Advances on data, information, and knowledge in the internet of things

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Published online: 13 August 2014
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The internet of things (IoT) is a dynamic smart networked system with connected sensors, processors, and actuators that are designed to sense and interact with the physical world. Achieving the benefits of IoT requires the fusion and management of large scale heterogeneous data using knowledge-based decision systems and the integration of different technologies. Many challenges exist, including identifying things correctly and safely in IoT, modeling and integrating variety and volumes of data, acquiring knowledge automatically from the big data, and ensuring security and privacy, etc.

This theme issue aims to explore these challenges through papers which address: (1) data models and big data and information processing in IoT; (2) how collaboration and interaction in IoT can be facilitated leveraging the best practices developed in social computing, social and community intelligence, and wireless sensor networks; and (3) the security and privacy issues in IoT and mobile computing.

This issue is in collaboration with the international workshop on Identification, Information, and Knowledge in

the Internet of Things (IIKI2013) held in October 2014, Beijing, China (<http://ireg.bnu.edu.cn/IIKI2014/>).

Following a strict review process, we accept seventeen papers for this theme issue finally. Each of the papers was peer-reviewed by at least two experts in the field. In the following, we provide a brief introduction to each paper.

Data dissemination is a challenging issue for mobile social activities in IoT. The paper titled “strengthen nodal cooperation for data dissemination in mobile social networks” by Guoliang Liu et al. proposes an incentive scheme to stimulate the users in a network to be more cooperative for data dissemination by considering selfishness factors of the users. Each node’s ability to fetch messages of a specific kind of interest is evaluated, and every single user can rent other nodes to help with obtaining the interested messages by paying credits. Extensive simulations on real traces are implemented to evaluate the proposed incentive scheme.

The paper “self-Universum support vector machine” (SUSVM) by Dalian Liu et al. provides a theoretical explanation for an improved twin support vector machine based on the concept of Universum, which takes the positive class and negative class as Universum separately for the binary classification problem. Furthermore, SUSVM is improved by a special formulate of linear programming, which leads to the better generalization performance and less computational time.

Data management and information organization play key roles in IoT realization. Yunchuan Sun et al. propose an extensible and active semantic information organization model for IoT in the paper titled “An extensible and active semantic model of information organizing for the Internet of Things.” The proposed model is well defined and involves two layers: the object layer and the event layer, which are both discussed in detail including the

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conceptions, schema definitions, and the rule-based knowledge representation. Semantic reasoning can be supported by the knowledge base which involves in a set of reasoning rules of semantic relations. Its primary idea is “object-cored organizing data, event-based explaining data, and knowledge-based using data.”

The paper titled “mDHT: a multi-level indexed DHT algorithm to extra-large data retrieval on HDFS/Hadoop architecture” by Yu Tang et al. proposes a multi-level indexed distributed hash table (mDHT) algorithm and develops a map reduce application using the proposed algorithm on the open standard HDFS/Hbase. The approach uses a columnar storage structure for energy consumption data storage and creates a hashed index table to provide a quick search and retrieval method for extra-large-scale data processing systems. Compared to single-indexed DHT (sDHT), mDHT can reduce time cost of data retrieval.

The paper “A synergetic mechanism for digital library service in mobile and cloud computing environment” by Junsheng Zhang et al. proposes a synergetic mechanism for digital library to provide information service in the mobile and cloud computing environment, which combines the digital library servers, mobile hosts, and personal cloud space into a synergetic work group seamlessly. The proposed mechanism could help promoting knowledge sharing, and improve work efficiency of users in the mobile and cloud computing environment.

Benefit from technical advances in the internet of things, many social media applications relative to folksonomy have become ubiquitous. The paper titled “On improving aggregate recommendation diversity and novelty in folksonomy-based social systems” by Hao Wu et al. introduces a simple yet elegant method diversity-aware personalized page rank (DaPPR) from the aggregate perspective to address the key challenge on how to find the most useful individual recommendations among diverse niche resources. A hybrid DaPPR model is specifically designed by combining two ranking processes on the user-resource and the resource-tag bipartite graphs to meet the requirements in folksonomy-based systems. According to solid experiments, the proposed method yields better results balancing both aggregate accuracy and aggregate diversity.

Security and privacy issues are vital challenges for IoT. The paper titled “Toward inference attacks for K-anonymity” by Yan Sun et al. develops a privacy inference graph based on attack graph theory to address on the inference attacker from inferring privacy information for K-anonymous datasets. The concept of valid inference path to analyze the privacy disclosures is proposed by using the privacy inference graph. Some algorithms for inference paths are developed to find optimal privacy strategies to resist inference attack. The correctness of the algorithms is

proved in theory, and the performance of the approximate algorithm and their time complexity are also analyzed. To ensure automatic identification and data capture safely, Junyu Wang et al. propose two protocols for authorization, authentication, and key establishment based on symmetric cryptography in the paper titled “Session-based security enhancement of RFID systems for emerging open-loop applications.” The proposed protocols adopt a timed-session-based authorization scheme, and all reader-to-tag operations are authorized by a trusted third party (TTP) using a newly defined class of timed sessions. Both protocols can successfully resist most security threats toward open-loop RFID systems except physical attacks. The timing and scalability of the two protocols are also discussed in detail. The paper titled “Secured access control for vehicles in RFID systems on roads” by Yanfei Lu et al. proposes a novel access control system based on the RFID (radio frequency identification) systems on Roads to meet the route-tracking requirement. A route encryption algorithm is also developed to ensure the security access from the attackers from both outside and inside. The experiment results demonstrate the effectiveness of the proposed algorithm.

Smart home and smart grid are typical scenarios of IoT. The paper “WTrack: HMM-based walk pattern recognition and indoor pedestrian tracking using phone inertial sensors” by Xiaoguang Niu et al. presents an indoor pedestrian tracking system called WTrack using only geomagnetic sensors and acceleration sensors that are commonly carried by smartphones. WTrack can track indoor pedestrians by continuously recognizing the pre-defined pedestrians’ walk pattern. WTrack is able to resist both the interference of body swing of natural walking and the geomagnetic disturbances of nearby objects. Their experimental results reveal that the location error adequate for indoor location-based-service applications. The paper titled “When smart grid meets PHEVs: a smart load distribution mechanism in smart grid” by Kai Xing et al. analyzes the impact of large-scale usage of hybrid electric vehicles (PHEVs) and address the load distribution problem by solving a decentralized optimization problem and smoothening the peak load with pricing strategies in the power grid. The influence of charging time and charging mode on load distribution is also investigated. The simulation study on PJM’s data warehouse shows that the proposed strategies can well smooth the peak load by pricing on the charging time and mode and thus improving the stability and reliability of the power grid.

The paper titled “Performance monitoring and evaluation in dance teaching with mobile sensing technology” by Yu Wei et al. develops an automatic grading system to assess users’ performances for dance teaching by monitoring the performance of dance trainers through sensors

embedded in smart phones. The system can evaluate the correctness of motion gesture and rhythm management by measuring the similarity between the motion data of trainers and the standard data with a DTW-based algorithm. The experiments results show that the proposed algorithms work well.

In mobile wireless sensor networks (MWSNs), mobile nodes collect data and send data to a sink station. How to predict a mobile receiver's movement for the purpose of keeping the direction of transmitter's antenna is a challenge. Paper titled "Directional communication with movement predicting in mobile wireless sensor networks" by Xiaofeng Lu proposes a mobility predicting algorithm is based on the knowledge extracted from real vehicles traces. The validation experiments indicate that the predicting accuracy rate of the algorithm is 96.5 %, and the communication using directional antenna with movement predicting saves about 92.6 % energy consumption with a suitable beam width and shakehand interval.

The paper titled "Research on the comprehensive traffic state evaluation model linked with drivers' perception under the vehicle networking" by Guangyu Zhu et al. develops a comprehensive traffic state evaluation model linked with driver's perception under the vehicle networking. Statistical analysis on drivers' perceptions about certain traffic state can be useful to adjust the release of traffic state. The simulation results demonstrate that the model works well with a high rate of convergence, a high identification precision, and the generalization ability to conduct researches on the identification of traffic state.

The wireless body area network can be applied in U-health especially for elder people. The paper "A utility maximization approach for information-communication trade-off in wireless body area networks" by Hui Wang et al. presents a new bottom-up management approach to U-Health smart home deployment with a particular

emphasis on the characteristics of sensor systems and the value of information and semantic reasoning. A prototype of the system is also deployed in a real apartment to highlight the benefit of the approach and as a showcase for several emerging technologies.

Structural health monitoring has received remarkable attention due to the arising structural safety problems. In the paper titled "Structural health monitoring by using a sparse coding based deep learning algorithm with wireless sensor networks" by Junqi Guo et al., sparse coding is employed to achieve structural health monitoring of a bridge equipped with a wireless sensor network to avoid the requirement of large amount of data for the training. Features learned from sparse coding can be used to train a neural network classifier to distinguish different statuses of the bridge. Experimental results show the sparse coding-based deep learning algorithm achieves higher accuracy for structural health monitoring under the same level of environmental noises, compared with some existing methods.

The paper "Novel itinerary-based KNN query algorithm leveraging grid division routing in wireless sensor networks of skewness distribution" by Yibo Han et al. proposes a novel KNN query algorithm based on grid division routing in the setting of skewness distribution, where the itinerary is formed based on the connectivity of adjacent grid cells centers. The void region problem is well addressed based on the proximity of neighbor grid cells. Experiment result shows that our technique performs better in several aspects including query accuracy, data redundancy, and energy efficiency.

Finally, we would like to thank all authors for their valuable contributions to this theme issue. We are indebted to all anonymous reviewers for their hard work which help the authors further enhance the quality of the manuscripts. We also honor to serve as the guest editors of this issue.