Introduction to the Special Issue on Signal and Information Processing for Social Networks

We live our lives in digital networks. We wake up in the morning, check our e-mail, make a quick phone call, commute to work, buy lunch. Many of these transactions leave digital breadcrumbs—tiny records of our daily experiences. Pulling together these crumbs using statistical analysis and machine learning methods offers an increasingly comprehensive picture of our lives, both individually and collectively, with the potential of transforming our understanding of ourselves, our organizations, and our society in a fashion that was barely conceivable just a few years ago.

A single most important source of data is the ubiquitous mobile phone. Every time a person uses a mobile phone, a few bits of information can be collected. The phone pings the nearest mobile-phone towers, revealing its location. Accelerometers already in some phones can record patterns of physical activity, and the phone’s signal processing hardware can analyze the user’s speaking patterns.

In addition, we have also witnessed the emergence of large-scale social network communities such as Napster, Facebook, Twitter, and YouTube where millions of users form a dynamically changing infrastructure to share content. Such proliferation and introduction of the new concept of web-based social networking creates a technological revolution not only for the personal and entertainment purposes, but also for many new applications of government/school/industry/research that bring new experiences to users. The massive content production also poses new challenges to the scalable and reliable sharing of (multimedia) content over large and heterogeneous networks. While demanding effective management of enormous amount of unstructured content that users create, share, link, and reuse, this also raises critical issues of intellectual property protection and privacy issues.

In large-scale social networks, millions of users actively interact with each other, and such user dynamics not only influence each individual user but also affect the system performance. To provide a predictable and satisfactory level of service, it is of ample importance to analyze the impact of human factors on multimedia social networks, and to provide important guidelines to better design of multimedia systems. Similarly, the economics community has made significant progress toward understanding social learning, asking how networked agents can form a consensus in their estimates or actions given state measurements.

Out of nearly 50 submissions, the papers in this special issue include those presented in the first IEEE Thematic Workshop on March 15, 2010, at Dallas during ICASSP, aiming to highlight the advances of signal and information processing for social networks and social learning. The goal is to encourage researchers from different areas (signal processing, information management, computer sciences, and psycho-sociology) to come together to explore and understand the impact of signal and information processing for the emerging research field of social networks, and ultimately to design systems with more efficient, secure, context-aware, and personalized services.

Humans like to draw inspiration from how a successful group of entities interacts, and then apply it to some other population, aiming to increase their performance. Underlying this methodology is the idea that there is something good to learn from them, reckoning that they have found a good way to maximize their collective wellness. This raises interesting questions: Could they do any better? How much? Which changes could lead to an improvement? The paper, “Measuring the Collective Potential of Populations from Dynamic Social Interaction Data” by Cebrian et al. sheds light on these questions.

Users in video-sharing social networks actively interact with each other, and it is of critical importance to model user behavior and analyze the impact of human factors on video sharing systems. Each user wants to maximize his/her own payoff, and they negotiate with each other to achieve fairness and address this conflict. However, some selfish users may cheat to their peers and manipulate the system to maximize their own payoffs, and cheat prevention is a critical requirement in many social networks to stimulate user cooperation. In the paper “Impact of Social Network Structure on Multimedia Fingerprinting Misbehavior Detection and Identification” by Zhao and Liu, the impact of network structures on misbehavior detection and identification is considered.

Peer-to-peer (P2P) networks can be easily deployed to distribute user-generated content at a low cost, but the free-rider problem hinders the efficient utilization of P2P networks. Using game theory, the next paper, “A Game Theoretic Analysis of Incentives in Content Production and Sharing over Peer-to-Peer Networks” by Park and van der Schaar, investigates incentive schemes to overcome the free-rider problem in content production and sharing. It builds a basic model and considers both the non-cooperative outcome without any incentive scheme and the cooperative outcome, then proposes and examines three incentive schemes based on pricing, reciprocation, and intervention.

The paper, “Distance-Dependent Kronecker Graphs for Modeling Social Networks,” by Bodine-Baron et al., focuses on a generalization of stochastic Kronecker graphs, introducing a Kronecker-like operator and defining a family of generator matrices dependent on distances between nodes in a specified graph embedding. It proves that any lattice-based network model with sufficiently small distance-dependent connection probability will have a Poisson degree distribution and provide a general framework to prove searchability for such a network.

In the next paper, “Context-adaptive information flow allocation and media delivery in online social networks” by Chakareski and P. Frossard, context-driven flow allocation
and media delivery in online social networks is investigated. It exploits information on contacts and content preferences found in social networks to provide efficient networking services and operation at the underlying transport layer. It formulates a linear programming framework that maximizes the information flow-cost ratio of the transport network serving the nodes in the social graph and design a context-aware packet scheduling technique that maximizes the utility of media delivery among the members of the social network.

There is little work on the investigation of large-scale human data in terms of multimodality for human activity discovery. The next paper, “Probabilistic Mining of Socio-Geographic Routines from Mobile Phone Data” by Farrahi and D. Gatica-Perez, suggests that human interaction data, or human proximity, obtained by Bluetooth sensor data, can be integrated with human location data, obtained by mobile cell tower connections, to mine meaningful details about human activities from large and noisy datasets. It proposes a bag of multimodal behavior that integrates the modeling of variations of location over multiple time-scales, and the modeling of interaction types from proximity.

The last paper of this special issue, “The Use of Mobile Devices in Aiding Dietary Assessment and Evaluation,” by Zhu et al., concerns about chronic diseases and other health problems related to diet including obesity and cancer. The need to accurately measure diet (what foods a person consumes) becomes imperative. Dietary intake provides valuable insights for mounting intervention programs for prevention of chronic diseases. In this paper, a novel mobile telephone food record that will provide an accurate account of daily food and nutrient intake is described by the use of image analysis tools for identification and quantification of food that is consumed at a meal.

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