that are sensible to moral sanctions.

15.A Novel Scene of Viral Marketing for Complementary Products

Jianxiong Guo and Weili Wu

This paper designs a multi-layer network model under IC model to adapt to multiple complementary products and define the seed selection problem for complementary products model (IMCP) and composite complementary products model (IMCCP) under knapsack constraint. Two efficient techniques are proposed to solve IMCP problem, called Greedy and General-TIM. The Greedy uses simple greedy Hill-climbing algorithm under knapsack constraint, and get $(1/2)(1-(1/e))$-approximation, but the time complexity is hard to accept. The second algorithm, General-TIM, forms a weighted set cover problem by means of randomized sampling, which reduces the time consuming significantly. For IMCCP problem, it is difficult to handle with because no ready-made algorithms exist to optimize a function that is nonsubmodular and nonsupermodular. Then, the authors get help from sandwich method by finding upper and lower bounds. Finally, the correctness of the proposed algorithms is evaluated on several real data sets.

16. Anonymization in Online Social Networks Based on Enhanced Equi-Cardinal Clustering

Madhuri Siddula, Yingshu Li, Xiuzhen Cheng, Zhi Tian, and Zhipeng Cai

This paper considers data privacy on online social networks at the network level rather than the user level. This network level privacy helps users to prevent information leakage to third-party users like advertisers. A novel scheme is proposed that combines the privacy of all the elements of a social network: node, edge, and attribute privacy by clustering the users based on their attribute similarity. The authors use an enhanced equi-cardinal clustering as a way to achieve k-anonymity; and they further improve k-anonymity with l-diversity. The proposed enhanced equi-cardinal clustering ensures that there are at least k users in any given network as well as the attributes in each cluster have at least l-distinct values. They further provide proofs on how the proposed equi-cardinal clustering ensures k-anonymity and the maximum information loss. With the help of two real-world data sets, the proposed method in terms of privacy and efficiency is evaluated.

Social Computing: From Crowdsourcing to Crowd Intelligence by Cyber Movement Organizations

Origin and Goals in History

The idea of modern social computing can be traced back to Vannevar Bush's seminal work in 1945. In his inspiring article "As we may think", a communication device to associate and enhance human memory and collaboration capacity named "memex" is proposed [1]. Douglas Englebart, who created the first hypermedia online system, published a report named "Augmenting human intellect: A conceptual framework" in 1962, which pointed out that all computing technologies must be integrated into the science of psychology and organizational development [2]. In 1968, J.C.R. Licklider outlined the methods of computer-aided group collaboration and identified the concept of Computer as a Communication Device with Robert Taylor [3]. All of these great ideas, visions, platforms, and systems were the sources of innovations of the Internet, Worldwide Web, and Social Computing. Although the term of social computing was never mentioned in the original literature of their era, the prospect of the computing of socialization and computational social behaviors has been indicated.

The term of social computing was first proposed by Schuler [4], which he claimed that "social computing describes any type of computing application in which software serves as an intermediary or a focus for a social relation." Researchers from IBM also noticed the social feature of the Internet in 1999 and introduced social computing to the design of information technology systems [5]. Wang [6] from Chinese Academy of Sciences observed a social media enabled paradigm shift in social computing in the early 21st century, and redefined its concept as the computing research of social process, social organization, social relation, and social function [7] in 2004. In the same year, he developed a new research framework for social computing named artificial societies, computational experiments, and parallel execution (ACP) approach: artificial societies for modeling, computational experiments for analysis, and parallel execution for management and control [8].

ACP-Based Parallel Societies

The ACP-based social computing enables building social systems and software for embedding actionable social knowledge in applications rather than merely describing social information. It includes three steps: 1) construction of artificial systems to model social units, processes, and systems using software-defined methods; 2) design of computational experiments to explore and evaluate the systems inner logic, mechanisms, and the emergence of complex social phenomena; and 3) parallel execution to prescribe and manage complex social and cyber behaviors. The artificial system provides a virtual but reliable experimental environment for learning, training, and testing to provide better decision-making supports to society management and control.

Since the pervasive use of smart mobile devices, location-based services, and recommendation Apps, together with the ubiquitous Internet of Things, has made it possible for the first time to study human dynamics across social, physical, and cyber world with big data, we believe that all kinds of complex societal systems can be modeled and studied through the parallel system's manner. Nowadays, the ACP-based approach has been widely used in national and homeland security [9], [10], autonomous driving [11]–[13], traffic management and control [14], [15], and blockchain [16], with remarkable achievements.

In particular, we believe that after tremendous advancement in mechanization, electrification, information, and network technology, modern society has entered the parallel age of virtual-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 phrase of development: the parallel society or society 5.0, where ACP-based parallel intelligence would be its defining characteristic.

State of the Art

After nearly 30 years of development, social computing has become a worldwide important topic attracting broad interests from not only researchers, technologists, software, and online game vendors but also Web entrepreneurs, business strategists, political analysts, and digital government practitioners, to name a few. It stressed the importance of human participation and their social needs in driving the progress of every aspects of our society with quantifiable metrics, which truly promoted the application of advanced computational and intelligent technologies into solving social problems, such as searching for relatives after a disaster (which is generally called human flesh search (HFS) [17], [18]), recommending the best restaurant in a city, and predicting the spreading trends of diseases or results of political elections.

To better understand the development trends in this field, an automated text mining process is conducted for searching papers published on academic journals, magazines, and conference proceedings indexed by the Web of Science database, using a set of keywords including "social computing", "social context mining", "social cognition", "social intelligence", "computational social science", "social informatics", "social analytics", "social media analytics", and "social network analysis". Finally, a data set of 18 274 papers (including 13 592 journal and magazine papers, and 4 682 proceeding papers) is constructed. The citation relation among these 18 274 papers is depicted as Fig. 1. It is clear that most of the papers are clustered into four groups: 1) social network analysis, focusing on social network structure, content and semantic analysis, with great attention on cross-domain academic collaborations; 2) agent-based social behavior modeling/social event triggered collective behavior detection and prediction, with obvious online–offline interacted and augmented characteristics; 3) social learning and social cognition, trying to figure out how the complex macro social phenomena are formed by simple micro individual behaviors; and 4) application of social computing in business and politics scenes, such as e-commerce recommendation and political elections.

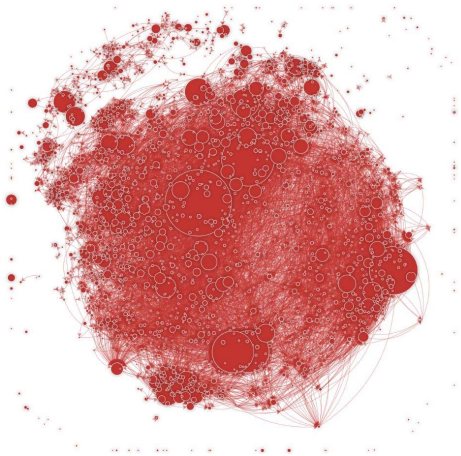

Fig. 1. The state of the art of social computing.

Social Cognition and Intelligence Augmentation

Social cognition, as a terminology, mainly refers to a specific approach that how an individual recognizes or understands his surrounded conspecifics (members of the same species) or even other species (such as pet). For humans, like many animal species, survival depends on effective social functioning. Social skills facilitate our access to sustenance, protection, and mates, and socially adept individuals tend to be healthier and live longer [19], [20]. However, social interaction in humans is exceedingly complex compared with that in other animal species: representations of internal somatic states, knowledge about the self, perceptions of others, and interpersonal motivations are carefully orchestrated to support skilled social functioning. This complex set of processes is broadly referred to as social cognition [21].

Social cognition has been studied from various theoretical and methodological perspectives. In the behavioral sciences, social psychologists have investigated how the self interacts dynamically with the social environment, and how knowledge structures of social groups (such as stereotypes) might influence behavior through both conscious and unconscious mechanisms [22]–[24]. Although social psychologists have developed a rich theoretical and methodological framework for examining and understanding social cognition, they have only recently begun to consider its neural substrates. Neuroscientists, meanwhile, have investigated how underlying neural structures support unique yet coordinated roles in various aspects of social cognition. Initially, neuro-scientific explorations of social cognition arose from neuropsychological studies of patients [25], [26]. More recently, noninvasive neuroimaging methods such as functional MRI (fMRI) have permitted neuroscientists to explore the neural correlates of social cognitive phenomena in normally functioning humans. As a result of these evolving fields, social psychologists and cognitive neuro-scientists have begun to cross paths in the domain of social cognitive neuroscience [27].

A second perspective for social cognition study comes from the social computing. Similar research is also addressed in computational neurosciences. Starting from personal computing, this field now goes further to focus on more attractive topics, like how a group consensus is formed, how to facilitate the collaborations as well as social interactions, in general, to describe, predict and prescribe the social behaviors. Cognitive functions such AS human internal states, self-knowledge, perceptions of others, as well as related social interactions, are mainly investigated via computational cognitive models [28], [29]. With the advance of Internet and Web technologies, the increasing accessibility of computing resources and mobile devices, and the prevalence of rich media contents, researchers increasingly focus on the study of social cognition using advanced social computing technologies. Through trial-and-error, researchers are able to examine polices and strategies that can impact individuals cognitive process in the virtual system. This provides us a configurable experiment platform, which successfully overcomes the difficulty for the test in the real system. Moreover, such social cognitive computing together with the actual social system could be and should be a part of a large framework that includes cognition reconstruction and prescription so that the real and virtual are coanalyzed and symbiotic. As such, social computing, a new paradigm of computing and technology development, is playing a central role across a number of information and communication technology fields.

With such paradigm, activities in the cyber space such as searching, game, animation, and instant messaging can be analyzed qualitatively and quantitatively. By interacting the cyber movement organizations, crowd intelligence can be emerged where the individual intelligence, information communication, and social networks are coevolved. Therefore, the dynamic analysis of cyber movement organizations based on social computing and virtual-real coevolution will be the fundamental support of the future intelligent industries [30].

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