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Editorial for the the special issue of WWW journal on Computational Aspects of Network Science (CAoNS)

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Network Science is a rapidly evolving area with numerous practical applications spanning different fields like telecommunications, biology, sociology, computer science, just to name a few. The foundations of Network Science are based on Graph Theory, Statistics, Physics and Data Mining. The field has grown significantly during the past twenty years, with dedicated conferences, journals and books studying different aspects of networks including the theory, the algorithmic techniques applied and the applications. Based on the importance of the Network Science field, we organized this Special Issue of the WWW Journal focusing on the Computational Aspects of Network Science.

The Call for Papers for this Special Issue attracted twenty paper submissions related to the topics of the call. Among these papers, ten of them were selected to be included in the Special Issue, based on relevance, originality and overall quality. We are grateful to the anonymous reviewers who offered their time to provide constructive comments and suggestions and assisted us to select the best articles. Also, we are grateful to the authors who selected this Special Issue to publish their work.

In the sequel, we present briefly, in random order, the articles accepted for publication in the Special Issue.

CSR: A Community based Spreaders Ranking algorithm for Influence Maximization in Social Networks
by
Sanjay Kumar, Aaryan Gupta, Inder Khatri

In this paper, the authors propose a novel method to solve the problem of influence maximization named Communities based Spreader Ranking (CSR), which is based on the notions of communities and bridge nodes. It identifies bridge nodes as influential nodes based

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on three concepts: community diversity, community modularity, and community density. Community diversity is used to identify bridge nodes and the rest two are used to identify significant communities. Extensive experimentation validation on various datasets using popular information diffusion models demonstrates that the proposed method delivers proficient results compared to numerous previously known contemporary influence maximization methods.

GuidedWalk: Graph Embedding with Semi-Supervised Random Walk
by
Mohsen Fazaeli, Saeedeh Momtazi

In this paper, the authors propose GuidedWalk, which is a semi-supervised random walk-based graph embedding method that can outperform other random walk-based competitors as well as GNNs in the semi-supervised setting on graphs without node attributes. The proposed model works based on exploring graph paths with more emphasis on the paths that connect nodes of the same class. The neural processing core of DeepWalk and Node2Vec propagates latent features across sampled paths. Therefore, the selected paths increase the chances of propagating the right latent features, which is appropriate for the node classification task. Experiments on Cora, Pubmed, Twitch DE, and Facebook datasets, show 0.53%, 0.78%, 5.07%, and 7.13% improvement in node classification accuracy compared to the state-of-the-art techniques in the field.

LEOnto+: A Scalable Ontology Enrichment Approach
by
Salma Sassi, Anis Tissaoui, Richard Chbeir

In this paper, the authors propose LEOnto+, which is an extended version of LEOnto, to provide a new approach for automatic ontology enriching from textual corpus. In LEOnto+, LDA is used to for dimensionality reduction and to identify semantic relationships between topic-document and word-topic using probability distributions. Several experiments have been conducted using different evaluation techniques (evaluation based criteria, cold standard evaluation, expert evaluation, task-based evaluation and corpus-based evaluation). The paper also presents a comparative study with two existing methods using their respective datasets. The evaluation results show that LEOnto+ outperforms the aforementioned methods, particularly in terms of precision.

Graph Embeddings in Criminal Investigation: towards combining precision, generalisation and transparency
by
Valerio Bellandi, Paolo Ceravolo, Samira Maghool, Stefano Siccardi

Criminal investigation adopts Artificial Intelligence to enhance the volume of the facts that can be investigated and documented in trials. This paper studies the the use of graph embedding procedures to retrieve potential criminal actions based on patterns defined in enquiry protocols. The study reveals that a significant level of accuracy can be achieved but different graph reformation procedures imply different levels of precision, generalization, and transparency.

Event Prediction from News Text using Subgraph Embedding and Graph Sequence Mining
by
Recep Firat Cekinel, Pinar Karagoz

In this paper, the authors focus on news prediction and model the problem as subgraph prediction. The aim is to predict the news skeleton in the form of a subgraph. To this aim, graph-based representations of news articles are constructed and a graph mining based pattern extraction method is proposed. The proposed method consists of three main steps. Initially, graph representation of the news text is constructed. Then, frequent subgraph mining and sequential rule mining algorithms are adapted for pattern prediction on graph sequences. Finally, the extracted sequential patterns are used for predicting the future news skeleton. In order to measure the similarity, graph embedding techniques are being used. The proposed method is analyzed on both a collection of news from an online newspaper and on a benchmark news dataset against baseline methods.

TG-OUT: Temporal outlier patterns detection in Twitter attribute induced graphs
by
Ilias Dimitriadis, Marinos Poiitis, Christos Faloutsos, Athena Vakali

This paper proposes TG-OUT, a pipeline of methods which: (a) model the temporal evolution of attribute induced graphs to detect peculiar attributes, (b) identify temporal patterns in attribute distributions, (c) investigate differences in patterns emerging from bot and/or non-bot accounts, (d) extract tailored sets of exploitable features. Experimental results show that: most of the individual attribute distributions remain stable over time following mostly power laws norm. The temporal evolution of attribute induced graphs obey certain laws and deviations are outliers. The authors discovered that patterns present deviations which depend on the type of accounts which use each attribute. Finally, the authors show that careful selection of only two features which are used to train a simple machine learning algorithm, produces a model which efficiently identifies attributes mainly used by bots.

Maximal Paths Recipe for Constructing Web User Sessions
by
Murat Ali Bayir, Ismail Hakki Toroslu

This paper introduces a new method for the session construction problem, which is the first main step of the Web usage mining process. The proposed method defines user sessions as a set of navigation paths in the Web graph and produces complete set of all possible maximal paths. The new method is capable of generating navigation paths which can not be extracted by using previous greedy approaches. Through experiments performed on real data, it is shown that when the new technique is being used, it outperforms previous approaches in Web usage mining applications such as next page prediction. The analysis on Web user sessions exposes an important observation: Web user sessions contain navigation graphs that have small number of nodes where users branch out their navigation into multiple paths.

Link prediction in Complex Networks using Node Centrality and Light Gradient Boosting Machine
by

Sanjay Kumar, Abhishek Mallik, B. S. Panda

In this paper, the authors propose a novel generic approach for link prediction based on the idea of using various node centralities and different machine learning classifiers. The authors utilize some popular and recently introduced node centralities to capture better the network's local, quasi-local and global structure. The value of various node centralities acts as feature labels for the nodes in the network. The existent and non-existent edge in the network is labeled as positive and negative sample respectively. The features of the nodes at the end of the edges, along with the positive or negative label, form a well-defined dataset for the task of link prediction. The dataset is then fed into various machine learning classifiers, and the best results are obtained with Light Gradient Boosted Machine (LGBM) classifier. The authors investigate the performance of the proposed model on multiple real-life networks using various performance metrics and reveal that the proposed approach outperforms many popular and recently proposed link prediction techniques.

Foreseeing Private Car Transfer between Urban Regions with Multiple Graph-based Generative Adversarial Networks

by

Chenxi Liu, Zhu Xiao, Dong Wang, Minhao Cheng, Hongyang Chen, Jiawei Cai

Private car transfer indicates that people drive private cars and travel between urban regions to perform daily activities. Foreseeing private car transfer between urban regions can facilitate a broad scope of applications ranging from route planning, hot region discovery to urban computing. In this paper, the authors propose MG-GAN (Multiple Graph-based Generative Adversarial Network) to predict private car transfer. The authors design a multi-graph dense convolution with gated recurrent networks as the generative network to capture multiple spatio-temporal correlations. Then, the attentive multi-graph convolutional network is designed as a discriminative network to learn the stay duration correlations of private cars in each region. The iterative adversarial processes between generating and discriminating networks enhance the MG-GAN's ability to tackle the sparse data problem. Besides, a topic clustering algorithm based on multi-source data fusion is proposed to balance the fused data. Extensive experiments on real-world private car and taxi trip datasets demonstrate that MG-GAN performs better than the state-of-the-art baselines.

Efficient Information Diffusion in Time-Varying Graphs through Deep Reinforcement Learning

by

Matheus Ribeiro Furtado de Mendonça, André da Motta Sales Barreto, Artur Ziviani

In this paper, the authors propose Spatio-Temporal Influence Maximization (STIM), a model trained with Reinforcement Learning and Graph Embedding over a set of artificial TVGs that is capable of learning the temporal behavior and connectivity pattern of each node, allowing it to predict the best moment to start a diffusion through the TVG. The focus is put on the scenario where some nodes in the TVG present periodic connectivity patterns, an aspect that received little attention in previous approaches. Moreover, the authors develop a special set of artificial TVGs used for training that simulate a stochastic diffusion process in TVGs, showing that the STIM network can learn an efficient policy even over a non-deterministic environment. After training, STIM can be used in TVGs of any size, since the number of parameters of the model is independent to the size of the TVG

being processed. STIM is also evaluated in two real-world TVGs, where it also manages to efficiently propagate information through the nodes. Finally, the authors show that the STIM model has a time complexity of O(\|E\|). STIM is also highly versatile, where one can change the goal of the model by simply changing the adopted reward function.

We hope that this Special Issue will help readers to advance their ideas in Network Science and that will motivate young researchers to pursue research in the area of Network Science.

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