2019 IEEE 35th International Conference on Data Engineering (ICDE) ICDE 2019

Table of Contents

Message from the ICDE 2019 Chairs	xxxiv
Organizing Committee	xxxvi
Program Committee	xxviii

Keynotes

AsterixDB Mid-Flight: A Case Study in Building Systems in Academia
 Data Management at Huawei: Recent Accomplishments and Future Challenges
Building a Broad Knowledge Graph for Products
 Knowledge Graphs and Enterprise AI: The Promise of an Enabling Technology

Panel

Research Track

Research (1) - Graphs 1: Query Processing 1

Answering Why-Questions for Subgraph Queries in Multi-attributed Graphs Qi Song (Washington State University), Mohammad Hossein Namaki (Washington State University), and Yinghui Wu (Washington State University; Pacific Northwest National Laboratory)	40
Enumerating k-Vertex Connected Components in Large Graphs Dong Wen (University of Technology Sydney), Lu Qin (University of Technology Sydney), Ying Zhang (University of Technology Sydney), Lijun Chang (University of Sydney), and Ling Chen (University of Technology Sydney)	52
Index-Based Optimal Algorithm for Computing K-Cores in Large Uncertain Graphs Bohua Yang (University of Technology Sydney), Dong Wen (University of Technology Sydney), Lu Qin (University of Technology Sydney), Ying Zhang (University of Technology Sydney), Lijun Chang (The University of Sydney), and Rong-Hua Li (Beijing Institute of Technology)	64
Computing a Near-Maximum Independent Set in Dynamic Graphs Weiguo Zheng (Fudan University), Chengzhi Piao (The Chinese University of Hong Kong), Hong Cheng (The Chinese University of Hong Kong), and Jeffrey Xu Yu (The Chinese University of Hong Kong)	76
Contextual Community Search Over Large Social Networks Lu Chen (Swinburne University of Technology), Chengfei Liu (Swinburne University of Technology), Kewen Liao (Charles Darwin University), Jianxin Li (Deakin University), and Rui Zhou (Swinburne University of Technology)	88

Research (2) - Distributed, Parallel and P2P Data Management

Rima: An RDMA-Accelerated Model-Parallelized Solution to Large-Scale Matrix Factorization Jinkun Geng (Tsinghua University), Dan Li (Tsinghua University), and Shuai Wang (Tsinghua University)	100
Accelerating Partial Evaluation in Distributed SPARQL Query Evaluation Peng Peng (Hunan University), Lei Zou (Peking University; Beijing Institute of Big Data Research; National Engineering Laboratory for Big Data Analysis Technology and Application (PKU), China), and Runyu Guan (Hunan University)	112
Blockplane: A Global-Scale Byzantizing Middleware Faisal Nawab (University of California) and Mohammad Sadoghi (UC Davis)	124
BENU: Distributed Subgraph Enumeration with Backtracking-Based Framework Zhaokang Wang (Nanjing University), Rong Gu (Nanjing University), Weiwei Hu (Nanjing University), Chunfeng Yuan (Nanjing University), and Yihua Huang (Nanjing University)	136

Efficient Synchronization of State-Based CRDTs 1	148
Vitor Enes (HASLab / INESC TEC and Universidade do Minho), Paulo	
Sérgio Almeida (HASLab / INESC TEC and Universidade do Minho), Carlos	
Baquero (HASLab / INESC TEC and Universidade do Minho), and João	
Leitão (NOVA LINCS, FCT and Universidade NOVA de Lisbon)	

Research (3) - Data Cleaning

Learning Individual Models for Imputation	. 160
CurrentClean: Spatio-Temporal Cleaning of Stale Data Zheng Zheng (McMaster University), Mostafa Milani (McMaster University), and Fei Chiang (McMaster University)	. 172
Fine-Grained Provenance for Matching & ETL Nan Zheng (University of Pennsylvania), Abdussalam Alawini (University of Illinois, Urbana-Champaign), and Zachary G. Ives (University of Pennsylvania)	. 184
 Unsupervised String Transformation Learning for Entity Consolidation Dong Deng (Rutgers University), Wenbo Tao (MIT), Ziawasch Abedjan (TU Berlin), Ahmed Elmagarmid (QCRI HBKU), Ihab F. Ilyas (University of Waterloo), Guoliang Li (Tsinghua University), Samuel Madden (MIT), Mourad Ouzzani (QCRI HBKU), Michael Stonebraker (MIT), and Nan Tang (QCRI HBKU) 	. 196
A Semi-Supervised Framework of Clustering Selection for De-Duplication Shrinu Kushagra (University of Waterloo), Hemant Saxena (University of Waterloo), Ihab F. Ilyas (University of Waterloo), and Shai Ben-David (University of Waterloo)	. 208

Research (4) - Graphs 2: Query Processing and Indexing

Scaling Up Subgraph Query Processing with Efficient Subgraph Matching Shixuan Sun (Hong Kong University of Science and Technology) and Qiong Luo (Hong Kong University of Science and Technology)	
Efficient Parallel Subgraph Enumeration on a Single Machine	
Shixuan Sun (Hong Kong University of Science and Technology), Yulin	
Che (Hong Kong University of Science and Technology), Lipeng Wang	
(Hong Kong University of Science and Technology), and Qiong Luo (Hong	
Kong University of Science and Technology)	
Fast Dual Simulation Processing of Graph Database Queries	
Stephan Mennicke (Institute for Information Systems, TU Braunschweig),	
Jan-Christoph Kalo (Institute for Information Systems, TU	
Braunschweig), Denis Nagel (Institute for Information Systems, TU	
Braunschweig), Hermann Kroll (Institute for Information Systems, TU	
Braunschweig), and Wolf-Tilo Balke (Institute for Information Systems,	
TU Braunschweig)	

Efficient and Incremental Clustering Algorithms on Star-Schema Heterogeneous Graphs	. 256
Lu Chen (Zhejiang University), Yunjun Gao (Zhejiang University),	
Yuanliang Zhang (Zhejiang University), Christian S. Jensen (Aalborg	
University), and Bolong Zheng (Aalborg University)	
G*-Tree: An Efficient Spatial Index on Road Networks	. 268
Zijian Li (Hong Kong University of Science and Technology), Lei Chen	
(Hong Kong University of Science and Technology), and Yue Wang (Hong	

Kong University of Science and Technology)

Research (5) - Recommendation and Clustering

DBSVEC: Density-Based Clustering Using Support Vector Expansion Zhen Wang (Tsinghua University), Rui Zhang (The University of Melbourne), Jianzhong Qi (The University of Melbourne), and Bo Yuan (Tsinghua University)	280
A Joint Context-Aware Embedding for Trip Recommendations Jiayuan He (The University of Melbourne), Jianzhong Qi (The University of Melbourne), and Kotagiri Ramamohanarao (The University of Melbourne)	292
AIR: Attentional Intention-Aware Recommender Systems Tong Chen (The University of Queensland), Hongzhi Yin (The University of Queensland), Hongxu Chen (The University of Queensland), Rui Yan (Peking University), Quoc Viet Hung Nguyen (Griffith University), and Xue Li (The University of Queensland and Dalian Neusoft University of Information)	304
No, That's Not My Feedback: TV Show Recommendation Using Watchable Interval Kyung-Jae Cho (Hanyang University), Yeon-Chang Lee (Hanyang University), Kyungsik Han (Ajou University), Jaeho Choi (Naver Corporation), and Sang-Wook Kim (Hanyang University)	316
Adaptive Wavelet Clustering for Highly Noisy Data Zengjian Chen (Huazhong University of Science and Technology), Jiayi Liu (University of Massachusetts Amherst), Yihe Deng (University of California, Los Angeles), Kun He (Huazhong University of Science and Technology), and John E. Hopcroft (Cornell University)	328

Research (6) - Strings, Texts, and Keyword Search

An Efficient Parallel Keyword Search Engine on Knowledge Graphs Yueji Yang (National University of Singapore), Divykant Agrawal (University of California at Santa Barbara), H. V. Jagadish (University of Michigan of Ann Arbor), Anthony K. H. Tung (National University of Singapore), and Shuang Wu (National University of Singapore)	. 338
Towards Longitudinal Analytics on Social Media Data Fan Xia (East China Normal University), Bin Yang (Aalborg University), Chengcheng Yu (Shanghai Polytechnic University), Weining Qian (East China Normal University), and Aoying Zhou (East China Normal University)	. 350

LCJoin: Set Containment Join via List Crosscutting	362
Dong Deng (Inception Institute of Artificial Intelligence), Chengcheng	
Yang (Inception Institute of Artificial Intelligence), Shuo Shang	
(Inception Institute of Artificial Intelligence), Fan Zhu (Inception	
Institute of Artificial Intelligence), Li Liu (Inception Institute of	
Artificial Intelligence), and Ling Shao (Inception Institute of	
Artificial Intelligence)	
Bridging the Semantic Gap with SQL Query Logs in Natural Language Interfaces to Databases Christopher Baik (University of Michigan), H. V. Jagadish (University of Michigan), and Yunyao Li (IBM Research - Almaden)	374
MF-Join: Efficient Fuzzy String Similarity Join with Multi-level Filtering	386

Research (7) - Graphs 3: Social Networks

 Finding Temporal Influential Users Over Evolving Social Networks	;98
Seed Selection and Social Coupon Allocation for Redemption Maximization in Online Social Networks4 Tung-Chun Chang (Research Center for Information Technology Innovation, Academia Sinica, Taiwan), Yishuo Shi (Institute of Information Science, Academia Sinica, Taiwan), De-Nian Yang (Institute of Information Science, Academia Sinica, Taiwan), and Wen-Tsuen Chen (Department of Computer Science, National Tsing Hua University, Taiwan)	10
 Keyword-Centric Community Search	122
Cohesive Group Nearest Neighbor Queries Over Road-Social Networks	34
Maximizing Multifaceted Network Influence	146

Research (8) - Approximation

GB-KMV: An Augmented KMV Sketch for Approximate Containment Similarity	V Search
Yang Yang (University of New South Wales), Ying Zhang (University of	
Technology Sydney), Wenjie Zhang (University of New South Wales), and	
Zengfeng Huang (Fudan University)	

ARROW: Approximating Reachability Using Random Walks Over Web-Scale Graphs Neha Sengupta (Indian Institute of Technology Delhi), Amitabha Bagchi (Indian Institute of Technology Delhi), Maya Ramanath (Indian Institute of Technology Delhi), and Srikanta Bedathur (Indian Institute of Technology Delhi)	470
Taster: Self-Tuning, Elastic and Online Approximate Query Processing Matthaios Olma (EPFL), Odysseas Papapetrou (TU Eindhoven), Raja Appuswamy (EURECOM), and Anastasia Ailamaki (EPFL)	482
An Iterative Scheme for Leverage-Based Approximate Aggregation Shanshan Han (Harbin Institute of Technology), Hongzhi Wang (Harbin Institute of Technology), Jialin Wan (Harbin Institute of Technology), and Jianzhong Li (Harbin Institute of Technology)	494
Deletion Propagation for Multiple Key Preserving Conjunctive Queries: Approximations and Complexity Zhipeng Cai (Georgia State University), Dongjing Miao (Harbin Institute of Technology; Georgia State University), and Yingshu Li (Georgia State University)	506

Research (9) - Machine Learning and Data Science

Enumerating Minimal Weight Set Covers Zahi Ajami (The Hebrew University of Jerusalem) and Sara Cohen (The Hebrew University of Jerusalem)	518
Constraints-Based Explanations of Classifications Daniel Deutch (Tel Aviv University) and Nave Frost (Tel Aviv University)	530
 KARL: Fast Kernel Aggregation Queries <i>Tsz Nam Chan (Hong Kong Polytechnic University, The University of Hong Kong), Man Lung Yiu (Hong Kong Polytechnic University), and Leong Hou U (University of Macau)</i> 	542
Assessing and Remedying Coverage for a Given Dataset Abolfazl Asudeh (University of Michigan), Zhongjun Jin (University of Michigan), and H. V. Jagadish (University of Michigan)	554

Research (10) - Graphs 4: Mining 1

Social Influence-Based Group Representation Learning for Group Recommendation	566
Hongzhi Yin (The University of Queensland), Qinyong Wang (The	
University of Queensland), Kai Zheng (University of Electronic Science	
and Technology of China), Zhixu Li (Soochow University), Jiali Yang	
(Soochow University), and Xiaofang Zhou (The University of Queensland)	
MIDAS: Finding the Right Web Sources to Fill Knowledge Gaps	578
Xiaolan Wang (University of Massachusetts Amherst), Xin Luna Dong	
(Amazon Inc.), Yang Li (Google Inc.), and Alexandra Meliou (University	
of Massachusetts Amherst)	

Exploiting Centrality Information with Graph Convolutions for Network Representation Learning	590
Hongxu Chen (The University of Queensland), Hongzhi Yin (The	
University of Queensland), Tong Chen (The University of Queensland),	
Quoc Viet Hung Nguyen (Griffith University), Wen-Chih Peng (National	
Chiao Tung University), and Xue Li (The University of Queensland;	
Dalian Neusoft University of Information)	
Route Recommendations on Road Networks for Arbitrary User Preference Functions Pranali Yawalkar (Google) and Sayan Ranu (IIT Delhi)	. 602
NSCaching: Simple and Efficient Negative Sampling for Knowledge Graph Embedding	614
Yongqi Zhang (the Hong Kong University of Science and Technology),	014
Quanming Yao (4Paradigm), Yingxia Shao (Beijing University of Posts	
and Telecommunications), and Lei Chen (the Hong Kong University of	
Science and Technology)	
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	

### Research (11) - Database Privacy, Security, and Trust

<ul> <li>ServeDB: Secure, Verifiable, and Efficient Range Queries on Outsourced Database</li></ul>
<ul> <li>Collecting and Analyzing Multidimensional Data with Local Differential Privacy</li></ul>
<ul> <li>Partitioned Data Security on Outsourced Sensitive and Non-Sensitive Data</li></ul>
SecEQP: A Secure and Efficient Scheme for SkNN Query Problem Over Encrypted Geodata on Cloud
Joins Over Encrypted Data with Fine Granular Security

## Research (12) - Modern Hardware and In-Memory Database Systems

Column-Oriented Database Acceleration Using FPGAs	686
Satoru Watanabe (Hitachi, Ltd.), Kazuhisa Fujimoto (Hitachi, Ltd.),	
Yuji Saeki (Hitachi, Ltd.), Yoshifumi Fujikawa (Hitachi, Ltd.), and	
Hiroshi Yoshino (Hitachi ULSI Systems Co., Ltd.)	

Hardware-Conscious Hash-Joins on GPUs	698
Panagiotis Sioulas (École polytechnique fédérale de Lausanne),	
Periklis Chrysogelos (École polytechnique fédérale de Lausanne), Manos	
Karpathiotakis (École polytechnique fédérale de Lausanne), Raja	
Appuswamy (École polytechnique fédérale de Lausanne), and Anastasia	
Ailamaki (École polytechnique fédérale de Lausanne)	
	710
Zechao Shang (University of Chicago), Jeffrey Xu Yu (Chinese	
University of Hong Kong), and Zhiwei Zhang (Hong Kong Baptist	
University)	
LDC: A Lower-Level Driven Compaction Method to Optimize SSD-Oriented Key-Value Stores	722
Yunpeng Chai (Renmin University of China), Yanfeng Chai (Renmin	
University of China), Xin Wang (Tianjin University), Haocheng Wei	
(Renmin University of China), Ning Bao (Renmin University of China),	
and Yushi Liang (Renmin University of China)	
No False Negatives: Accepting All Useful Schedules in a Fast Serializable Many-Core System	734
Dominik Durner (Technical University of Munich) and Thomas Neumann	
(Technical University of Munich)	

## Research (13) - Graphs 5: Mining 2

Discovering Maximal Motif Cliques in Large Heterogeneous Information Networks Jiafeng Hu (The University of Hong Kong), Reynold Cheng (The University of Hong Kong), Kevin Chen-Chuan Chang (University of Illinois at Urbana-Champaign), Aravind Sankar (University of Illinois at Urbana-Champaign), Yixiang Fang (The University of Hong Kong), and Brian Y.H. Lam (University of Cambridge)	746
REPT: A Streaming Algorithm of Approximating Global and Local Triangle Counts in Parallel Pinghui Wang (Xi'an Jiaotong University), Peng Jia (Xi'an Jiaotong University, China), Yiyan Qi (Xi'an Jiaotong University, China), Yu Sun (Xi'an Jiaotong University, China), Jing Tao (Xi'an Jiaotong University), and Xiaohong Guan (Xi'an Jiaotong University)	758
Information Diffusion Prediction via Recurrent Cascades Convolution	. 770
Finding Densest Lasting Subgraphs in Dynamic Graphs: A Stochastic Approach Xuanming Liu (University of Massachusetts, Lowell), Tingjian Ge (University of Massachusetts, Lowell), and Yinghui Wu (Washington State University)	782
Multicapacity Facility Selection in Networks Alvis Logins (Aarhus University), Panagiotis Karras (Aarhus University), and Christian S. Jensen (Aalborg University)	.794

## **Research (14) - Query Processing, Indexing and Optimization**

An MBR-Oriented Approach for Efficient Skyline Query Processing Ji Zhang (Auburn University), Wenlu Wang (Auburn University), Xunfei Jiang (Earlham College), Wei-Shinn Ku (Auburn University), and Hua Lu (Aalborg University)	806
Dynamic Set kNN Self-Join Daichi Amagata (Osaka University), Takahiro Hara (Osaka University), and Chuan Xiao (Nagoya University)	818
Packed Memory Arrays - Rewired Dean De Leo (CWI) and Peter Boncz (CWI)	830
GEM ² -Tree: A Gas-Efficient Structure for Authenticated Range Queries in Blockchain Ce Zhang (Hong Kong Baptist University), Cheng Xu (Hong Kong Baptist University), Jianliang Xu (Hong Kong Baptist University), Yuzhe Tang (Syracuse University), and Byron Choi (Hong Kong Baptist University)	842
Effective Filters and Linear Time Verification for Tree Similarity Joins Thomas Hütter (University of Salzburg), Mateusz Pawlik (University of Salzburg), Robert Löschinger (University of Salzburg), and Nikolaus Augsten (University of Salzburg)	854

### **Research (15) - Temporal and Spatial Data 1**

KV-Match: A Subsequence Matching Approach Supporting Normalization and Time Warping	866
Efficient Maximal Spatial Clique Enumeration	878
Cluster-Based Subscription Matching for Geo-Textual Data Streams	890
Time-Dependent Hop Labeling on Road Network	902
<ul> <li>Weight-Constrained Route Planning Over Time-Dependent Graphs</li></ul>	914

## Research (16) - Graphs 6: Data Science

Skyline Queries Constrained by Multi-cost Transportation Networks	926
<ul> <li>Online Social Media Recommendation Over Streams</li> <li>Xiangmin Zhou (RMIT University, Melbourne, Australia), Dong Qin (RMIT</li> <li>University, Melbourne, Australia), Xiaolu Lu (RMIT University,</li> <li>Melbourne, Australia), Lei Chen (Hong Kong University of Science and</li> <li>Technology, Hong Kong, China), and Yanchun Zhang (Victoria University,</li> <li>Melbourne, Australia; CIAT, Guangzhou University, China)</li> </ul>	938
Canonicalization of Open Knowledge Bases with Side Information from the Source Text	950
<ul> <li>Walking with Perception: Efficient Random Walk Sampling via Common Neighbor Awareness</li></ul>	962

### **Research (17) - Search and Information Extraction**

SimMeme: A Search Engine for Internet Memes Tova Milo (Tel Aviv Univesity), Amit Somech (Tel Aviv Univesity), and Brit Youngmann (Tel Aviv Univesity)	974
A Hierarchical Framework for Top-k Location-Aware Error-Tolerant Keyword Search Junye Yang (Tsinghua University), Yong Zhang (Tsinghua University), Xiaofang Zhou (The University of Queensland), Jin Wang (University of California), Huiqi Hu (East China Normal University), and Chunxiao Xing (Tsinghua University)	986
2ED: An Efficient Entity Extraction Algorithm Using Two-Level Edit-Distance	998
Bridging Quantities in Tables and Text Yusra Ibrahim (Max Planck Institute for Informatics), Mirek Riedewald (Northeastern University), Gerhard Weikum (Max Planck Institute for Informatics), and Demetrios Zeinalipour-Yazti (University of Cyprus)	1010

## **Research (18) - Temporal and Spatial Data 2**

<ul> <li>An Efficient Insertion Operator in Dynamic Ridesharing Services</li></ul>	)22
Auction-Based Order Dispatch and Pricing in Ridesharing	134
<ul> <li>When Geo-Text Meets Security: Privacy-Preserving Boolean Spatial Keyword Queries</li></ul>	)46
<ul> <li>Moving Object Linking Based on Historical Trace</li></ul>	)58
<ul> <li>ImageProof: Enabling Authentication for Large-Scale Image Retrieval</li></ul>	070

### Research (19) - Graphs 7: Mining 3

<ul> <li>Time Constrained Continuous Subgraph Search Over Streaming Graphs</li></ul>
<ul> <li>Utilizing Dynamic Properties of Sharing Bits and Registers to Estimate User Cardinalities Over Time</li></ul>
Key Laboratory for Intelligent Networks and Network Security, Xi'an Jiaotong University, China; Department of Automation and NLIST Lab, Tsinghua University, Beijing, China), and Don Towsley (School of Computer Science, University of Massachusetts Amherst, MA, USA)

Tracking Influential Nodes in Time-Decaying Dynamic Interaction Networks	106
Junzhou Zhao (King Abdullah University of Science and Technology),	
Shuo Shang (Inception Institute of Artificial Intelligence), Pinghui	
Wang (Xi'an Jiaotong University), John C.S. Lui (The Chinese	
University of Hong Kong), and Xiangliang Zhang (King Abdullah	
University of Science and Technology)	
Fast and Accurate Graph Stream Summarization	118
Xiangyang Gou (Peking University), Lei Zou (Peking University),	
Chenxingyu Zhao (Peking University), and Tong Yang (Peking University)	
Mining Periodic Cliques in Temporal Networks	130
Hongchao Qin (Northeastern University), Rong-Hua Li (Beijing Institute	
of Technology), Guoren Wang (Beijing Institute of Technology), Lu Qin	
(University of Technology Sydney), Yurong Cheng (Beijing Institute of	
Technology), and Ye Yuan (Northeastern University)	

## **Research (20) - Data Integration, Probabilistic Databases**

Coloring Embedder: A Memory Efficient Data Structure for Answering Multi-set Query
<ul> <li>Mining Order-Preserving Submatrices Under Data Uncertainty: A Possible-World Approach</li></ul>
Multi-Dimensional Genomic Data Management for Region-Preserving Operations
<ul> <li>Improved Algorithms for Maximal Clique Search in Uncertain Networks</li></ul>
Lazo: A Cardinality-Based Method for Coupled Estimation of Jaccard Similarity and Containment

Samuel	Madden	(MIT

## Research (21) - Indexing

<ul> <li>TARDIS: Distributed Indexing Framework for Big Time Series Data</li></ul>	202
<ul> <li>Mostly Order Preserving Dictionaries</li></ul>	214
Multi-copy Cuckoo Hashing	226
Efficient Scalable Multi-attribute Index Selection Using Recursive Strategies	238
To Index or Not to Index: Optimizing Exact Maximum Inner Product Search	250

## **Research (22) - Road Networks**

Distributed In-memory Trajectory Similarity Search and Join on Road Network	1262
Stochastic Weight Completion for Road Networks Using Graph Convolutional Networks Jilin Hu (Aalborg University), Chenjuan Guo (Aalborg University), Bin Yang (Aalborg University), and Christian S. Jensen (Aalborg University)	1274
Identifying the Most Interactive Object in Spatial Databases Daichi Amagata (Osaka University) and Takahiro Hara (Osaka University)	1286
An Efficient Framework for Correctness-Aware kNN Queries on Road Networks Dan He (University of Queensland), Sibo Wang (the Chinese University of Hong Kong), Xiaofang Zhou (University of Queensland), and Reynold Cheng (the University of Hong Kong)	1298
MPR — A Partitioning-Replication Framework for Multi-Processing kNN Search on Road Networks Siqiang Luo (The University of Hong Kong), Ben Kao (The University of Hong Kong), Xiaowei Wu (University of Vienna), and Reynold Cheng (The University of Hong Kong)	1310

### **Research (23) - Learning, Temporal and Spatial Data**

<ul> <li>AppUsage2Vec: Modeling Smartphone App Usage for Prediction</li></ul>	1322
<ul> <li>iFair: Learning Individually Fair Data Representations for Algorithmic Decision Making</li></ul>	1334
<ul> <li>DBSCAN-MS: Distributed Density-Based Clustering in Metric Spaces</li></ul>	1346
Computing Trajectory Similarity in Linear Time: A Generic Seed-Guided Neural Metric Learning Approach Di Yao (Institute of Computing Technology, Chinese Academy of Sciences), Gao Cong (Nanyang Technological University, Singapore), Chao Zhang (University of Illinois at Urbana-Champaign), and Jingping Bi (Institute of Computing Technology, Chinese Academy of Sciences)	1358
Bursty Event Detection Throughout Histories	1370

## Research (24) - Knowledge Discovery

RUM: Network Representation Learning Using Motifs	1382
Finding Significant Items in Data Streams Tong Yang (Peking University, China), Haowei Zhang (Peking University, China), Dongsheng Yang (Peking University, China), Yucheng Huang (Peking University, China), and Xiaoming Li (Peking University, China)	1394
Knowledge-Aware Deep Dual Networks for Text-Based Mortality Prediction Ning Liu (Tsinghua University), Pan Lu (Tsinghua University), Wei Zhang (East China Normal University), and Jianyong Wang (Tsinghua University)	1406
Robust High Dimensional Stream Classification with Novel Class Detection Zhuoyi Wang (University of Texas at Dallas), Zelun Kong (University of Texas at Dallas), Swarup Changra (University of Texas at Dallas), Hemeng Tao (University of Texas at Dallas), and Latifur Khan (University of Texas at Dallas)	1418
Towards the Completion of a Domain-Specific Knowledge Base with Emerging Query Terms Sihang Jiang (Fudan University), Jiaqing Liang (Fudan University), Yanghua Xiao (Fudan University), Haihong Tang (Alibaba Group), Haikuan Huang (Alibaba Group), and Jun Tan (Alibaba Group)	1430

## Research (25) - Crowdsourcing and Learning

Cooperation-Aware Task Assignment in Spatial Crowdsourcing Peng Cheng (HKUST), Lei Chen (HKUST), and Jieping Ye (AI Labs, DiDi Chuxing)	1442
Minimizing Maximum Delay of Task Assignment in Spatial Crowdsourcing	1454
<ul> <li>Physical Representation-Based Predicate Optimization for a Visual Analytics Database</li></ul>	1466
<ul> <li>Adaptive Dynamic Bipartite Graph Matching: A Reinforcement Learning Approach</li></ul>	1478

## **Research (26) - Data Mining**

Scalable Frequent Sequence Mining with Flexible Subsequence Constraints	1490
<ul> <li>Adaptive Influence Blocking: Minimizing the Negative Spread by Observation-Based Policies</li></ul>	1502
<ul> <li>Fraction-Score: A New Support Measure for Co-location Pattern Mining</li></ul>	1514
Discovery and Ranking of Functional Dependencies	1526
Adaptive Deep Reuse: Accelerating CNN Training on the Fly	1538

## **Research Short Papers**

Slic	e Finder: Automated Data Slicing for Model Validation	1550
	Yeounoh Chung (Brown University), Tim Kraska (MIT), Neoklis Polyzotis	
	(Google Research), Ki Hyun Tae (KAIST), and Steven Euijong Whang	
	(KAIŠT)	

<ul> <li>Neural Multi-task Recommendation from Multi-behavior Data</li></ul>	554
<ul> <li>AUC-MF: Point of Interest Recommendation with AUC Maximization</li></ul>	558
Efficient Batch One-Hop Personalized PageRanks	562
BB-Tree: A Main-Memory Index Structure for Multidimensional Range Queries	566
<ul> <li>Explaining Queries Over Web Tables to Non-experts</li></ul>	570
Nonlinear Models Over Normalized Data       15         Zhaoyue Cheng (University of Toronto) and Nick Koudas (University of Toronto)       15	574
Continuous Search on Dynamic Spatial Keyword Objects	578
Top-K Frequent Term Queries on Streaming Data       15         Sara Farazi (University of Alberta) and Davood Rafiei (University of Alberta)       15	582
<ul> <li>Parallel and Distributed Processing of Reverse Top-k Queries</li></ul>	586
Distributed Discovery of Functional Dependencies	590
<ul> <li>AID: An Adaptive Image Data Index for Interactive Multilevel Visualization</li></ul>	594

<ul> <li>Collecting Preference Rankings Under Local Differential Privacy</li></ul>	3
Muses: Distributed Data Migration System for Polystores	2
PriSTE: From Location Privacy to Spatiotemporal Event Privacy	5
Continuous Range Queries Over Multi-attribute Trajectories	)
Insecurity and Hardness of Nearest Neighbor Queries Over Encrypted Data	ŀ
Modeling Multidimensional User Preferences for Collaborative Filtering       1618         Farhan Khawar (The Hong Kong University of Science and Technology) and       1618         Nevin L. Zhang (The Hong Kong University of Science and Technology)       1618	3
A Queueing-Theoretic Framework for Vehicle Dispatching in Dynamic Car-Hailing	2
Maximizing the Utility in Location-Based Mobile Advertising	5
Automated Grading of SQL Queries	)
Parameter Discovery in Unsupervised Clustering	ŀ
Interaction-Aware Arrangement for Event-Based Social Networks       1638         Feifei Kou (Beijing University of Posts and Telecommunications), Zimu       2hou (ETH Zurich), Hao Cheng (Beihang University), Junping Du (Beijing         University of Posts and Telecommunications), Yexuan Shi (Beihang       University), and Pan Xu (University of Maryland)	;
Optimizing Cross-Platform Data Movement	2

<ul> <li>Highly Efficient Pattern Mining Based on Transaction Decomposition</li></ul>	46
Procrastination-Aware Scheduling: A Bipartite Graph Perspective	50
<ul> <li>Hankel Matrix Factorization for Tagged Time Series to Recover Missing Values During Blackouts</li></ul>	54
<ul> <li>PerRD: A System for Personalized Route Description</li></ul>	58
<ul> <li>Scalable Metric Similarity Join Using MapReduce</li></ul>	52
<ul> <li>An Indexing Framework for Efficient Visual Exploratory Subgraph Search in Graph Databases</li></ul>	56
I-LSH: I/O Efficient c-Approximate Nearest Neighbor Search in High-Dimensional Space	70
T-Sample: A Dual Reservoir-Based Sampling Method for Characterizing Large Graph Streams	74

Real Time Principal Component Analysis	578
A Fast Sketch Method for Mining User Similarities Over Fully Dynamic Graph Streams	582
A Collaborative Framework for Similarity Enforcement in Synthetic Scaling of Relational Datasets	586
Meta Diagram Based Active Social Networks Alignment	590
Entity Integrity, Referential Integrity, and Query Optimization with Embedded Uniqueness Constraints 16 Ziheng Wei (The University of Auckland), Uwe Leck (The University of Flensburg), and Sebastian Link (The University of Auckland)	594
Efficient Pattern Mining Based Cryptanalysis for Privacy-Preserving Record Linkage	598
<ul> <li>ECOQUG: An Effective Ensemble Community Scoring Function</li></ul>	702
<ul> <li>CN-Probase: A Data-Driven Approach for Large-Scale Chinese Taxonomy Construction</li></ul>	706
Understanding Data Science Lifecycle Provenance via Graph Segmentation and Summarization	710
Efficient Partitioning and Query Processing of Spatio-Temporal Graphs with Trillion Edges	714
Top-K Entity Resolution with Adaptive Locality-Sensitive Hashing       17         Vasilis Verroios (Stanford University) and Hector Garcia-Molina	718
Finding Average Regret Ratio Minimizing Set in Database	122

<ul> <li>HyMJ: A Hybrid Structure-Aware Approach to Distributed Multi-way Join Query</li></ul>
<ul> <li>Accelerate MaxBRkNN Search by kNN Estimation</li></ul>
Efficient Bottom-Up Discovery of Multi-scale Time Series Correlations Using Mutual Information
Fingerprinting Big Data: The Case of KNN Graph Construction
Outer and Anti Joins in Temporal-Probabilistic Databases
<ul> <li>Workload-Driven Fragment Allocation for Partially Replicated Databases Using Linear Programming 1746</li> <li>Stefan Halfpap (Hasso Plattner Institute, University of Potsdam, Germany) and Rainer Schlosser (Hasso Plattner Institute, University of Potsdam, Germany)</li> </ul>
OSMAC: Optimizing Subgraph Matching Algorithms with Community Structure
Workload-Aware Subgraph Query Caching and Processing in Large Graphs
How I Learned to Stop Worrying and Love Re-optimization
CRA: Enabling Data-Intensive Applications in Containerized Environments

## **Industry Track**

## Industry (1) - Data Systems Optimizations

Scalable Similarity Joins of Tokenized Strings	1766
Ahmed Metwally (LinkedIn) and Chun-Heng Huang (Google)	

MLlib*: Fast Training of GLMs Using Spark MLlib	1778
Zhipeng Zhang (Peking University), Jiawei Jiang (Tencent Inc.), Wentao	
Wu (Microsoft Research, Redmond, USA), Ce Zhang (ETH Zurich,	
Switzerland), Lele Yu (Tencent Inc.), and Bin Cui (Peking University)	
DirectLoad: A Fast Web-Scale Index System Across Large Regional Centers	1790
An Qin (Baidu Inc.), Mengbai Xiao (The Ohio State University), Jin Ma	
(Baidu Inc.), Dai Tan (Baidu Inc.), Rubao Lee (United Parallel	
Computing Corporation), and Xiaodong Zhang (The Ohio State University)	
Presto: SQL on Everything	1802
Raghav Sethi (Facebook, Inc.), Martin Traverso (Facebook, Inc.), Dain	
Sundstrom (Facebook, Inc.), David Phillips (Facebook, Inc.), Wenlei	
Xie (Facebook, Inc.), Yutian Sun (Facebook, Inc.), Nezih Yegitbasi	
(Facebook, Inc.), Haozhun Jin (Facebook, Inc.), Eric Hwang (Facebook,	
Inc.), Nileema Shingte (Facebook, Inc.), and Christopher Berner	
(Facebook, Inc.)	
Improving RDF Query Performance Using In-memory Virtual Columns in Oracle Database	1814

Eugene Inseok Chong (Oracle), Matthew Perry (Oracle), and Souripriya
Das (Oracle)

## Industry (2) - Data Analytics

SEBDB: Semantics Empowered BlockChain DataBase	1820
<ul> <li>Large Scale Traffic Signal Network Optimization - A Paradigm Shift Driven by Big Data</li> <li>Liang Yu (Alibaba Cloud), Jinqiang Yu (Alibaba Cloud), Maolei Zhang</li> <li>(Alibaba Cloud), Xin Zhang (Alibaba Cloud), Yuehu Liu (Alibaba Cloud),</li> <li>Hui Zhang (Alibaba Cloud), and Wanli Min (Alibaba Cloud)</li> </ul>	1832
Domain-Independent Automated Processing of Free-Form Text Data in Telecom Rajarshi Bhowmik (Rutgers University) and Ahmet Akyamac (Bell Labs, Nokia)	1841
DRIVEN: a Framework for Efficient Data Retrieval and Clustering in Vehicular Networks Bastian Havers (Chalmers University), Romaric Duvignau (Chalmers University), Hannaneh Najdataei (Chalmers University), Vincenzo Gulisano (Chalmers University), Ashok Chaitanya Koppisetty (Volvo Cars), and Marina Papatriantafilou (Chalmers University)	1850

## Industry (3) - Driving Business Applications

Accurate Product Attribute Extraction on the Field	1862
Martin Rezk (Rakuten Inc), Laura Alonso Alemany (Universidad Nacional	
de Cordoba), Lasguido Nio (Rakuten Inc), and Ted Zhang (Rakuten Inc)	

CATS: Cross-Platform E-Commerce Fraud Detection
<ul> <li>Caladrius: A Performance Modelling Service for Distributed Stream Processing Systems</li></ul>
<ul> <li>FAIR: Fraud Aware Impression Regulation System in Large-Scale Real-Time E-Commerce Search Platform . 1898</li> <li>Zhao Li (Alibaba Group), Junshuai Song (Peking University), Shichang</li> <li>Hu (Alibaba Group), Shasha Ruan (Alibaba Group), Long Zhang (Alibaba</li> <li>Group), Zehong Hu (Alibaba Group), and Jun Gao (Peking University)</li> </ul>
Micro-Browsing Models for Search Snippets

## Industry (4) - Learning from Data

Interpretable Multi-task Learning for Product Quality Prediction with Attention Mechanism	10
Learning Effective Embeddings From Crowdsourced Labels: An Educational Case Study	122
<ul> <li>A Prescription Trend Analysis using Medical Insurance Claim Big Data</li></ul>	28
<ul> <li>Differential Data Quality Verification on Partitioned Data</li></ul>	940
Logan: A Distributed Online Log Parser	946

## **Demo Track**

#### **Demo Session 1**

<ul> <li>WebPut: A Web-Aided Data Imputation System for the General Type of Missing String Attribute Values 1952 Shuangli Shan (Soochow University, China; Neusoft Corporation), Zhixu Li (Soochow University, China), Yang Li (Soochow University, China), Qiang Yang (King Abdullah University of Science and Technology, Saudi Arabia), Jia Zhu (South China Normal University), Mohamed Sharaf (The University of Queensland), and Xiaofang Zhou (The University of Queensland)</li> </ul>	2
<ul> <li>FGreat: Focused Graph Query Autocompletion</li></ul>	5
<ul> <li>Aucher: Multi-modal Queries on Live Audio Streams in Real-Time</li></ul>	)
<ul> <li>SAC: A System for Big Data Lineage Tracking</li></ul>	ł
A Gossip-Based System for Fast Approximate Score Computation in Multinomial Bayesian Networks 1968 Arun Zachariah (University of Missouri-Kansas City), Praveen Rao (University of Missouri-Kansas City), Anas Katib (University of Missouri-Kansas City), Monica Senapati (University of Missouri-Kansas City), and Kobus Barnard (University of Arizona)	3
<ul> <li>Faster, Higher, Stronger: Redesigning Spreadsheets for Scale</li></ul>	2
RecovDB: Accurate and Efficient Missing Blocks Recovery for Large Time Series	5

AI Pro: Data Processing Framework for AI Models	. 1980
IVLG: Interactive Visualization of Large Graphs Maria Krommyda (NTUA), Verena Kantere (University of Ottawa), and Yannis Vassiliou (NTUA)	. 1984
Just in Time: Personal Temporal Insights for Altering Model Decisions Naama Boer (Tel Aviv University), Daniel Deutch (Tel Aviv University), Nave Frost (Tel Aviv University), and Tova Milo (Tel Aviv University)	. 1988
GeoSparkViz in Action: A Data System with Built-in Support for Geospatial Visualization Jia Yu (Arizona State University), Anique Tahir (Arizona State University), and Mohamed Sarwat (Arizona State University)	1992
Hybrid.Poly: A Consolidated Interactive Analytical Polystore System Maksim Podkorytov (Florida State University) and Michael Gubanov (Florida State University)	. 1996

#### **Demo Session 2**

<ul> <li>EXPLAINER: Entity Resolution Explanations</li></ul>
CEP-Wizard: Automatic Deployment of Distributed Complex Event Processing
A Comparison of Allocation Algorithms for Partially Replicated Databases
PePPer: Fine-Grained Personal Access Control via Peer Probing
COBRA: Compression Via Abstraction of Provenance for Hypothetical Reasoning
CogLearn: A Cognitive Graph-Oriented Online Learning System
GRIT: Consistent Distributed Transactions Across Polyglot Microservices with Multiple Databases
vABS: Towards Verifiable Attribute-Based Search Over Shared Cloud Data

An Environment-Aware Market Strategy for Data Allocation and Dynamic Migration in Cloud Database 2032 Tengjiao Wang (Peking University), Binyang Li (University of International Relations), Wei Chen (Peking University), Yuxiao Zhang (Peking University), Ying Han (Peking University), Jinzhong Niu (City University of New York), and Kam-fai Wong (The Chinese University of Hong Kong)
<ul> <li>Vaite: A Visualization-Assisted Interactive Big Urban Trajectory Data Exploration System</li></ul>
<ul> <li>SciDetector: Scientific Event Discovery by Tracking Variable Source Data Streaming</li></ul>
Demonstrating Spindra: A Geographic Knowledge Graph Management System

## Tutorials

Native Storage Techniques for Data Management Ilia Petrov (Reutlingen University), Andreas Koch (Technische Universität Darmstadt), Sergey Hardock (Technische Universität Darmstadt), Tobias Vincon (Reutlingen University), and Christian Riegger (Reutlingen University)	2048
Crowdsourcing Database Systems: Overview and Challenges Chengliang Chai (Tsinghua University), Ju Fan (Renmin University), Guoliang Li (Tsinghua University), Jiannan Wang (Simon Fraser University), and Yudian Zheng (Twitter)	2052
Telco Big Data Research and Open Problems Constantinos Costa (University of Pittsburgh) and Demetrios Zeinalipour-Yazti (University of Cyprus)	2056
Geospatial Data Management in Apache Spark: A Tutorial Jia Yu (Arizona State University) and Mohamed Sarwat (Arizona State University)	2060
Hierarchical Decomposition of Big Graphs Ying Zhang (University of Technology Sydney), Lu Qin (University of Technology Sydney), Fan Zhang (University of New South Wales), and Wenjie Zhang (University of New South Wales)	2064

Cohesive Subgraph Computation Over Large Sparse Graphs	2068
Lijun Chang (The University of Sydney) and Lu Qin (University of	
Technology Sydney)	
Robust Query Processing: Mission Possible	2072
Jayant R. Haritsa (Indian Institute of Science)	

## PhD Symposium

Automated Documentation of End-to-End Experiments in Data Science	2076
Explaining Results of Data-Driven Applications	2081
Towards Explaining the Effects of Data Preprocessing on Machine Learning	2086
Don't Fear the REAPER: A Framework for Materializing and Reusing Deep-Learning Models	2091
Knowledge Representation for Emotion Intelligence       2         Shuo Wang (Renmin University of China)	2096
Disambiguation and Result Expansion in Keyword Search Over Relational Databases	2101
Event Recommendation using Social Media	2106

## **TKDE Posters**

11
13
15
17

Efficient Multi-Class Probabilistic SVMs on GPUs	119
C2Net: A Network-Efficient Approach to Collision Counting LSH Similarity Join(Extended Abstract) 21 Hangyu Li (City University of Hong Kong), Sarana Nutanong (Vidyasirimedhi Institute of Science and Technology), Hong Xu (City University of Hong Kong), Chenyun Yu (City University of Hong Kong), and Foryu Ha (City University of Hong Kong)	121
LinkBlackHole*: Robust Overlapping Community Detection Using Link Embedding (Extended Abstract) 21 Jungeun Kim (KAIST), Sungsu Lim (Chungnam National University), Jae-Gil Lee (KAIST), and Byung Suk Lee (University of Vermont)	123
<ul> <li>Fusion OLAP: Fusing the Pros of MOLAP and ROLAP Together for In-memory OLAP (Extended Abstract) 21</li> <li>Yansong Zhang (Renmin University of China), Yu Zhang (National</li> <li>Satellite Meteorological Centre, Beijing, China), Shan Wang (Renmin</li> <li>University of China), and Jiaheng Lu (University of Helsinki)</li> </ul>	125
In Search of Indoor Dense Regions: An Approach Using Indoor Positioning Data	127
Optimizing Quality for Probabilistic Skyline Computation and Probabilistic Similarity Search       21         (Extended Abstract)       21         Xiaoye Miao (Zhejiang University), Yunjun Gao (Zhejiang University),       21         Linlin Zhou (Zhejiang University), Wei Wang (University of New South       21         Wales), and Qing Li (The Hong Kong Polytechnic University)       21	129
On Efficiently Answering Why-Not Range-Based Skyline Queries in Road Networks (Extended Abstract) 21 Xiaoye Miao (Zhejiang University), Yunjun Gao (Zhejiang University), Su Guo (Zhejiang University), and Gang Chen (Zhejiang University)	131
<ul> <li>SLADE: A Smart Large-Scale Task Decomposer in Crowdsourcing</li></ul>	133
<ul> <li>XINA: Explainable Instance Alignment using Dominance Relationship (Extended Abstract)</li></ul>	135
A Hardware-Accelerated Solution for Hierarchical Index-Based Merge-Join(Extended Abstract)	137
<ul> <li>Finding Most Popular Indoor Semantic Locations Using Uncertain Mobility Data</li></ul>	139

Uncertain Graph Sparsification (Extended Abstract)
Rule-Based Entity Resolution on Database with Hidden Temporal Information (Extended Abstract)
<ul> <li>BRIGHT - Drift-Aware Demand Predictions for Taxi Networks (Extended Abstract)</li></ul>
Order-Sensitive Imputation for Clustered Missing Values (Extended Abstract)
DeepDirect: Learning Directions of Social Ties with Edge-Based Network Embedding (Extended Abstract) 2149 Chaokun Wang (Tsinghua University), Changping Wang (Tsinghua University), Zheng Wang (Tsinghua University), Xiaojun Ye (Tsinghua University), Jeffrey Xu Yu (Chinese University of Hong Kong), and Bin Wang (Tsinghua University)
A Utility-Optimized Framework for Personalized Private Histogram Estimation (Extended Abstract)
<ul> <li>Near-Accurate Multiset Reconciliation (Extended Abstract)</li></ul>
<ul> <li>Answering Why-Not Group Spatial Keyword Queries (Extended Abstract)</li></ul>
Effective and Efficient Community Search Over Large Directed Graphs (Extended Abstract)

Exploring Communities in Large Profiled Graphs (Extended Abstract)	2159
Yankai Chen (The University of Hong Kong), Yixiang Fang (The	
University of Hong Kong), Reynold Cheng (The University of Hong Kong),	
Yun Li (Nanjing University), Xiaojun Chen (Shenzhen University), and	
Jie Zhang (Nanyang Technological University)	
Index-Based Densest Clique Percolation Community Search in Networks (Extended Abstract)	2161
Long Yuan (Nanjing University of Science and Technology), Lu Qin	
(QCIS, University of Technology, Sydney), Wenjie Zhang (The University	
of New South Wales), Lijun Chang (The University of Sydney), and	
Jianye Yang (Central South University)	

Author Index	 	 3