Guest Editorial:
Introduction to the Special Issue on
Advances in Semantic Computing

I. INTRODUCTION

SEMANTIC Computing (SC) is an emerging field that addresses computing technologies allowing users to search, create and manipulate computational resources (including data, documents, tools, devices, etc.) based on semantics ("meaning", "context", "intention"). It includes the computing technologies (e.g., artificial intelligence, natural language, software engineering, data and knowledge engineering, computer systems, signal processing, etc.), and their interactions, with an aim to extract or process computational contents and descriptions [1]. While some aspects of Semantic Computing have appeared as isolated topics in individual disciplines, the hallmark of Semantic Computing is to glue these segments together into an integrated and coherent theme with synergetic interactions. It addresses not only the analysis and transformation of signals (e.g., pixels, words) into meaningful information, but also prescribes efficient mechanisms for accessing and synthesizing such information.

The connection between contents and humans can be made via (1) Analytics, which analyzes the contents into a description (semantics); (2) Semantic Description and Integration, which integrates the contents and semantics from multiple sources; (3) Applications, and (4) Semantic Interface, which attempts to interpret naturally expressed user intentions. The reverse process entails converting descriptions of human intentions to create contents of different types.

Some parts of the first layer *(Analytics)* have been well developed and commercialized. One example is text analytics. Growth in this area has been driven by the technology's central role in social-media analysis and by text analytics' contributions to advanced, semantic search and search-based applications.

Another example is Big Data. The use of big data offers remarkable untapped potential for generating value. Numerous organizations in industrial and business sector have stockpiles of big data which they can control to advance their allocation and coordination of human and physical resources, cut waste, increase transparency and accountability, and aid the discovery of new ideas and insights. Gartner Inc., in its March 2013 release, identified Semantic Technologies as one of the top technology trends that will play key roles in modernizing information management (IM) in 2013 and beyond: "One reason they are garnering more interest is the renewed business requirement for monetizing information as a strategic asset. Even more pressing is the technical need. Increasing volumes, variety and velocity - big data - in IM and business operations, requires semantic technology that makes sense out of data for humans, or automates decisions." [2].

The next layer of Semantic Computing, Semantic Description and Integration Languages, has been extensively studied by the Semantic Web research community led by the W3C (World Wide Web Consortium). More recently, major players such as Google and Amazon have been developing "graph databases" that allow users to query all knowledge about a subject, paving the way to a global "knowledge base".

While Semantic Computing was first substantiated in text analytics, it has the potential for much broader applications. The four layers of Semantic Computing define the core scientific components of Semantic Computing:

1. *Analysis of Contents and Intentions* (*Problems*), including data analysis, multimedia analysis, natural language understanding, compiler, circuit analysis, software analysis, network analysis, process analysis, multi-modal interface, etc.;
2. *Description of Semantics*, including formal models, search and access mechanisms, etc.;
3. *Integration of Descriptions*, including interoperateability, schema integration, etc.; and
4. *Problem Solving*, including general problem solving and vertical problem solving that derives solution(s) from contents (via semantic descriptions) to meet (human) intentions.

Semantic Computing can be considered as an integration, and elaboration for integration, of different fundamental areas in Computer Science. The driving force behind this integration and elaboration is the description, analysis and understanding of human intentions and mapping them with/to contents and/or relevant semantics. Instantiating the term "content", Semantic Computing may play an increasingly important role in other areas in Computer Science such as software engineering, multimedia, communication, security and privacy, operating system, database, and computer aided design [3].

This special issue addresses some of the above fundamental issues and applications of Semantic Computing. In the first article entitled "Sparse linear integration of content

and context modalities for semantic concept retrieval'', Qiusha Zhu and Mei-Ling Shyu propose a Sparse Linear Integration (SLI) model for semantic concept retrieval. Their proposed SLI model focuses on integrating visual content and its associated metadata which are referred to as the content and the context modalities respectively to address the challenge in bridging the semantic gap between low-level visual features and high-level semantics in content-based multimedia information retrieval. The integration process is formulated into an optimization problem that aims to approximate an instance using a sparse linear combination of other instances. That is, the difference between the feature representation of an instance and its reconstructed representation by a sparse linear combination of other instances is considered as the error to be minimized. The prediction score of a concept for a test instance measures how well it can be reconstructed by the positive instances of that concept. The evaluation of their proposed SLI model is conducted on two benchmark image datasets and their associated tags. The experimental results show promising performance by comparing it with the approaches based on a single modality and the approaches based on popular fusion methods.

The next article is authored by Fausto C. Fleites, Haohong Wang and Shu-Ching Chen who propose a multi-cue product detection framework for TV shopping in ''Enhancing product detection with multi-cue optimization for TV shopping applications''. The purpose is to allow the customers to interact with their smart TVs to purchase the products they are interested. Currently, the lack of content understanding does not allow smart TVs to provide the customers with a seamless TV shopping experience. If the customers are interested in purchasing products displayed in the TV shows, they must inconveniently resort to a store or the Web. In order to provide such a service, products in the content stream must be detected automatically and accurately so that similar products can be displayed to the customers on the TVs. Their proposed framework is generic since it is not tied to specific object detection approaches. Its object detection is achieved by utilizing three cues, namely appearance, topological and spatio-temporal, that make use of a related and easier-to-detect object class to improve the detection results of the target and a more-difficult product class. The best path of the occurrences of the target product class can be followed in the video and thus it eliminates false positive occurrences. The empirical results demonstrate the advantages of their proposed framework in improving the precision of the results.

Next, Yuxia Huang and Ling Bian present an ontology-based approach to online tour planning in the paper entitled ''Using ontologies to integrate heterogeneous tourism information for on-line tour planning''. The authors attempt to address the challenge of integrating semantically diverse on-line information from the providers into a single unified representation that considers the perspectives of both the tourists and tourism information providers.

In their proposed approach, one ontology is developed for the tourists (using the information in the tourism literature from the perspective of the tourists) and another ontology for the tourism information providers (which integrates heterogeneous information from various tourism web sites using a Formal Concept Analysis (FCA) approach). After these two ontologies are built, a mapping between them using an FCA and a Bayesian approach is used to devise a tour plan. The authors show that their proposed approach allows effective retrieval of heterogeneous on-line information and generation of personalized recommendations for the tourists, and it can be extended to support other similar service related systems or systems that need to integrate information from multiple sources.

With an attempt to give a theoretical statistical justification of the Latent Semantic Analysis (LSA) technique based on the Truncated Singular Value Decomposition (TSVD), Giovanni Pilato and Giorgio Vassallo propose the use of an information geometry approach to interpreting the TSVD decomposition as a stochastic estimator in ''TSVD as a statistical estimator in the latent semantic analysis paradigm''. The idea is to map the matrix that represents a sample distribution over a dyadic domain into a statistical manifold. Instead of the Frobenius distance used in the traditional LSA, the Hellinger distance is adopted. While LSA can roughly capture and code the semantics of words and documents, which has been successfully applied to typical Semantic Computing applications, it suffers from the lack of a sound statistical interpretation. Hence, the authors present a new point of view to give a statistical interpretation of the traditional LSA paradigm based on the TSVD estimator since it can guarantee the minimal distance between the sample probability distribution and the inferred probabilistic model. The authors evaluate their proposed TSVD estimator by the number of the singular values retained after truncation and the guaranteed minimal distance between the sample probability distribution and the inferred probabilistic model.

In the next article, Markatopoulou, Mezaris, Pittaras, and Patras propose the use of a two-layer stacking architecture for score refinement in video concept detection. Semantic concept detection is to assign one or more labels (called semantic concepts) to video sequences based on a predefined list of concepts. First, how the ORB binary local descriptor can be used for concept detection is examined. Next, the color extensions for SIFT, SURF and ORB local descriptors are introduced. An improved way of performing Principal Component Analysis (PCA) to reduce the color descriptor's dimensionality is presented, which improves the results of SIFT/SURF/ORB color extensions when combined with Vector of Locally Aggregated Descriptors (VLAD) encoding. A comparative study with respect to the learning stage of concept detection is conducted, and an improved stacked model that captures concept correlations by using multi-label classification methods in the last level of the stack is proposed. Assigning concepts to video shots is in fact considered as a multi-label classification problem since

multiple concepts may describe a single video shot. Hence, the authors form model vectors from the predictions of multiple binary relevance concept detectors and use them as a meta-learning training set for a second round of learning. The effectiveness of their proposed two-layer architecture and local features is evaluated in both semantic video indexing within a large video collection and individual video annotations with semantic concepts using the 2013 TRECVID data set.

The article entitled ''Wikipedia-based semantic similarity measurements for noisy short texts using extended naive Bayes'' is authored by Masumi Shirakawa, Kotaro Nakayama, Takahiro Hara and Shojiro Nishio. In this paper, the authors propose the use of a bag of Wikipedia entities that are related to a real-world short text as its semantic representation. Although the Explicit Semantic Analysis (ESA) method can be used to search Wikipedia entities (articles) from each word and sum the scores of entities, it is not suitable for short texts due to the insufficient amount of information. Furthermore, it is challenging to add related entities to texts since it involves the extraction of key terms, finding the related entities for each key term, and the aggregation of related entities. To address such challenges, the authors adopt a probabilistic weighting mechanism based on the Bayes' theorem called Extended Naïve Bayes (ENB), and show that their method is effective especially when the short text is semantically noisy, i.e., they contain some meaningless or misleading terms for estimating the main topics.

In ''Discover the expert: Context-adaptive expert selection for medical diagnosis'', Cem Tekin, Onur Atan, and Mihaela van der Schaar propose an expert selection system that learns online the best expert to assign to each patient based on the context information of the patient. There can be an enormous number and variety of context information for a patient, including the patient's health condition, age, gender, previous drug does, etc. If the most relevant context information can be identified for a patient, it is believed that the best clinic and expert for the diagnosis can be recommended for that patient. However, the relevant context information may be different for different health conditions. To address these challenges, the authors model the problem as a distributed context-adaptive online learning problem and develop a class of algorithms to discover the most relevant content information adaptively based on a patient's context information. Their proposed system promotes cooperation among clinics, and each clinic benefits from the expertise of other clinics by asking for their diagnosis recommendations for the patients. In addition, their proposed system learns the optimal experts very fast. For each patient, their proposed system provides confidence bounds on the accuracy of the selected diagnosis action and guarantees to discover the best or near-optimal expert with a high probability for the patient. A real-world breast cancer diagnosis dataset is used to illustrate the functionality and performance of their proposed system.

He, Wu, and Li propose a supervised approach called the Label Correlation Mixture Model (LCMM) for multi-label spoken document categorization as well as multi-label text categoarization in their article entitled ''Label correlation mixture model: A supervised generative approach to multi-label spoken document categorization''. Text categorization is an important and basic problem in natural language processing, while spoken document categorization can be considered as a special text categorization problem. In LCMM, labels and topics have one-to-one correspondences. LCMM consists of two important components, namely a label correlation model and a multi-label conditioned document model. The label correlation model formulates the label generation process that considers the dependencies between the labels. An efficient algorithm is also proposed to calculate the probability of generating an arbitrary subset of labels. The multi-label conditioned document model can be regarded as a supervised label mixture model whose parameter learning adopts a discriminative approach based on the minimum classification error rate training (MCE) in addition to maximum likelihood estimation (MLE). The LCMM is evaluated using multi-label categorization experiments on a spoken document data set and three standard text data sets, and the experimental results demonstrate the effectiveness of LCMM.

The last article, entitled ''A semantic early warning system for natural environment crisis management'' by Poslad, Middleton, Chaves, Tao, Necmioglu, and Bügel, attempts to address the challenges encountered during the practical deployment of a semantic EWS (Early Warning System) based on a multi-semantic representation model to be used in aiding the management of rapid onset geological type natural disasters. An EWS is a core information system used for environment disaster risk and effect management. The potential benefits of using a semantic type EWS include easier sensor and data source plug-and-play and simpler, more dynamic and richer metadata-driven data analysis, service interoperability and orchestration. On the other hand, the challenges are: (1) the need for scalable time-sensitive data exchange and processing, especially involving heterogeneous data sources, and (2) the resilience to changing ICT resource constraints in a crisis zone. The authors use ''lightweight'' domain semantics for metadata to enhance rich sensor data acquisition, while using 'heavyweight' semantics for the top level W3C OWL ontology models of a multi-leveled knowledge base and for semantically-driven decision support and workflow orchestration. Their proposed approach is validated by determining a set of system related metrics and a case study involving an advanced prototype system of the semantic EWS, integrated with a deployed EWS infrastructure.

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