Pramod Anantharam

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Probabilistic machine learning for Internet of Things applications
Ohio Center of Excellence in Knowledge-enabled Computing (Kno.e.sis),
377 Joshi Research Center,
3640 Colonel Glenn Highway,
Dayton, OH, USA 45435
+1 937-708-9327
Homepage, Google Scholar, LinkedIn, G+   pramod.anantharam@us.bosch.com

Education

- **Wright State University**   Dayton, USA
  Doctor of Philosophy (PhD) in Computer Science and Engineering   *May 2009 - April 2016*
    - Dissertation title: *Knowledge-empowered Probabilistic Graphical Models for Physical-Cyber-Social Systems*

- **Visvesvaraya Technological University**   Bangalore, India
  Bachelor of Engineering (BE) in Electrical and Electronics   *2002 - 2006*

Awards & Recognition

- 2015 Selected to participate in the NSF-funded Data Science Workshop at University of Washington, Seattle, Aug 5–7.

- 2015 Our ACM Transactions on Intelligent Systems (TIST) Journal paper was a featured article on the ACM TIST website and the 5th most downloaded article.

- 2014 Offered the Eric & Wendy Schmidt Data Science for Social Good Fellowship.

- 2013 A short article on my research appeared in Wright State University newsroom.

- 2013 Invited to attend Dagstuhl Seminar on Physical-Cyber-Social Computing.

- 2013 Invited to present my work on *Data Analytics for Internet of Things (IoT)* at University of Debrecen, Hungary.

- 2012 NSF travel award for attending the International Semantic Web Conference (ISWC).

- 2012 Best research showcase award for my internship work at IBM Research, India.

Professional Activities

- Program Committee member: IEEE Internet of Things Journal - 2016, Data Mining and Knowledge Discovery Journal - 2016, Semantics and Knowledge track at 26th International World Wide Web (WWW) Conference, ESWC 2016, Web Science track at WWW 2016, Semantics and Big Data track at WWW 2016, Semantic Sensor Networks and Terra Cognita (SSN-TC) at ISWC 2015, Journal of Internet Services and Applications, ISWC 2015, The 6th Workshop on Semantics for Smarter Cities (S4SC 2015) at ISWC 2015, Web Science Track at WWW 2015, 5th Workshop on Semantics for Smarter Cities at ISWC 2014, Second International Workshop on Internet of

Things, in Conjunction with CollaborateCom 2014, Semantic Sensor Network Workshop at ISWC 2013, ISWC 2014, The ICSE 2014 Workshop on Inclusive Web Programming, Hypertext 2014, Web Science Track at WWW 2014, SSN Workshop at ISWC 2013, DeRiVE Workshop, ISWC 2013, IJCAI 2013

- Society Membership: SIAM (Society for Industrial and Applied Mathematics)

Professional Experience

- **Research Scientist**   Bezirk, Robert Bosch LLC, Pittsburgh, PA, USA
  Expert, IoT Personalization Technologies   *May 2016 - Present*
  - Keywords: Probabilistic machine learning, resource constrained learning, personalization, recommendation
  - Constantly keep abreast of innovations and technology trends in Personalization in the IoT to constantly push towards next generation products
  - Develop new ideas and prototypes to demonstrate possible technical directions and value proposition by communicating ideas to both technical and business teams
  - Design and implement software encapsulating new ideas and prototypes in the form of products that utilize IoT Personalization in variety of domains

- **Bosch Research and Technology Center**   Pittsburgh, PA
  Research Intern   *May 2014 - Aug 2014*
  - Widespread use of mobile devices and availability of sensors has resulted in unprecedented opportunities across many domains. One such opportunity is in leveraging Internet of Things (IoT) environment for assisting people in Do-It-Yourself (DIY) tasks.
  - I worked on representation of tasks and recommendation of step-by-step instructions to accomplish DIY tasks in IoT environment.
  - Specifically, I proposed a Markov Decision Process (MDP) based approach for task recommendation. I also worked on transforming domain knowledge of tasks (such as task complexity and resource requirements) into MDP parameters.
  - My work was deployed as a task recommendation module into a larger IoT middleware designed by Bosch.

- **University of Surrey**   Guildford, United Kingdom
  Visiting Doctoral Student   *Sep 2013 - Dec 2013*
  - Cities are crippling under immense pressure from increasing people and limited natural resources, given that three-quarters of the worlds population will be living in cities by 2050.
  - A city with intelligent infrastructure would be a boon to its citizens and also facilitate conservation and efficient utilization of natural resources. Many citizens in a city talk about various problems they face and even recommend possible solutions.
  - At Center for Communications Systems Research (CCSR), I worked closely with Dr. Payam Barnaghi on the problem of extracting city traffic-related events from Twitter.
  - Specifically, I proposed algorithms to extract traffic events from short text messages from a city and compared it with ground-truth data from city authorities with promising results.

- **IBM Research**   Delhi, India.
  Research Intern   *Jun 2012 - Sep 2012*
  - Traffic is a major challenge in most of the cities around the world for both citizens and city policy makers.

- My research focused on leveraging dynamic SMS updates of traffic incidents from city authorities in the city of Delhi to assess its impact on traffic. Further, I worked on updating static schedule of public transport vehicles based on these dynamic updates.
- The result of my internship work was integrated into a journey planner called IRL-Transit used to provide event-aware route recommendation for commuters.
- My work was awarded the best research showcase in the poster presentation competition.

- **IBM Research** — Delhi, India.
  Research Intern — *Jun 2011 - Sep 2011*
  - I worked on a project that was part of the IBM Smart Planet initiative. Specifically, I worked on devising Bayesian reasoning techniques to evolve a Smart City ontology.
  - The ontology had concepts and relationships describing various systems in a city, e.g. departments and services offered by them. Services offered by different departments may vary from one city to the other.
  - Departments in a city may choose to add or remove new service offerings. Starting from a core ontology, incoming evidences (terms extracted from domain specific documents) were analyzed to evolve the core ontology.

- **Hewlett-Packard Global Soft Ltd** — Bangalore, India.
  Software Engineer — *Jul 2006 - Dec 2008*
  - My role was to develop and enhance various software applications involving content management systems.
  - I was responsible for many application migrations that were part of DCC (Data Center Consolidation) project.
  - I was recognized for my contributions in the form of e-awards. Some technical skills gained are shell scripting, Java programming, and use of Documentum for content management applications.

- **Honeywell Technology Solutions Lab** — Bangalore, India.
  Intern — *Feb 2006 - May 2006*
  - The goal of this internship was to develop an Internet-enabled device that monitored a set of sensors attached to it and reported the sensor observations to a database.
  - People or an application can use these observations and take appropriate action based on sensor states.
  - The complete implementation of the project was done in C. Some technical skills acquired are in utilizing a microcontroller and its interfacing with sensors resulting in my first IoT project.

Research Experience

- **Graduate Research Assistant** — Kno.e.sis
  Lead Researcher, Sustainability and IoT — *Jan 2012 - April 2016*
  - Keywords: Event extraction from text, sensor data analysis, time series analysis, anomaly detection, linear dynamical systems
  - Collaboration: CityPulse consortium, IBM Research
  - Extraction of traffic-related events in a city from social data (e.g., SMS messages, Twitter)
  - Modeling and understanding traffic dynamics using time series models
  - Understanding city traffic-related events utilizing both sensor and social data streams

- **Graduate Research Assistant**   Kno.e.sis
  Lead Researcher, kHealth for Asthma   *Dec 2012 - April 2016*
    - Keywords: Asthma management, active sensing, passive sensing, sensors and mobile devices
    - Collaboration: Dayton Children's
    - Lead the development of sensor-enabled mobile application for collecting asthma-related observations from personal, public, and population level sources
    - Completed a pilot study involving six patients with promising results in combining active sensing (user involved in data collection) with passive sensing (user not involved in data collection)
    - Took lead in writing a NIH proposal which received very good ratings; awaiting funding

- **Graduate Research Assistant**   Kno.e.sis
  Team member, Semantic Sensor Web project   *Sep 2009 - Dec 2011*
    - Keywords: Knowledge representation, sensor modeling, observation modeling, annotation, trustworthiness, Bayesian models
    - Worked on modeling sensors and their observations using the W3C Semantic Sensor Network ontology for various applications and sponsor requirements
    - Assessing trustworthiness of sensor nodes utilizing Bayesian approaches
    - Implemented a Bayesian reputation system for over 30,000 weather stations from MesoWest

- **Teaching Assistant**   Computer Science Dept., Wright State University
  C programming lab   *Sep 2009 - March 2010*
    - Responsible for teaching basic C programming and conducting lab sessions

- **Graduate Research Assistant**   Kno.e.sis
  Team member, Twitris project   *Feb 2009 - Aug 2009*
    - Keywords: Text processing, relevance ranking
    - Worked on algorithms to fetch relevant multimedia content from various sources based on the event descriptors.

- **Graduate Research Assistant**   Kno.e.sis
  Team member, T.cruzi project   *Feb 2009 - Aug 2009*
    - Keywords: Semantic technologies, Resource Description Framework (RDF), Web Ontology Language (OWL), SPARQL Protocol and RDF Query Language (SPARQL)
    - Responsible for ontology-driven RDF translation of relational data
    - Explored tools like D2RQ engine, Jena, and other APIs for reading and writing RDF data

Patents

Co-inventor of 2 US Patents

- US20150006644 A1: Assessing Impact of Events on Public Transportation Network

- US20140372364 A1: A System and Method for Utility-Based Evolution in a Constrained Ontology

Tutorials

- **Pramod Anantharam**, Amit Sheth, and Payam Barnaghi, Data Processing and Semantics for Advanced Internet of Things (IoT) Applications: modeling, annotation, integration, and perception, at the International Conference on Web Intelligence, Mining, and Semantics (WIMS 13), Madrid, Spain, June 12 - 14, 2013.

- Krishnaprasad Thirunarayan and **Pramod Anantharam**, Trust Networks: Interpersonal, Sensor, and Social, In: Proceedings of 2011 International Conference on Collaborative Technologies and Systems (CTS 2011), Philadelphia, Pennsylvania, USA, May 23-27, 2011.

Publications

1 Journal Papers

- Krishnaprasad Thirunarayan, **Pramod Anantharam**, Cory Henson, and Amit Sheth, Comparative Trust Management with Applications: Bayesian Approaches Emphasis, In the Journal of Future Generation Computer Systems (FGCS), Elsevier, 25 pages, May 2013, http://dx.doi.org/10.1016/j.future.2013.05.006 [Impact Factor: 2.63]

- **Pramod Anantharam**, Payam Barnaghi, Krishnaprasad Thirunarayan, and Amit Sheth. 2015. Extracting city traffic events from social streams. ACM Trans. Intell. Syst. Technol. 6, 4, Article 43 (June 2015), 27 pages. DOI: http://dx.doi.org/10.1145/2717317

2 Conference and Workshop Papers

- **Pramod Anantharam**, Krishnaprasad Thirunarayan, Surendra Marupudi, Amit Sheth, and Tanvi Banerjee. (2016) Understanding City Traffic Dynamics Utilizing Sensor and Textual Observations. at The Thirtieth AAAI Conference on Artificial Intelligence (AAAI-16), February 12–17, Phoenix, Arizona, USA (accepted).

- Tanvi Banerjee, **Pramod Anantharam**, William L. Romine, Larry Lawhorne, and Amit Sheth, Evaluating a Potential Commercial Tool for Healthcare Application for People with Dementia , International Conference on Health Informatics and Medical Systems (HIMS), July 27-30, 2015, Las Vegas, USA.

- **Pramod Anantharam**, Tanvi Banerjee, Amit Sheth, Krishnaprasad Thirunarayan, Surendra Marupudi, Vaikunth Sridharan, and Shalini G. Forbis, Knowledge-driven Personalized Contextual mHealth Service for Asthma Management in Children , IEEE 4th International Conference on Mobile Services, June 27 - July 2, 2015, New York, USA.

- Pratikkumar Desai, Amit Sheth, and **Pramod Anantharam**, Semantic Gateway as a Service architecture for IoT Interoperability , IEEE 4th International Conference on Mobile Services, June 27 - July 2, 2015, New York, USA.

- Amit Sheth, **Pramod Anantharam**, and Krishnaprasad Thirunarayan, kHealth: Proactive Personalized Actionable Information for Better Healthcare, Workshop on Personal Data Analytics in the Internet of Things (PDA@IOT 2014), collocated at VLDB 2014, Hangzhou, China, September 5th, 2014.

- Amit Sheth, **Pramod Anantharam**, Krishnaprasad Thirunarayan, Applications of Multimodal Physical (IoT), Cyber and Social Data for Reliable and Actionable Insights , Second International

Workshop on Internet of Things (C-IOT 2014) In conjunction with IEEE CollaborateCom 2014, Oct 22nd, 2014, Miami, Florida.

- **Pramod Anantharam** and Biplav Srivastava. 2013. City Notifications as a Data Source for Traffic Management. In Proceedings of the 20th ITS World Congress 2013, October 14-18, 2013, Tokyo, Japan.

- **Pramod Anantharam**, Biplav Srivastava, and Amit Sheth. 2013. Utility-driven evolution recommender for a constrained ontology. In Proceedings of the 3rd International Conference on Web Intelligence, Mining and Semantics (WIMS '13). ACM, New York, NY, USA, Article 14, 11 pages. DOI=10.1145/2479787.2479794 http://doi.acm.org/10.1145/2479787.2479794

- **Pramod Anantharam**, Payam Barnaghi, and Amit Sheth. 2013. Data processing and semantics for advanced internet of things (IoT) applications: modeling, annotation, integration, and perception. In Proceedings of the 3rd International Conference on Web Intelligence, Mining and Semantics (WIMS '13). ACM, New York, NY, USA, , Article 5 , 5 pages. DOI=10.1145/2479787.2479821 http://doi.acm.org/10.1145/2479787.2479821

- Amit Sheth and **Pramod Anantharam**. 2013. Physical cyber social computing for human experience. In Proceedings of the 3rd International Conference on Web Intelligence, Mining and Semantics (WIMS '13). ACM, New York, NY, USA, , Article 1 , 7 pages. DOI=10.1145/2479787.2479865 http://doi.acm.org/10.1145/2479787.2479865

- **Pramod Anantharam**, Krishnaprasad Thirunarayan, and Amit Sheth, Traffic Analytics using Probabilistic Graphical Models Enhanced with Knowledge Bases, 2nd International Workshop on Analytics for Cyber-Physical Systems (ACS-2013) at SIAM International Conference on Data Mining (SDM13), pp. 13-20, Texas, USA, May 2-4, 2013.

- Amit Sheth, **Pramod Anantharam**, and Cory Henson, Physical-Cyber-Social Computing: An Early 21st Century Approach, IEEE Intelligent Systems, pp. 79-82, Jan./Feb. 2013.

- **Pramod Anantharam**, Krishnaprasad Thirunarayan, and Amit Sheth, Topical Anomaly Detection for Twitter Stream, In the Proceedings of ACM Web Science 2012, In Conjunction with NetSci 2012 Evanston, Illinois, June 22-24, 2012.

- **Pramod Anantharam**, Alan Smith, Josh Pschorr, Krishnaprasad Thirunarayan, and Amit Sheth, Demonstration: Dynamic Sensor Registration and Semantic Processing for ad-hoc MOBile Environments (SemMOB), In: Proceedings of 5th International Workshop on Semantic Sensor Networks 2012 (SSN 2012), co-located with the 11th International Semantic Web Conference (ISWC 2012), Boston, USA, 2012.

- Pratikkumar Desai, Cory Henson, **Pramod Anantharam**, and Amit Sheth, SECURE: Semantics Empowered resCUe Environment, In: Proceedings of 4th International Workshop on Semantic Sensor Networks 2011 (SSN 2011), co-located with the 10th International Semantic Web Conference (ISWC 2011), Bonn, Germany, pp. 110-113, 2011.

- Krishnaprasad Thirunarayan and **Pramod Anantharam**, Trust Networks: Interpersonal, Sensor, and Social, In: Proceedings of 2011 International Conference on Collaborative Technologies and Systems (CTS 2011), pp. 13-21, Philadelphia, Pennsylvania, USA, May 23-27, 2011 (invited paper).

- **Pramod Anantharam**, Cory A. Henson, Krishnaprasad Thirunarayan, and Amit P. Sheth, Trust Model for Semantic Sensor and Social Networks: A Preliminary Report, In: Proceedings of 2010 National Aerospace & Electronics ConferenceDayton, OH, USA, July 14-16, 2010.

- Krishnaprasad Thirunarayan, **Pramod Anantharam**, Cory A. Henson, and Amit P. Sheth, Some Trust Issues in Social Networks and Sensor Networks, In: Proceedings of 2010 International Symposium on Collaborative Technologies and Systems (CTS 2010), Chicago, IL, May 17-21, 2010.

- Ashutosh Jadhav, Hemant Purohit, Pavan Kapanipathi, **Pramod Ananthram**, Ajith Ranabahu, Vinh Nguyen, Pablo Mendes, Gary Alan/Allen Smith, Michael Cooney, and Amit P. Sheth, Twitris 2.0 : Semantically Empowered System for Understanding Perceptions From Social Data, Demo submitted to, 9th International Semantic Web Conference, ISWC 2010, Shanghai, China, November 7-11, 2010.

- Satya S. Sahoo, D. Brent Weatherly, Raghava Mutharaju, **Pramod Anantharam**, Amit P. Sheth, and Rick L. Tarleton, Ontology-driven Provenance Management in eScience: An Application in Parasite Research, OnTheMove Federated Conferences & Workshops (OTM 2009) - ODBASE& #39;09, Vilamoura, Algarve-Portugal, Nov 03 - 04 - 05, 2009.

- Ashutosh Jadhav, Wenbo Wang, Raghava Mutharaju, **Pramod Anantharam**, Vinh Nyugen, Amit P. Sheth, Karthik Gomadam, Meenakshi Nagarajan, and Ajith Ranabahu, Twitris: Socially Influenced Browsing, Semantic Web Challenge 2009, 8th International Semantic Web Conference, Oct. 25-29 2009, Washinton, DC, USA.

- **Pramod Anantharam**, Satya S. Sahoo, D. Brent Weatherly, Flora Logan, Raghava Mutharaju, Amit P. Sheth, and Rick Tarleton, Trykipedia: Collaborative Bio- Ontology Development using Wiki Environment, Ohio Collaborative Conference on BioInformatics (OCCBIO 2009), June 14-17, 2009.

- Raghava Mutharaju, Satya S. Sahoo, D. Brent Weatherly, **Pramod Anantharam**, Flora Logan, Amit P. Sheth, and Rick Tarleton, 'Ontology Driven Integration of Biology Experiment Data', Ohio Collaborative Conference on BioInformatics (OCCBIO 2009), June 14-17, 2009.

3 Technical Reports

- **Pramod Anantharam**, Krishnaprasad Thirunarayan, Vahid Taslimi, and Amit Sheth, Predicting Parkinson's Disease Progression with Smartphone Data, Technical Report, Submitted to the Parkinson's disease challenge sponsored by The Michael J. Fox Foundation for Parkinson's Research, March, 2013.

- **Pramod Anantharam**, Biplav Srivastava, Raj Gupta, Dynamic Update of Public Transport Schedules in Cities Lacking Traffic Instrumentation, IBM Research Technical Report 2014.

Courses (relevant to my research)

Artificial Intelligence, Information Retrieval, Probability and Statistics for Engineers, Programming Languages, Computational Complexity, Algorithm Design, Knowledge Representation and Semantic Web, Communications in Science, Machine Learning *(Coursera)* , Statistical Learning *(Stanford Online)* , Probabilistic Graphical Models *(Coursera)*

Technical Skills

- **Machine Learning**: Bayesian Networks, Conditional Random Field (CRF), Linear Dynamical System (LDS), Markov Decision Process (MDP), Hidden Markov Model (HMM), Linear

Regression, Logistic Regression, Decision Trees, Random Forest, Support Vector Machine, Neural Networks, Ensemble Methods

- **Databases**: MySQL, Virtouso, Jena, Neo4j

- **Languages**:

  - Programming: Java, Python (incl. NumPy, SciPy, scikit-learn, matplotlib, Pandas), R, Matlab, Shell, PHP, Scheme, Java Script
  - Knowledge Representation: RDF, RDFS, OWL

Professional References

- Prof. Amit Sheth
  Founder & Executive Director, Kno.e.sis Center
  Department of Computer Science & Engineering
  Wright State University
  3640 Colonel Glenn Hwy, Dayton, OH 45435
  amit@knoesis.org

- Prof. Krishnaprasad Thirunarayan
  Professor, Kno.e.sis Center
  Department of Computer Science & Engineering
  Wright State University,
  3640 Colonel Glenn Hwy, Dayton, OH 45435
  t.k.prasad@wright.edu

- Dr. Biplav Srivastava
  Senior Researcher,
  IBM India Research Lab,
  Delhi, India.
  sbiplav@in.ibm.com

- Dr. Payam Barnaghi
  Assistant Professor,
  Centre for Communication Systems Research (CCSR)
  University of Surrey, UK
  p.barnaghi@surrey.ac.uk

- Dr. Cory Henson
  Senior Research Scientist
  Robert Bosch LLC
  Research and Technology Center North America
  Pittsburgh, PA
  Cory.Henson@us.bosch.com