Dan Roth is a Professor in the Department of Computer Science and the Beckman Institute at the University of Illinois at Urbana-Champaign and a University of Illinois Scholar. He is the director of the DHS funded Center for Multimodal Information Access & Synthesis (MIAS) and has faculty positions also at the Statistics and Linguistics Departments, at the graduate School of Library and Information Science and at the Electrical and Computer Engineering Department.

Roth is a Fellow of the AAAS, ACM, AAAI, and ACL, for his contributions to the foundations of machine learning and inference and for developing learning centered solutions for natural language processing problems.

Prof. Roth has made major conceptual and theoretical advances in artificial intelligence (AI) that have changed how computer scientists develop algorithms and programs for natural language understanding, and how they think about computational modeling of learning and reasoning.

Roth's Research is in the area of AI and intelligent access to unstructured data, where he has made seminal contributions spanning multiple aspects—from theoretical questions in Learning and Reasoning, to new models and large scale system development in Natural Language Processing (NLP)—and has contributed significantly to the wide use of machine learning techniques in research and industry. Roth has published over 250 articles in top international journals and highly selective conferences and a book on Textual Entailment. Some of his key research contributions are summarized below.

Learning and reasoning have been long recognized as fundamental phenomena of intelligence. Roth has made seminal contributions to the development of a unifying computational theory for the two phenomena. His theoretical work in the late 1990s, on the Learning to Reason framework, laid the foundations for integrating learning into large scale intelligent decision systems by exhibiting the advantage of jointly studying learning and reasoning. These ideas are now mainstream, and the joint study of learning and inference has had a major impact in the context of NLP.

Roth has continued to have significant influence in this area, studying Learning and Inference over structured output, viewing inference as a constrained optimization problem. He has contributed to developing theoretical understanding for when to jointly learn and when to decouple learning from joint inference, and the inference framework he has developed has been used broadly in NLP. In particular, a lot of the work done in global inference in NLP follows his Integer Linear Programming (ILP) in NLP framework, incorporating declarative knowledge along with statistical models for making global decisions; this, along with his Constraints Driven Learning approach, have been extremely influential and have been used in dozens of NLP papers, including multiple best papers awards in top conferences. Roth’s work on inference in NLP has facilitated work on a range of NLP tasks that require global inference in a range of tasks in NLP including, but not limited to, his own work on Semantic Role Labeling, Co-reference resolution, Wikification and Entity Linking, Textual Entailment, temporal and quantitative reasoning, and more.

Machine Learning in NLP: Roth was a pioneer of the use of advanced machine learning methods in NLP, with several influential contributions. (1) His theoretical work has contributed to developing better understanding of the relations between probabilistic models of classification and discriminative models and, in particular, explained the success of generative models in this area via the learning theoretical notion of Structural Risk Minimization. (2) His work has established the ubiquity of linear classifiers and has shown that popular models, including naive Bayes and Hidden Markov Models, are linear models and can be studied and be understood this way. These understandings, now mainstream, have had a significant impact on NLP research and, in particular, provided insight into extensions of these methods to structure learning, now commonly used in NLP. (3) Along with studying theories and algorithms, Roth’s group has developed a number of mature tools that have been downloaded and used by thousands of researchers and in industry. His online demos (http://cogcomp.cs.illinois.edu/) are also frequently used, including in NLP and Computational Linguistics classes. In particular, Roth’s group has been leading the way in developing...
computational approaches and state-of-the-art solutions to a range of fundamental natural language processing and information extraction problems. Research work and commercial systems (e.g., at Google) on problems such as Semantic Role Labeling (SRL), Co-reference Resolution, Name Entity Recognition (NER), Entity Linking and Wikification, were all highly influenced by the work of Roth’s group.

Structured Learning with Indirect Supervision: over the last few years it became clear that machine learning problems in natural language processing and information extraction require the ability to learn and support inference with respect to *structures*, where the task is to assign values to multiple interdependent variables. Expecting standard supervised machine learning methods to scale up to these task is unrealistic. Roth’s group has developed Indirect Supervision methods for the structured domain that were highly influential. From the Constrained Driven Learning (CoDL) protocol [3, 6] that has led to work by other groups on Posterior Regularization, to work on Structured Output Learning with Indirect Supervision [4] and with latent representation [5]. One of the recent innovations in this direction has stated with his work on Response Driven Learning [8] that has also influenced all work done today in training semantic parsers.

Structured learning is difficult partly since it involves an inference step that accounts for interaction between a set of variables one wants to assign values to. Roth’s group has shown that this inference can always be formulated as an Integer Linear Program, and has recently developed exciting results providing an amortized analysis of inference that is based on new sensitivity theorems for Integer Linear Programs [12]. This new line of work is bound to have significant impact since experiments show that it can be used to cut up to 85% of the inference cost in realistic structured prediction problems in natural language processing.

Probabilistic Inference: Roth has made several seminal contributions in Probabilistic Inference. 1) He has proved a now classical result showing that exact inference in Bayesian network is #P-complete [14], along with results on the complexity of approximate inference. 2) Roth was the first to develop a general-purpose and exact Lifted, first-order probabilistic inference algorithm [2]. This algorithm takes first-order logic description of a Markov network, and, without propositionalizing (that is, independently of the vocabulary size), it performs exact inference. This algorithm has already had significant impact on the probabilistic inference community, making Lifted Inference a very active research area. This is bound to change the way probabilistic inference is done. 3) Given the intractability of probabilistic inference with standard representations of probability distributions, Roth was among the first to study a new, Multi-Linear Representation of discrete distributions, and the first to propose a learning algorithm for these representations [17]; this has also become a very active research area recently.

Computer Vision: Roth has done early work on Machine Learning in Computer Vision and was among the pioneers of the Part-based (constellation) method” in object recognition [1].

Roth continues to make innovative contributions in broad AI areas. His new initiative on Trustworthiness of Information stands out [13]. While much work in NLP has focused on determining what a document means, Roth has started to study computational methods and inference techniques to also determine whether we can believe it. This is vital in the era of information overload and rapid publishing and has the potential for significant societal impact. He presented a tutorial on Trustworthiness of Information in AAAI’13.

Text Correction and English as a Second Language (ESL): Roth has pioneered the use of machine learning methods in text correction [9] and, more recently, in supporting second language learning; he has developed some of the best tools around for grammatical correction of text written by ESL writers [19]. Roth’s group won all software competitions in this area in the last few years, including the last two CoNLL shared tasks.

Big Data & Data Science: Roth’s work in Machine Learning and Natural Language Processing led to a broad range of interdisciplinary collaborations within and outside the University of Illinois. Key in this direction is his work in the Health Domain. In recent years Roth has embarked on a new challenge of developing Natural Language Processing tools for the Medical Domain. It has become clear that the ability to “understand” electronic health records and the biomedical literature is at the heart of facilitating intelligent access to medical information, and of supporting better care and medical research. Dealing with medical information has its own challenges, though, and making progress requires a focused effort. Roth’s program has already developed some of the best NLP tools available today for the medical domain [10] and he is collaborating with several medical programs to pursue advances in this area. Most of this work was done as part of the
SHARPS project [http://sharps.org/] and more recently, as part of the BD2K Center of Excellence. In addition, current efforts include collaborations that focus on natural language processing with Harvard Medical School and a local hospital in Urbana, and machine learning & data science collaboration with Mayo Clinic and UIC.

Roth has been actively developing other Data Science collaborations, including an active research program with Psycholinguistics [7] (now in its second period of NIH funding), a long term collaboration with Quantitative Political Scientists developing Data Analytics methods for the study of societal stability (for which he was recently awarded a Linowes Fellow) and a long term and very successful collaboration with Education researchers in the area of English as a Second Language.

**Education and Service:** Roth is a leader in the Big Data community at the University of Illinois and has led several campus level committees and initiatives in this area. He founded the Data Science Summer Institute (DSSI, [http://mias.illinois.edu/DSSI2012]), probably the first program of its kind in the nation, and directed it for six years, bringing to campus dozens of students—many from minority serving institutions—and top researchers. The institute has been supported by DHS, Yahoo! and local IT companies. DSSI was successful in providing opportunities to strong students from minority institutions to get into the top schools educational pipeline – several of our graduates got into top PhD programs and, as of this academic year, two are faculty in CS and Information Systems departments.

Beyond DSSI and outside Illinois, Roth’s service contributions and educational initiatives have significantly enriched the AI, Machine Learning, and Natural Language Processing (NLP) communities. Roth was among the founders of the Association for Computational Linguistics’ (ACL’s) Special Interest Group on Natural Language Learning, serving as its president and secretary, as program chair of their CoNLL conference and, currently, as a board member. In this role, he helped start and run the CoNLL shared task, an annual software competition that has had an enormous impact by developing methodologies, data, and benchmarks for a large number of NLP tasks, setting the standards in that area. He also chaired ACL, the main Computational Linguistics and NLP conference, and AAAI, the main AI conference, and has organized several symposia on Machine Learning and Natural Language processing, contributing to better interaction and flow of ideas between these communities.

Roth has graduated 30 Ph.D. students, 22 MS students, and over 30 undergraduate students; many of the undergrads have moved to top graduate programs, two of them were nationally recognized with a honorable mention and one as a finalist in the Computing Research Association’s Outstanding Undergraduate Award.

Roth is currently the Editor-in-Chief of the Journal of Artificial Intelligence Research (JAIR), one of the top Journals in AI, after serving as an Associate Editor-in-Chief 2013-2014. He was the program chair of AAAI’11, CoNLL’02 and of ACL’03, has served as an area chair and senior program committee member for all major conferences in his research areas, and has been on the editorial board of several journals in his research areas.

Prof. Roth has given keynote talks in major conferences, including AAAI, The Conference of the American Association Artificial Intelligence; EMNLP, The Conference on Empirical Methods in Natural Language Processing, ECML & PKDD, the European Conference on Machine Learning and the Principles and Practice of Knowledge Discovery in Databases and EACL, the European Conference of the Association of Computational Linguistics (EACL) and the Chinese Conference on NLP. He has also presented tutorials in universities and conferences including at AAAI, ACL and the European ACL and has won several teaching and paper awards.

**Selected References:**

4. M. Chang and V. Srikumar and D. Goldwasser and D. Roth, “Structured Output Learning with Indirect Supervision”, ICML 2010
5. M. Chang and D. Goldwasser and D. Roth and V. Srikumar, “Discriminative Learning over Constrained


