## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute Mission</td>
<td>4</td>
</tr>
<tr>
<td>Message from the President</td>
<td>6</td>
</tr>
<tr>
<td>Note from the Chief Academic Officer</td>
<td>8</td>
</tr>
<tr>
<td>Institute Overview</td>
<td>9</td>
</tr>
<tr>
<td>Awards and Honors</td>
<td>10</td>
</tr>
<tr>
<td>New Faculty</td>
<td>11</td>
</tr>
<tr>
<td>Faculty Promotion and Tenure</td>
<td>12</td>
</tr>
<tr>
<td>Faculty by Area</td>
<td>13</td>
</tr>
<tr>
<td>Postdocs</td>
<td>13</td>
</tr>
<tr>
<td>Research and Responsibility</td>
<td>14</td>
</tr>
<tr>
<td>Research Philosophy</td>
<td></td>
</tr>
<tr>
<td>Algorithms and Complexity</td>
<td></td>
</tr>
<tr>
<td>Computational Biology</td>
<td></td>
</tr>
<tr>
<td>Computer Vision and Computational Photography</td>
<td></td>
</tr>
<tr>
<td>Machine Learning</td>
<td></td>
</tr>
<tr>
<td>Robotics</td>
<td></td>
</tr>
<tr>
<td>Speech and Language Technologies</td>
<td></td>
</tr>
<tr>
<td>Collaboration and Cooperation</td>
<td>40</td>
</tr>
<tr>
<td>Talks, Seminars and Workshops</td>
<td>42</td>
</tr>
<tr>
<td>Education</td>
<td>50</td>
</tr>
<tr>
<td>The PhD Program</td>
<td></td>
</tr>
<tr>
<td>Student Progress</td>
<td></td>
</tr>
<tr>
<td>TTIC Curriculum Servicing the University of Chicago</td>
<td></td>
</tr>
<tr>
<td>TTIC Student Awarded University of Chicago TA Prize</td>
<td></td>
</tr>
<tr>
<td>Student Publications, Posters, Abstracts</td>
<td></td>
</tr>
<tr>
<td>TTIC’s Largest Incoming Class</td>
<td></td>
</tr>
<tr>
<td>Financial Support</td>
<td></td>
</tr>
<tr>
<td>Exchange Students</td>
<td></td>
</tr>
<tr>
<td>Institute Goals</td>
<td>56</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>----</td>
</tr>
<tr>
<td>Accreditation</td>
<td></td>
</tr>
<tr>
<td>Board Strategy for Continued Improvements</td>
<td></td>
</tr>
<tr>
<td>External Advisory Committee Visit 2016</td>
<td></td>
</tr>
<tr>
<td>Endowment Growth and Investment Collaboration with University of Chicago</td>
<td></td>
</tr>
<tr>
<td>Computing Capacity Doubles in 2016</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interns and Visiting Scholars</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute Financial Reports</td>
<td>62</td>
</tr>
<tr>
<td>Faculty Research Highlights</td>
<td>64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Governance</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board of Trustees</td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equal Opportunity Statement</th>
<th>73</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special Thanks</td>
<td>74</td>
</tr>
</tbody>
</table>
The Research Mission

TTIC aims to achieve international impact through world-class research in fundamental computer science and information technology. Here, we clarify the intended meaning of the terms in this statement.

**Impact.** The mission statement focuses on academic impact. A number of criteria may serve to evaluate such impact. These include volume of peer-reviewed publications; reputation of venues in which publications appear; visibility of work in the community, as expressed in citations by others; number and reputation of co-authors, in particular in other institutions; recognition by research community, including awards, prizes, invited talks, and invitation or election to serve in senior service positions in professional organizations; reports by external advisory bodies comprised of reputable senior researchers, etc. Precise objective measures of academic impact are controversial and elusive, and no one of the criteria above is alone a solid measure in itself. However, the combined evaluation of these and similar criteria helps assess the academic impact achieved by TTIC researchers.

Note that the number of patents filed, or the amount of extramural research funding, are not considered measures of academic impact. Although funding is clearly an important tool in achieving impact, it is only a tool and not an end in itself.

**Fundamental.** The mission statement is intended to focus on scientifically fundamental research. A scientific result is fundamental to the extent that it has open-ended implications. It is important to distinguish being fundamental from being economically important. A calendar program can be economically successful, and hence important, without adding to fundamental knowledge. The concept of NP-completeness adds greatly to the fundamental understanding of computation without having clear economic significance.
Computer Science and Information Technology. Computer science and information technology encompasses many sub-disciplines. In the selection of sub-disciplines for study at TTIC there should be some consideration of relevance to society as a whole. The interpretation of “computer science” and “information technology” should be such that TTIC remains relevant to the societal impact of computation and information.

The Education Mission

The educational mission of TTIC is to achieve international impact through the accomplishments of its graduates as productive scientists and citizens. The notion of “impact” in the educational mission is broader than in the research mission. The graduates of TTIC might achieve impact by starting successful companies, managing successful products, or influencing government directions in research funding. Of course, TTIC also strives to produce PhDs who achieve academic impact throughout their careers. The institute strives to produce graduates who contribute to society through their intellectual leadership in computer science and information technology. Success in the educational mission requires appropriate selection of curriculum, effective teaching to enable learning, effective assessment and mentorship of students, and effective marketing of students in the job market. TTIC strives to place its PhD graduates at high quality research institutions. TTIC also strives to make its PhD students visible to the academic community before graduation. This can be done most effectively through publications prior to graduation.
MESSAGE FROM THE PRESIDENT

During 2015-2016, the Toyota Technological Institute at Chicago (TTIC) continued its steady progress towards fulfilling its mission: achieve international impact through world-class research and education in fundamental computer science and information technology. Four new non-tenure-track faculty members will arrive and four new students will enroll at the start of the 2016-17 academic year. In recognition of his outstanding research, professional stature, and contributions to TTIC, Dr. Greg Shakhnarovich has been promoted to Associate Professor with tenure.

The level of recognition and impact of research at TTIC continues to steadily increase, the latest examples being the Best Paper Award given to Li-Yang Tan at the 56th Annual Symposium on Foundations of Computer Science (FOCS 2015) for the paper "An Average-Case Depth Hierarchy Theorem for Boolean Circuits," co-authored with Benjamin Rossman and Rocco Servedio, and the Best Student Paper Award given to Hao Tang at the IEEE ICASSP conference for “Signer-independent fingerspelling recognition with deep neural network adaptation.” The faculty actively pursued federal research grants with sufficient success that the grant volume kept about the same amount as the last year.

2015-16 was a significant year for the development of TTIC’s educational program and institutional structure. Under the accreditation renewal process, TTIC received formal notification from the Institutional Action Council (IAC) of the Higher Learning Commission of the North Central Association of Colleges and Schools (HLC) in March 2015, stating some concerns and informing us that TTIC was in danger of being placed on Notice, the first level of sanction. The concerns involved: (a) its financial independence, (b) autonomy of the Board of Trustees to make decisions for the future of the institution, (c) assessment of study learning, and (d) retention, persistence, and completion rate.

TTIC and its Board have made significant progress and have implemented thoughtful changes to address the concerns. In July 2015, TTIC submitted its report to the HLC, and at an Institutional Actions Council hearing held on
September 1, 2015, our team explained what actions the institute had undertaken in the nine months prior to the hearing, engaged in Q&A with the panel, and promoted their understanding of TTIC’s improvement strategies. On September 11, 2015, TTIC received the official action letter and report from the HLC. The letter did not recommend sanction but instead recommended accreditation renewal for ten years with an interim report that addresses TTIC progress on HLC concerns by 2017, and an additional site visit in four years. We believe that this process has strengthened TTIC in a variety of dimensions.

The HLC letter also requested TTIC make a Substantive Change Application to ask for accreditation of the institute’s Master’s within the PhD program degree. TTIC completed the application, and maintained all documentation and preparation to accept an HLC team visit on June 20 and 21, 2016. The HLC team visit was successful, and they made an official report recommending to approve the application. On August 19, TTIC received an official letter from the HLC’s IAC stating that they approved the TTIC’s application and the outcome would be publicly posted online in early September.

Our relationship with Toyota Technological Institute (TTIJ) in Nagoya continues to strengthen. Two TTIJ exchange students spent a quarter at TTIC during 2015-2016 academic year, and several TTIJ faculty spent time at TTIC conducting joint research with our faculty. The institute’s relationship with the University of Chicago remains strong, both in respect to various kinds of administrative aid, student support and to the potential for collaborative research and academic endeavors. TTIC is recently involved in collaboration agreements with several Japanese institutes, and newly established an agreement with the Artificial Intelligence Research Center of the National Institute of Advanced Industrial Science and Technology. We look forward to fruitful collaboration with many more research institutes.

As TTIC continues to mature as an institution, we are committed in furthering improvement of academic excellence and to enhancing the already strong relations with our academic partners. We will continue hiring the strongest faculty possible.

Sadaoki Furui
President
2015-16 was a fairly eventful year for TTIC. We completed an accreditation renewal. We held the first Midwest Robotics Workshop and the annual Midwest Vision Workshop. We held a successful distinguished lecture series. Research Assistant Professor Li-Yan Tang won a very prestigious Best Paper Award at FOCS 2015, one of the two flagship conferences in theoretical computer science. PhD candidate Hao Tang won a Best Student Paper award at ICASSP 2016. Greg Shakhnarovich was promoted to Associate Professor with Tenure. Congratulations, Greg!

This year we were very sorry to say goodbye to Anna Ruffolo who served TTIC for the better part of a decade as Controller and Director of Operations. Anna left TTIC for a position as Senior Vice President of Finance and Operations at a considerably larger organization, an offer she could not refuse. We all have fond memories of Anna and were very sorry to see her go.

In May 2016, we welcomed Jessica Johnston as Chief Financial Officer. Jessica was most recently Controller at the American College of Chest Physicians. Welcome, Jessica!

The world around us continues to change rapidly. This year saw continued dramatic improvements in computer vision systems due to the continuing evolution of deep neural network methods. The error rate on the flagship benchmarks in computer vision was roughly cut in half from the previous year. In another development, the computer system Alphago defeated Li Sedol, one of, if not the, best Go player in the world. This level of computer play in Go was not expected for decades. Research in self-driving cars continued to accelerate, with the number of companies involved growing to over thirty. Many of these companies have announced plans to have products on the market within five years. Industry continues to play an increasing role in basic research in artificial intelligence and deep learning. Sakichi Toyoda famously said, “Respect the spirit of research and creativity, and always strive to stay ahead of the times.” Staying ahead of the current times appears to require some serious striving. We will strive.

David McAllester
Chief Academic Officer
# INSTITUTE OVERVIEW

## Faculty and Staff

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<thead>
<tr>
<th>Title</th>
<th>Count</th>
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<tbody>
<tr>
<td>Professors</td>
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<tr>
<td>Associate Professors</td>
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<tr>
<td>Assistant Professors</td>
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</tr>
<tr>
<td>Research Assistant Professors</td>
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</tr>
<tr>
<td>Adjoint Faculty</td>
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</tr>
<tr>
<td>Administrative Office Staff and IT</td>
<td>8</td>
</tr>
</tbody>
</table>

## PhD Program

<table>
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<tr>
<th>Category</th>
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<tbody>
<tr>
<td>Students Enrolled for 2015-16</td>
<td>28</td>
</tr>
<tr>
<td>Master’s within the PhD Program Degrees Awarded</td>
<td>4</td>
</tr>
<tr>
<td>PhD Degree Requirement Completion</td>
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</tr>
<tr>
<td>Applicants for the 2015-16 Academic Year</td>
<td>89</td>
</tr>
<tr>
<td>Admitted</td>
<td>21</td>
</tr>
<tr>
<td>Enrolling</td>
<td>9</td>
</tr>
<tr>
<td>Exchange Students in 2015-16</td>
<td>2</td>
</tr>
</tbody>
</table>
AWARDS AND HONORS

2016 March Hao Tang

PhD Candidate Hao Tang received Best Student Paper Award at the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2016) held in Shanghai, China for “Signer-independent fingerspelling recognition with deep neural network adaptation,” co-authored by Taehwan Kim, Weiran Wang and Karen Livescu.

2016 March Jian Peng

TTIC alumnus Jian Peng has been named a 2016 Sloan Research Fellow by the Alfred P. Sloan Foundation. Jian Peng received his bachelor's and master's degrees in Computer Science at Wuhan University, and his PhD in Computer Science from TTIC in 2013. Peng went on to postdoctoral research at the Berger Lab of Massachusetts Institute of Technology and is currently an assistant professor in the Computer Science Department at the University of Illinois, Urbana-Champaign. Peng was also the recipient of a Microsoft PhD Fellowship while studying at TTIC.

The Alfred P. Sloan Research Fellowship was founded in 1955 to encourage young scholars with great achievements or huge potential in the fields of physics, math and chemistry. Fields have since expanded to include neuroscience, economics, computer science and computational and evolutionary molecular biology. Each Fellow is awarded $50,000 to support their early career development. Since the beginning of the program in 1955, forty-three fellows have won the Nobel Prize in their respective field, sixteen have received the Fields Medal in mathematics, and many have become eminent talents of their fields.

2015 October Li-Yang Tan

Prof. Li-Yang Tan was awarded Best Paper Award for The IEEE Symposium on Foundations of Computer Science (FOCS 2015) held in Berkeley, CA, for the paper, “An average-case depth hierarchy theorem for Boolean circuits,” with co-authors Benjamin Rossman and Rocco A. Servedio.
NEW FACULTY

Srinadh Bhojanapalli
Research Assistant Professor
PhD - University of Texas, Austin

Srinadh Bhojanapalli obtained his M.S. and PhD in Electrical and Computer Engineering from The University of Texas at Austin in 2012 and 2015, respectively. Prior to that he obtained Bachelors in Technology from Indian Institute of Technology Bombay in 2010. He has spent some summers as intern at Microsoft Research India and ebay Research labs. He is currently a Research Assistant Professor at TTIC.

His research is primarily focused on designing algorithms for large scale machine learning problems with statistical guarantees. He is interested in Matrix and Tensor factorization, Optimization and Sublinear time algorithms. Recently he has been working on designing scalable algorithms for Semidefinite Optimization with provable convergence guarantees.

Dr. Bhojanapalli also has a personally maintained website which can be found at www.ttic.edu/bhojanapalli.

Kevin Gimpel
Assistant Professor
PhD - Carnegie Mellon University

Kevin Gimpel received a B.S.E. in Computer Science from the University of Pennsylvania in 2004 and a PhD from the Language Technologies Institute at Carnegie Mellon University in 2012. He also worked at MIT Lincoln Laboratory from 2004 to 2006 and interned with the machine translation team at Google in 2009.

His research interests include several areas of computational linguistics, focusing on machine translation, statistical natural language processing, and machine learning for models of language. He is also interested in social media analysis, computational semantics, and forecasting real-world events using text data.

Dr. Gimpel also has a personally maintained website which can be found at www.ttic.edu/gimpel.

Li-Yang Tan
Research Assistant Professor
PhD - Columbia University

Li-Yang Tan received his PhD in 2014 from Columbia University, where he was advised by Rocco Servedio. He spent the 2014-15 academic year as a Microsoft Research Fellow at the Simons Institute at University of California, Berkeley, before joining TTIC in June 2015.

His research interests lie in theoretical computer science, with an emphasis on computational complexity. Specific interests include concrete complexity, the analysis of Boolean functions, property testing, and computational learning theory.

Dr. Tan also has a personally maintained website which can be found at www.ttic.edu/tan.
At the April 2016 meeting of the Board of Trustees, upon recommendation of the President, the Trustees approved Professor Greg Shakhnarovich for promotion to Associate Professor, with tenure.

Prof. Shakhnarovich began his appointment with TTIC in autumn of 2007. He teaches the course TTIC 31020: Introduction to Statistical Machine Learning, a core course in the PhD curriculum, and TTIC’s highest attended course by both TTIC and University of Chicago students. Prof. Shakhnarovich also serves as faculty IT liaison, working with the institute Director of IT to represent academic needs and planning, and as Admissions Director, working with senior faculty and institute administration to strategize recruitment efforts and execute the institute admissions goals for the year. Prof. Shakhnarovich is advising six students at TTIC: three in Candidacy, and three in the early stages of the PhD program. He played an active role in assisting with the ongoing accreditation process at TTIC, and contributed to the improved processes that were outcomes of the exercise. He is also the main organizer for the 2016 Midwest Vision Workshop held at the institute in the spring. Prof. Shakhnarovich has over thirty refereed publications.
FACULTY BY AREA

**Algorithms & Complexity**
Chuzhoy, Julia
Fortnow, Lance
Li, Shi
Makarychev, Yury
Nguyen, Huy Le
Razborov, Alexander
Tan, Li-Yang
Tulsiani, Madhur
Wright, Stephen

**Machine Learning**
Bhojanapalli, Srinadh
Garber, Dan
Lafferty, John
Mahdavi, Mehrdad
McAllester, David
Meshi, Ofer
Mita, Seichi
Nowak, Robert
Sasaki, Yutaka
Srebro, Nathan
Tomioka, Ryota

**Computational Biology**
Canzar, Stefan
Huang, Qixing
Khan, Aly
Naveed, Hammad
Xu, Jinbo

**Robotics**
Walter, Matthew

**Computer Vision & Computational Photography**
Chakrabarti, Ayan
Forsyth, David
Maire, Michael
Shakhnarovich, Greg

**Speech and Language Technologies**
Bansal, Mohit
Gimpel, Kevin
Livescu, Karen
Roth, Dan

**Post Doc**
Wang, Weiran
Research is the heart and soul of activity at the Toyota Technological Institute at Chicago. The institute has an energetic and determined team of professors, visiting professors, assistant professors, research assistant professors, adjoint professors and postdocs encompassing many areas of research interests, and from many countries, backgrounds, each bringing their own specialty to the Institute.

With a generous budget, distinguished professors, and an environment that promotes learning and sharing, there are ample opportunities for collaborative research. Being on the campus of the University of Chicago, there is opportunity for close and cooperative research with not only the University of Chicago Computer Science Department, but with the departments of Mathematics, Statistics, and most recently, the Booth Graduate School of Business. There are also many guests and visitors who come to TTIC to give talks, participate in workshops, and share their research findings, all heightening the feeling of enthusiasm that pulses through the Institute.

The mission of TTIC includes “…achieving international impact through world-class research and education in fundamental computer science and information technology.” The research component of the mission is implemented through high quality research in high impact areas. Currently, there are active research programs in six areas: machine learning, algorithms and complexity, computer vision and computational photography, speech and language technologies, computational biology, and robotics. The areas are introduced below, and in some, TTIC’s strategy for achieving impact is also described. A key part of the strategy for achieving impact in all areas is to foster collaboration and communication between the areas.
One of the central tasks in all areas of computer science is the writing of efficient software to perform required computation. In order to write such software, one must first design an efficient algorithm for the computational task at hand. The area of algorithms focuses on designing algorithms, and more generally developing powerful algorithmic tools, for solving fundamental computational problems that frequently occur in different areas of computer science. Complexity theory is the study of the power and the limits of efficient computation. The central problem studied by complexity theorists is “Which computational problems can, and which cannot, be solved efficiently?” The study of algorithms and complexity is a part of a broader area called “theory of computer science,” or just “theory.” The area of theory works on developing theoretical foundations for computer science, which lead to a deeper understanding of computation in general, and specific computational tasks in particular, which include better algorithms and faster software. Below is a list of the work done at TTIC this year in the area of Algorithms and Complexity.

**Julia Chuzhoy**
Associate Professor
www.ttic.edu/chuzhoy

**PUBLISHED/SUBMITTED PAPERS**


**TALKS**
“Excluded Grid Theorem: Improved and Simplified.” Plenary talk given at the 7th Workshop on Graph Optimization and Width Parameters, Aussois, France, October 2015.

“Excluded Grid Theorem: Improved and (somewhat) Simplified.” Plenary talk given at Graph Theory Workshop, Oberwolfach, Germany, January 2016.


“Approximation Algorithms for Graph Routing Problems.” Colloquium Distinguished Speaker talk given at Max Planck Institute at Saarbrucken, Germany, June 2016.


INVolvement
Editorial Board Member, *SIAM Journal on Computing*
Editor, FOCS 2014 special issue, *SIAM Journal on Computing*
Co-organizer, “Approximation Algorithms and the Hardness of Approximation” BIRS Workshop, Alberta, Canada, to be held November 2017

research Funding awards
NSF Grant, “AF: Small: Graph Routing, Vertex Sparsifiers, and Connections to Graph Theory.” September 2016-August 2019: $449,720

ClaSSes/semiNars
TTIC 31080 - Approximation Algorithms (CMSC 37503): The course covered several advanced topics related to the area of Approximation Algorithms, including: Graph Minor Theory; routing problems; iterative rounding technique; Lovász Local Lemma; oblivious routing and related graph decompositions.

MiScellAneous
Organizer, TTIC Distinguished Lecture Series
Member, Search Committee for CS Department Chair, University of Chicago Chair, Search Committee for Chief Academic Officer, TTIC
Student Support Coordinator
Minute Taker and Facilitator, TTIC Faculty meetings
Student supervision:
  Rachit Nimavat (TTIC)
  David H.K. Kim (UChicago CS department; co-supervised with Laszlo Babai)
  Joshua Kaplan (UChicago undergraduate student, summer internship in summer 2015 and REU during the 2015/2016 academic year)
  Vivek Madan (UIUC, summer intern, summer 2016)
  Sepideh Mahabadi (MIT, summer intern, summer 2016)

Yury Makarychev
Assistant Professor
www.ttic.edu/makarychev

PUBLISHED/SUBMITTED PAPERS
TALKS
“Satisfiability of Ordering CSPs Above Average Is Fixed-Parameter Tractable.” Talk given at Microsoft Research, Redmond, WA, October 2015.
Non-uniform Graph Partitioning with Unrelated Weights.” Workshop on Approximation Algorithms, Institute for Mathematical Sciences, National University of Singapore, February 2016.
“Metric Techniques in Computer Science.” Lecture series given at concentration week in Metric Spaces: Analysis, Embeddings into Banach Spaces, Applications; Texas A&M, College Station, TX, July 2016 (jointly with K. Makarychev).

INVOlVEMENT
Reviewer, Theory of Computing
Reviewed grant proposals for the Israel Science Foundation and Swiss National Science Foundation
Programming Experience Czar, TTIC

RESEARCH FUNDING AWARDS
NSF Career Award CCF-1150062.
NSF Grant IIS-1302662 (jointly with N. Srebro).

CLASSES/SEMINARS
TTIC 31010 / CMSC 37000-1 (Algorithms): This is a graduate level course on algorithms with the emphasis on central combinatorial optimization problems and advanced methods for algorithm design and analysis. Topics covered include asymptotic analysis, greedy algorithms, dynamic programming, amortized analysis, randomized algorithms and probabilistic methods, combinatorial optimization and approximation algorithms, linear programming, and advanced data structures.

Huy Le Nguyên
Research Assistant Professor
www.ttic.edu/nguyen

PUBLISHED/SUBMITTED PAPERS
Braverman, Mark, Ankit Garg, Tengyu Ma, Huy L. Nguyen, and David P. Woodruff. “Communication Lower Bounds for Statistical Estimation Problems via a Distributed Data


TALKS
“Distributed Machine Learning.” Talk given at Departmental Colloquium, Department of Computer Science, University of Iowa, September 2015.

INVolVEmENt
Program Committee Member, COCOON 2016

Razborov, Alexander
Adjoint Professor
www.ttic.edu/razborov

PUBLISHED/SUBMITTED PAPERS


TALKS
“Continuous Combinatorics.” Oberwolfach workshop, Germany, 2015.
“Continuous Combinatorics.” Talk given at Chebyshev Lab Colloquium, St. Petersburg State University, Washington, June 2015.
“Continuous Combinatorics.” Talk given at Microsoft Research Redmond, May 2016.
“Complexity of Semi-Algebraic and Algebraic Proofs.” Talk given at the Trends in Optimization Seminar, University of Washington, Seattle; Carnegie-Mellon University; TTIC; Moscow; and St. Petersburg State University, May 2016.

INVolVEmENt
Editorial boards: Forum of Mathematics, Pi and Sigma; Izvestiya of the Russian Academy of Science, ser. mathem.; Combinatorica; Combinatorics, Probability and Computing
CLASSES/SEMINARS
CMSC 27100 - Discrete Mathematics: University of Chicago: This course emphasizes mathematical discovery and rigorous proof, which are illustrated on a refreshing variety of accessible and useful topics. Basic counting is a recurring theme and provides the most important source for sequences, which is another recurring theme. Further topics include proof by induction; recurrences and Fibonacci numbers; graph theory and trees; number theory, congruences, and Fermat’s little theorem; counting, factorials, and binomial coefficients; combinatorial probability; random variables, expected value, and variance; and limits of sequences, asymptotic equality, and rates of growth.
CMSC 38410 - Quantum Computing: In this course we will discuss mathematical and complexity aspects of quantum computing, putting aside all questions pertaining to its physical realizability.
CMSC 37120 - Topics in Discrete Mathematics: Arithmetic Combinatorics

Li-Yang Tan
Research Assistant Professor
www.ttic.edu/tan

PUBLISHED/SUBMITTED PAPERS

TALKS
“An Average-Case Depth Hierarchy Theorem for Boolean Circuits.” Talk given for TCS+ Online Seminar series, October 2015.
“An Average-Case Depth Hierarchy Theorem for Boolean Circuits.” Talk given at Spectral Graph Theory Reunion Workshop, UC Berkeley Simons Institute, December 2015.


HONORS/AWARDS
Best Paper Award (with Benjamin Rossman and Rocca Servedio), FOCS 2015

RESEARCH FUNDING AWARDS
NSF Algorithmic Foundations Award 1563122, “Circuit Lower Bounds via Random Projections.” Medium, Collaborative Research (with Rocca Servedio), 2016-2020: $1,190,000 ($356,000 awarded to TTIC).

MISCELLANEOUS

Madhur Tulsiani
Assistant Professor and Director of Graduate Studies
www.ttic.edu/tulsiani

PUBLISHED/SUBMITTED PAPERS


TALKS

INVolVEMENT
Editorial board member: Theory of Computing, Algorithmica
Conference Reviews: STOC, FOCS, ICALP, CCC, TOC

CLASSES/SEMINARS
TTIC 31150 - Mathematical Toolkit (CMSC 31150) Autumn 2015: This is a new version of the 2013 course, which is now a list A course required for all TTIC students. The course focuses on various tools from linear algebra and probability required for research in computer science. Theory Reading Group.
Computational biology studies biological systems (e.g., cell, protein, DNA and RNA) through mathematical modeling and optimization. Machine learning methods (e.g., probabilistic graphical model and deep learning) and optimization techniques (e.g., linear programming and convex optimization) have significant applications in this field. Algorithm design and complexity analysis also play an important role, especially when we want to know if there is an efficient algorithm that can find an exact or approximate solution to a specific biological problem. Below is a list of the work done at TTIC this year in the area of Computational Biology.

Stefan Canzar  
Research Assistant Professor  
www.ttic.edu/canzar  
PUBLISHED/SUBMITTED PAPERS  
TALKS  
"Shedding Light on Invisible Transcripts by Algorithm Engineering." Invited talk given at Department of Informatics, Technical University of Munich, March 2016.  
"Computational Methods for Transcript Discovery and Quantification from RNA-seq Reads." Talk given at Clinical and Translational Sciences Institute, Northwestern University, Chicago, September 2016.  
INVOLVEMENT  
PC member: RECOMB-Seq (Massive Parallel Sequencing) and RECOMB-CCB (Computational Cancer Biology) 2016, ECCB 2016, Bioinformatics 2016  
Reviews: RECOMB 2016, ECCB 2016, and Bioinformatics 2016

Qixing Huang  
Research Assistant Professor  
www.ttic.edu/huang  
PUBLISHED/SUBMITTED PAPERS  
Hashemifar, Somaye, Qixing Huang, and Jinbo Xu. “Joint Alignment of Multiple Protein-Protein Interaction Networks via Convex Optimization.” Paper presented at the Annual International
Conference on Research in Computational Molecular Biology (RECOMB), Santa Monica, April 2016. doi:10.1089/cmb.2016.0025.


TALKS
"Visual Computing Using Big 3D Data." Talk given at Computer Science Departmental Seminar, Purdue University, March 2016.
"Visual Computing Using Big 3D Data." Talk given at University of Texas at Austin, March 2016.
"Visual Computing Using Big 3D Data." Talk given at University of California at Riverside, March 2016.
"Visual Computing Using Big 3D Data." Talk given at University of Southern California, April 2016.

INVOLVEMENT
Program Committee Members: Symposium on Geometry Processing 2016, Shape Modeling International 2016
Conference Reviews: SIGGRAPH, SIGGRAPH Asia, CVPR, ECCV, PAMI, IJCV

RESEARCH FUNDING AWARDS
PI: GIFT Award. Intel Labs, October 2015- June 2016: $30,000.

CLASSES/SEMINARS
Two lectures in the online machine learning course for TTI (Japan) students.

Aly Khan
Research Assistant Professor
www.ttic.edu/khan

PUBLISHED/SUBMITTED PAPERS

TALKS
“Computational Immunology: New Computational Approaches to Understand Immune Function.”
Talk given at University of California, San Diego, August 2015.
“Computational Immunology: New Computational Approaches to Understand Immune Function.”
Talk given at Northwestern University, Evanston, May 2016.

ININVOLVEMENT
Journal Reviews, Trends in Immunology, 2015.

RESEARCH FUNDING AWARDS
Deep Learning Hardware Grant, NVIDIA, October 2015.

CLASSES/SEMINARS
TTIC Reading Group participation: Bioinformatics and Computational Biology

MISCELLANEOUS
Thesis committee membership:
Karlynn Neu, PhD Committee, University of Chicago
Akinola Olumide Emmanuel, PhD Committee, University of Chicago
Yuta Asano, PhD Committee, University of Chicago

Hammad Naveed
Research Assistant Professor
www.ttic.edu/naveed

PUBLISHED/SUBMITTED PAPERS


**TALKS**


“An Integrated Structure and System-Based Framework to Identify Protein-Small Molecule Interactions.” Talk given at the IEEE International Conference on Biomedical and Health Informatics, Las Vegas, February 2016.

**INvolvement**

Preliminary exam committee, Jieling Zhao, PhD Candidate (Advisor: Jie Liang), Department of Bioengineering, UIC 2015

Co-organized and co-chaired a minisymposia titled “Computational precision medicine: prediction of cancer variants and druggable sites in proteins” at the BHI2016 IEEE International Conference on Biomedical and Health Informatics, Las Vegas, February 2016

Reviewer: *Cogent Biology, IEEE/ACM Transactions on Computational Biology and Bioinformatics, and Annual EMBS Conference*

**Classes/seminars**

University of Illinois Chicago: BIOE 483: Molecular Modeling in Bioinformatics: Class for graduate students at the Bioinformatics Program of the Bioengineering Department during the Spring 2016 semester.

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**Jinbo Xu**

Associate Professor

www.ttic.edu/xu

**Published/Submitted Papers**


**TALKS**

“Probabilistic Graphical Models of Multiple Protein Sequence Alignment.” Talk given at University of Texas at Austin, November 2015.

“Probabilistic Graphical Models of Multiple Protein Sequence Alignment.” Talk given at Colloquium, Tsinghua University, Beijing, December 2015.

**IN INVOLVEMENT**

Associate Editor, *IEEE/ACM Trans. Bioinformatics and Computational Biology*

Program Committee Member: ACM BCB 2015, ISMB 2016, RECOMB 2016, and others


**HONORS/AWARDS**

Best Poster award, IJCAI BOOM Workshop, 2016

**RESEARCH FUNDING AWARDS**


**CLASSES/SEMINARS**

TTIC 31050 - Introduction to Bioinformatics and Computational Biology: This course will focus on the application of mathematical models and computer algorithms to studying molecular biology.

Bioinformatics reading group.
Computer Vision involves getting computers to extract useful information from pictures and videos. It has applications in robotics, surveillance, autonomous vehicles, and automobile collision avoidance. Historically, this is a central research area of computer science. Below is a list of the work done at TTIC this year in the area of Computer Vision and Computational Photography.

Ayan Chakrabarti
Research Assistant Professor
www.ttic.edu/chakrabarti

PUBLISHED/SUBMITTED PAPERS

TALKS
"A Neural Approach to Blind Motion Deblurring." Talk given at the Midwest Vision Workshop, Chicago, April 2016.

INvolvEMENT
Program Committee Member and Local Arrangements Chair, IEEE International Conference on Computational Photography (ICCP), 2016
Workshop Reviews: Inverse Rendering (with ICCV 2015), Computational Cameras and Displays (with CVPR 2016)
Journal Reviews: IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI), IEEE Transactions on Computational Imaging (TCI), IEEE Transactions on Image Processing (TIP), SPIE Journal on Electronic Imaging (JEI), Computer Vision and Image Understanding (CVIU)

RESEARCH FUNDING AWARDS
Unrestricted Gift from Adobe Systems, August 2015: $5,000.

CLASSES/SEMINARS
Vision Reading Group
Deep Learning Reading Group
Michael Maire
Research Assistant Professor
www.ttic.edu/maire

PUBLISHED/SUBMITTED PAPERS

INvolvement
Area Chair, CVPR 2016

Greg Shakhnarovich
Associate Professor
www.ttic.edu/gregory

PUBLISHED/SUBMITTED PAPERS

Talks
“Zoom-out Features for Image Understanding.” Talk given at University of Toronto: University of California at Berkeley: and University of Massachusetts Amherst, October 2016.
“Rich Representations for Parsing Visual Scenes.” Talk given as part of AIIS Seminar, University of Illinois at Urbana-Champaign, December 2016.

INvolvement
Area Chair, CVPR 2016.
Associate Editor, Computer Vision and Image Understanding Journal
Organizer, Midwest Vision Workshop - April 2016
Conference Reviews: ICML, NIPS, ECCV

Research Funding Awards
Adobe Research Faculty Award, Spring 2016: $7,500.
Spare5 Data Annotation Gift, Summer 2016: $25,000.

Classes/SEMINARS
TTIC 31020 - Introduction to Statistical Machine Learning: Graduate level introduction to principles and practice of machine learning.
Vision Reading group (faculty coordinator): Weekly reading group focused on current literature in the area of computer vision.
Deep Learning Discussion group (organizer): Weekly discussion group focused on topics related to deep learning, across many application domains relevant to TTIC (speech, vision, NLP).

MISCELLANEOUS
Director of Admissions

Machine Learning

Machine Learning generally refers to an engineering or design paradigm where systems are built based on automatic training from examples, rather than detailed expert knowledge, much in the same way humans learn how to perform tasks and interact with the world. Most of modern Machine Learning is statistical in nature, and builds on statistical and probabilistic tools, as well as on algorithmic and computational developments. Especially in recent years, as training data is becoming plentiful, and massive computational and storage resources needed for handling the data are also becoming available, Machine Learning is playing a key role in many application areas. These include both classic Artificial Intelligence problems, such as computer vision, robotics, machine translation, question answering and dialogue systems. There are also a variety of “non-human” problems such as information retrieval, search, bioinformatics and stock market prediction to be considered. Below is a list of the work done at TTIC this year in the area of Machine Learning.

Srinadh Bhojanapalli
Research Assistant Professor
www.ttic.edu/bhojanapalli

PUBLISHED/SUBMITTED PAPERS

TALKS
“Dropping Convexity for Faster Semidefinite Optimization.” Talk given at Signals, Inference, and Networks (SINE) Seminar, University of Illinois at Urbana-Champaign, October 2015.

INVolvEMENT
Organized "Advances in Non-convex Analysis and Optimization" workshop at ICML 2016
Dan Garber
Research Assistant Professor
www.ttic.edu/garber

PUBLISHED/SUBMITTED PAPERS

TALKS
“Fast and Simple PCA via Convex Optimization.” Talk given at Optimization and Statistical Learning Seminar, Northwestern University, Evanston, April 2016.

INVOLVEMENT

Mehrdad Mahdavi
Research Assistant Professor
www.ttic.edu/mahdavi

PUBLISHED/SUBMITTED PAPERS

TALKS
“Lower and Upper Bounds on the Generalization of Stochastic Exponentially Concave Optimization.” Talk given at Data Science Institute, Columbia University, New York, August 2015.
“Stochastic Optimization for High-Dimensional Large-Scale Learning.” Talk given at Wisconsin Institute for Discovery, University of Wisconsin-Madison, March 2016.

David McAllester
Chief Academic Officer, Professor
www.ttic.edu/m callester

TALKS
“An Overview of Morphoid Type Theory.” Talk given at Purdue University, West Lafayette, IN, March 2016.
"An Overview of Morphoid Type Theory." Talk given at Indiana University, Bloomington, IN, March 2016.
"An Overview of Morphoid Type Theory." Talk given at Brown University, Providence, RI, April 2016.
"Strong AI, Prospects and Control." Talk given at Brown University, Providence, RI, April 2016.

CLASSES/SEMINARS
TTIC 31040 Introduction to Computer Vision (CMSC 35040): Introduction to deep learning for computer vision. Although deep learning based computer vision systems are evolving rapidly, this course attempts to teach material that will remain relevant and useful as the field changes. The course begins with general deep learning methods relevant to many applications and gradually focuses to a greater extent on computer vision. The course will emphasize theoretical and intuitive understanding to the extent possible.

Reading group on machine comprehension (with Kevin Gimpel, Mohit Bansal, Hai Wang, Takeshi Onishi).

Ofer Mesi
Research Assistant Professor
www.ttic.edu/meshi

PUBLISHED/SUBMITTED PAPERS

TALKS
"Scalable Machine Learning for High-Dimensional Structured Outputs." Talk given at Tel Aviv University, Israel, January 2016.
"Scalable Machine Learning for High-Dimensional Structured Outputs." Talk given at Bar Ilan University, Ramat Gan, Israel, January 2016.
"Scalable Machine Learning for High-Dimensional Structured Outputs." Talk given at Technion, Haifa, Israel, January 2016.
"Scalable Machine Learning for High-Dimensional Structured Outputs." Talk given at University of Illinois Urbana-Champaign, IL, March 2016.
"Scalable Machine Learning for High-Dimensional Structured Outputs." Talk given at University of Maryland, College Park, MD, March 2016.

INVOLVEMENT
Journal reviews: Computer Vision and Image Understanding (CVIU), IEEE Transactions on Pattern Analysis and Machine Intelligence.
CLASSES/SEMINARS
TTIC 31070 - Convex Optimization: Joint with Nathan Srebro: The course will cover techniques in unconstrained and constrained convex optimization and a practical introduction to convex duality. The course will focus on (1) formulating and understanding convex optimization problems and studying their properties; (2) understanding and using the dual; and (3) presenting and understanding optimization approaches, including interior point methods and first order methods for non-smooth problems. Examples will be mostly from data fitting, statistics and machine learning.
TTIC 31180 - Probabilistic Graphical Models, Spring 2016 - two lectures.

Nathan Srebro
Associate Professor
www.ttic.edu/srebro

PUBLISHED/SUBMITTED PAPERS

TALKS
"Regularization, Optimization and Generalization in MultiLayer Networks." Talk given as part of the Dagstuhl Workshop on Mathematical and Computational Foundations of Learning Theory, Germany, September 2015.
"Optimization, Regularization and Generalization in Multilayer Networks." Talk given at Hebrew University, Jerusalem; and Weizmann Institute, Rehovot, Israel, November 2015.
"Learning, Stability and Strong Convexity." Invited talk at NIPS Workshop on Adaptive Data Analysis, Montreal, December 2015.
"Supervised Learning without Discrimination." Talk given at Hebrew University, Jerusalem, May 2016.

ININVOLVEMENT
Two NSF Panels, 2015.
Area Chair: NIPS 2015, ICML 2016.
Senior Program Committee, COLT 2016.
IJCAI Program Committee.
ICLR Program Committee.

RESEARCH FUNDING AWARDS
NSF BIG-DATA, four years: $1,500,000.

CLASSES/SEMINARS
TTIC 31070 - Convex Optimization: The course will cover techniques in unconstrained and constrained convex optimization and a practical introduction to convex duality. The course will focus on (1) formulating and understanding convex optimization problems and studying their properties; (2) understanding and using the dual; and (3) presenting and understanding optimization approaches, including interior point methods and first order methods for non-smooth problems. Examples will be mostly from data fitting, statistics and machine learning, Machine Learning and Optimization Reading Group.
Robotics can generally be defined as a field concerned with the development and realization of intelligent, physical agents that are able to perceive, plan, and act intentionally in an uncertain world. Robotics is a broad field that includes mechanical design, planning and control, perception, estimation, and human-robot interaction, among others. At TTIC, robotics research currently focuses on developing advanced perception algorithms that endow robots with a rich awareness of, and the ability to act deliberately within, their surroundings. Researchers are particularly interested in algorithms that take multi-modal observations of a robot's surround as input, notably image streams and natural language speech, and infer rich properties of the people, places, objects, and actions that comprise a robot's environment. Integral to these technologies is their reliance on techniques from machine learning in developing probabilistic and statistical methods that are able to overcome the challenge of mitigating the uncertainty inherent in performing tasks effectively in real-world environments. These tasks include assistive technology for people living with physical and cognitive impairments, healthcare, logistics, manufacturing, and exploration. Below is a list of the work done at TTIC this year in the area of Robotics.

Matthew Walter
Assistant Professor
www.ttic.edu/walter

PUBLISHED/SUBMITTED PAPERS
Mei, Hongyuan, Mohit Bansal, and Matthew R. Walter. “Listen, Attend, and Walk: Neural Mapping of Navigational Instructions to Action Sequences.” Paper presented at the National...


TALKS
"Real-Time Analytics Onboard Self-Driving Cars: Perception-Driven Autonomous Vehicles." Talk given at Booth School of Business, University of Chicago, August 2015.


"Following Natural Language Instructions in Unknown Environments." Talk given at Department of Electrical Engineering and Computer Science, University of Michigan, February 2016.

"Following Natural Language Instructions in Unknown Environments." Talk given at University of Wisconsin, Madison, March 2016.


INVOLVEMENT
Senior Editor, Spatial Reasoning and Interaction for Real-World Robotics Special issue, RSJ Advanced Robotics
Associate Editor, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
Panelist, NSF National Robotics Initiative
Program Committee, 2016 Conference on Empirical Methods in Natural Language Processing (EMNLP)
Steering Committee, Northeast Robotics Colloquium

HONORS/AWARDS
Best Paper Award, 2015 NIPS Workshop on Multimodal Machine Learning
RESEARCH FUNDING AWARDS
Office of Naval Research (ONR), "Object Detection and Reacquisition from Visual and Lingual Signals via Zero-Shot Learning and Spatial-Semantic Mapping:" $160,000 (Pending).
Army Research Laboratory (ARL), Robotics Collaborative Task Alliance (RCTA), "Learning Task Ordering from Natural Language Directions:" $32,000.
Army Research Laboratory (ARL), Robotics Collaborative Task Alliance (RCTA), "Learning to Handle Objects from Human Demonstrations:" $45,000.

CLASSES/SEMINARS
TTIC 31180 - Probabilistic Graphical Models: This graduate-level course will provide a strong foundation for learning and inference with probabilistic graphical models. The course will first introduce the underlying representational power of graphical models, including Bayesian and Markov networks, and dynamic Bayesian networks. Next, the course will investigate contemporary approaches to statistical inference, both exact and approximate. The course will then survey state-of-the-art methods for learning the structure and parameters of graphical models.
Robotics Reading Group.
Rapid Robotics: Autonomous Systems with Open Source Software, Massachusetts Institute of Technology: Thanks to open source libraries and inexpensive robot platforms, creating advanced robot capabilities has never been more accessible. This course is a hands-on introduction to applied robotics software programming. You will learn to use the popular ROS robotics framework, open source autonomy libraries, and a small ground robot equipped with an RGB-depth sensor to demonstrate behaviors such as person-following, patrolling, exploration, and map-making. Lectures accompanying the laboratory exercises will cover the basics of robotics and autonomy algorithm theory. Participants will work in teams of two on robot systems.

MISCELLANEOUS
Supervisor, Hongyuan Mei, M.S. Physical Sciences, University of Chicago, 2016
Supervisor, Bharat Chandar, M.S. Statistics, University of Chicago, 2016
Supervisor, Andrea F. Daniele, Sapienza, Universita di Roma, 2016
Supervisor, Zhongtian Dai, TTIC
PhD Committee Member, Jianzhu Ma, TTIC
Qualifying Exam Committee Member, Mohammadreza Mostajabi, TTIC
Qualifying Exam Committee Member, Hai Wang, TTIC

Speech and Language Technologies

This area is concerned with getting computers to analyze and extract information from spoken language, as well as to generate spoken audio. At TTIC, current speech research focuses mainly on the analysis side. For example, speech recognition is the problem of transcribing the words being spoken in an audio signal, such as that recorded from a microphone. Speech processing heavily relies on techniques from machine learning and statistics, as well as ideas from linguistics and speech science, and shares algorithms with computer vision and computational biology. This area has applications such as automated telephone information centers, dictation systems, machine translation, archiving and search of spoken documents, assistance for the visually or hearing-impaired, and other human-computer interface systems. Below is a list of the work done at TTIC this year in the area of Speech and Language Technologies.
Mohit Bansal  
Research Assistant Professor  
www.ttic.edu/bansal

PUBLISHED/SUBMITTED PAPERS


TALKS
“Neural Attention Models for Natural Language Grounding and Generation.” Talk given at IIT Danpur, India, October 2015.
“Structured Learning of World Knowledge for Natural Language Semantics.” Talk given at University of California, Davis, April 2016.
“Structured Learning of World Knowledge for Natural Language Semantics.” Talk given at University of Texas at Austin, March 2016.

INVOLVEMENT
Tutorial Co-chair, NAACL 2016
Area Co-chair, NAACL 2016
Journal Reviews: TACL, TPAMI
Conference Reviews: EMNLP, NAACL, ACL, NIPS, ICLR, IJCAI
Demo Co-chair, ACL 2017

HONORS/AWARDS

RESEARCH FUNDING AWARDS
NVidia Hardware Grant, 2015.
Bloomberg Data Science Research Grant, 2016: $60,000.

Kevin Gimpel
Assistant Professor
www.ttic.edu/gimpel

PUBLISHED/SUBMITTED PAPERS

TALKS

INVOLVEMENT
Area Co-chair, NAACL 2016
Journal Reviews: Transactions of the Association for Computational Linguistics, Open Linguistics
Conference Reviews: AAAI, ACL, CoNLL, EMNLP, ICLR, MT Summit, SemEval

HONORS/AWARDS
Nomination, Best Paper Award, IEEE Automatic Speech Recognition and Understanding Workshop, 2015.
Ranked fifth out of forty, Best of SemEval, 2016.

RESEARCH FUNDING AWARDS
Microsoft Azure Sponsorship Offer, May 2016-2017: $20,000.
Argonne Leadership Computing Facility Allocation, May 2016-October 2016: 10,000 compute-hours.

CLASSES/SEMINARS
TTIC 31190: Natural Language Processing: Introductory course covering fundamental concepts, problems, and methods in natural language processing.

Karen Livescu
Assistant Professor
www.ttic.edu/livescu

PUBLISHED/SUBMITTED PAPERS

TALKS
“Segmental Models in the Neural Age.” Talk given at DSP Seminar, Technion, Haifa, Israel, January 2016.
“Segmental Models in the Neural Age.” Talk given at Northwestern CS Division Seminar, Northwestern University, Evanston, IL, May 2016.
"Multi-view Learning of Representations for Speech and Language." Talk given at Statistics Department Colloquium, University of Chicago, IL, February 2016.


"Triphone State Tying via Deep Canonical Correlation Analysis." Talk given at Midwest Speech and Language Days, Indiana University, Bloomington, May 2016.


IN INVOLVEMENT
Technical Co-chair, ASRU 2015
Associate Editor, IEEE Transactions on Audio, Speech, and Language Processing.
Area Chair, ICASSP 2016
Conference Reviews: Interspeech 2015, ASRU 2015, ICLR 2016

HONORS/AWARDS
Best Paper Nominee, ASRU 2015.
Best Student Paper of Speech and Language Processing, ICASSP 2016.

RESEARCH FUNDING AWARDS

CLASSES/SEMINARS
TTIC 31110: Speech Technologies: This course introduces techniques used in speech technologies, mainly focusing on speech recognition. Speech recognition is one of the oldest and most complex structured sequence prediction tasks receiving significant research and commercial attention, and therefore provides a good case study for many of the techniques that are used in other areas of artificial intelligence involving sequence modeling. It is also a good example of the effectiveness of combining statistics and learning with domain knowledge. The course includes practical homework exercises using Matlab and speech toolkits.
COLLABORATION and COOPERATION

TTIC expanded its efforts to engage in future research, academic coordination and exchange when it entered into an initial agreement during 2015-16 with the School of Computing, Tokyo Institute of Technology, and signed a Letter of Intent with the National Institute of Advanced Industrial Science and Technology Artificial Intelligence Research Center in Japan. In both instances, the institutions express a desire to work together in the future and collaborate to engage researchers and students for academic exchange if the opportunity arises, and to promote partnerships.

TTIC was one of fourteen institutions, departments and organizations that sponsored the 2015 Linguistic Summer Institute held in July 2015 at the University of Chicago. The four-week program was intended for anyone engaged in the academic discipline of linguistics: undergraduates, graduate students, and faculty members from countries around the world. TTIC’s Prof. Karen Livescu was a course instructor for Speech Technologies at the Summer Institute and her course introduced techniques used in speech technologies, mainly focusing on automatic speech recognition (ASR).

Mohit Bansal collaborated with Profs. Dhruv Batra and Devi Parikh of Virginia Tech and their students, some of whom interned with Prof. Bansal at TTIC. They worked on humor prediction and generation, visual story sorting, and visual question answering.

Prof. Bansal also collaborated with Makoto Miwa of TTI Japan on joint entity and relation extraction neural models, and with IBM Research members David McClosky (now at Google Research) and Sid Patwardhan, and a BarIlan intern on the role of context types and dimensionality in learning word embeddings.

Srinadh Bhojanapalli has ongoing collaboration with Prateek Jain and Praneeth Netrapalli at Microsoft Research India on various high dimensional statistical learning problems. He has started new collaboration on algorithms for smooth non-convex optimization with Stephen Wright, a TTIC adjunct professor from the University of Wisconsin.

Stefan Canzar is currently collaborating with a number of research groups in ongoing projects, such as with Jef Boeke of NYU School of Medicine and Zheng Kuang of the University of Texas Southwestern Medical Center studying alternative splicing during meiosis in fission yeast. He has also developed a metric to compare phylogenetic trees with Domagoj Matijević of the
University of Osijek and Khaled Elbassioni of the Masdar Institute of Science and Technology. Along with Hongjun Son of Johns Hopkins Medicine he has studied the regulation of translation in neurons. Natalia Maltsev from the Department of Human Genetics, University of Chicago, and Prof. Canzar have been working on an automatic pipeline for the functional annotation of isoforms. He has also been in collaboration with Heejung Shim of the Department of Statistics at Purdue University. They are developing a probabilistic model for alternative splicing.

Ayan Chakrabarti continued his collaboration with Kalyan Sunkavalli at Adobe's Imagination lab, and started a new collaboration with Prof. Sanjeev Koppal at the University of Florida.

Kevin Gimpel collaborated with Hua He and Jimmy Lin at the University of Maryland at College Park on deep learning for natural language processing. He is also involved in an ongoing collaboration with Aynaz Taheri and Tanya Berger-Wolf at the University of Illinois at Chicago related to using neural networks to learn graph representations.

Hammad Naveed collaborated with Jie Liang of University of Illinois at Chicago on computational modeling of beta barrel membrane proteins. Prof. Naveed also collaborated with Dr. Michael Maitland of University of Chicago Medicine on discovering novel targets for FDA-approved kinase inhibitors. Prof. Naveed also collaborated with Drs. Xin Gao and Stefan Arold of King Abdullah University of Science and Technology, Saudi Arabia, on computational characterization of protein drug interactions.

Matthew Walter has an ongoing collaboration with several universities, including the University of Rochester, Carnegie Mellon University, Massachusetts Institute of Technology, University of Pennsylvania, University of Central Florida; and institutions such as NASA's Jet Propulsion Laboratory and the Army Research Lab, as part of the Robotics Collaborative Technology Alliance (RCTA) to develop mobile robots and mobile manipulators that work alongside soldiers. The project is funded by the U.S. Army.

Prof. Walter also has a collaboration with MIT Lincoln Laboratory as part of an Office of Naval Research project focused on the use of heterogeneous teams of robots (wheeled and aerial vehicles) for mapping and surveillance.
Talks and seminars are an important part of any academic institution. They are both a way for researchers to promote their research, and to keep abreast of recent developments. They play an important role in establishing the level of intellectual activity and influx of innovative ideas at an organization: research is more likely to be productive in an active environment with significant interaction between researchers.

The table below lists seminars given at TTIC, many of which are given by speakers from other universities and research institutions, as part of the **TTIC Colloquium**: a forum for talks by invited speakers on work of current relevance and broad interest to the computer science community. Other talks may be a part of the **Research at TTIC** series: a weekly seminar series presenting research currently underway at the institute. Every week a different TTIC faculty member will present their research. The lectures are intended both for students seeking research topics and advisors, and for the general TTIC and University of Chicago communities interested in hearing what their colleagues are currently involved. New for 2015-16 is the **Young Researcher Seminar Series** featuring talks by PhD students and postdocs whose research is of broad interest to the computer science community. The series provides an opportunity for early-career researchers to present recent and promising work and to meet with students and faculty at TTIC and nearby universities. Lastly, some speakers may be part of research **Reading Groups**: people presenting papers that are of interest to a particular group, such as the theory group or the programming languages group. Most seminars are advertised outside of TTIC and are intended to be for a broad audience in computer science. In the spring quarter there are a large number of recruiting seminars which are talks given by candidates for faculty positions.

The TTIC Event Calendar can be found via the TTIC homepage: [www.ttic.edu](http://www.ttic.edu)

<table>
<thead>
<tr>
<th>Speaker</th>
<th>Institute</th>
<th>Title</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td>Yuan Yao</td>
<td>Peking University</td>
<td>Sparse Recovery via Dynamics</td>
<td>7/15/15</td>
</tr>
<tr>
<td>Sharon Goldwater</td>
<td>University of Edinburgh</td>
<td>Unsupervised Word Segmentation and Lexicon Discovery from Speech using Acoustic Word Embeddings</td>
<td>7/17/15</td>
</tr>
<tr>
<td>Paul Smolensky</td>
<td>Johns Hopkins University</td>
<td>What can vectorial representations do? Distributed structure processing in neural networks</td>
<td>7/20/15</td>
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<tr>
<td>Name</td>
<td>Institution</td>
<td>Title</td>
<td>Date</td>
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<tr>
<td>Jacob Steinhardt</td>
<td>Stanford University</td>
<td>Learning with Intractable Inference and Partial Supervision</td>
<td>7/27/15</td>
</tr>
<tr>
<td>Takeshi Onishi</td>
<td>TTIC</td>
<td>Student Talk: Neural Coreference Resolution</td>
<td>7/28/15</td>
</tr>
<tr>
<td>Tomer Michaeli</td>
<td>Technion</td>
<td>Blind deblurring and blind super-resolution using internal patch recurrence</td>
<td>8/3/15</td>
</tr>
<tr>
<td>Mrinalkanti Ghosh</td>
<td>TTIC</td>
<td>Student Talk: Bounded Complexity Families and Isomorphism Conjecture</td>
<td>8/10/15</td>
</tr>
<tr>
<td>Sanjeev Khanna</td>
<td>University of Pennsylvania</td>
<td>Approximate Matchings in Dynamic Graph Streams</td>
<td>8/10/15</td>
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<tr>
<td>Lev Reyzin</td>
<td>University of Illinois, Chicago</td>
<td>Sampling Strategies for Feature-Efficient and Active Learning</td>
<td>8/17/15</td>
</tr>
<tr>
<td>Robert Krauthgamer</td>
<td>Weizmann Institute of Science</td>
<td>Vertex Sparsification of Cuts, Flows, and Distances</td>
<td>8/31/15</td>
</tr>
<tr>
<td>Slav Petrov</td>
<td>Google Research NYC</td>
<td>Towards Universal Syntactic Processing of Natural Language</td>
<td>9/4/15</td>
</tr>
<tr>
<td>Jianzhu Ma</td>
<td>TTIC PhD Candidate</td>
<td>Thesis Defense: Protein Structure Prediction by Protein Alignments</td>
<td>9/17/15</td>
</tr>
<tr>
<td>Paris Smaragdis</td>
<td>University of Illinois, Urbana-Champaign</td>
<td>Machine Learning Approaches to Speech Enhancement</td>
<td>9/28/15</td>
</tr>
<tr>
<td>Sanjeev Arora</td>
<td>Princeton University</td>
<td>Random Walks on Discourse Spaces: a Generative Model Approach to Semantic Word Embeddings</td>
<td>9/30/15</td>
</tr>
<tr>
<td>Chandrajit Bajaj</td>
<td>University of Texas at Austin</td>
<td>Fast, Approximate and Scalable Geometric Optimization</td>
<td>10/5/15</td>
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<tr>
<td>Hammad Naveed</td>
<td>TTIC</td>
<td>Improved 3d Structure Prediction of Beta-Barrel Membrane Proteins Using Evolutionary Coupling Constraints and a Reduced State Space</td>
<td>10/9/15</td>
</tr>
<tr>
<td>William T. Freeman</td>
<td>Massachusetts Institute of Technology</td>
<td>A Big World of Tiny Motions</td>
<td>10/15/15</td>
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<tr>
<td>Nati Srebro</td>
<td>TTIC</td>
<td>Learning and Optimization: Deep and Distributed</td>
<td>10/16/15</td>
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<tr>
<td>Srinadh Bhojanapalli</td>
<td>TTIC</td>
<td>Dropping Convexity for Faster Semi-definite Optimization</td>
<td>10/23/15</td>
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<tr>
<td>Huy Nguyen</td>
<td>TTIC</td>
<td>Distributed Machine Learning</td>
<td>10/30/15</td>
</tr>
<tr>
<td>Gordon Kindlmann</td>
<td>University of Chicago</td>
<td>Diderot: a Domain-Specific Language for Portable Parallel Scientific Visualization and Image Analysis</td>
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<td>Li-Yang Tan</td>
<td>TTIC</td>
<td>An Average-Case Depth Hierarchy Theorem for Boolean Circuits</td>
<td>11/6/15</td>
</tr>
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<td>Tara Sainath</td>
<td>Google Research</td>
<td>Single and Multichannel Raw Waveform Neural Network Acoustic Models</td>
<td>11/9/15</td>
</tr>
<tr>
<td>Greg Shakhnarovich</td>
<td>TTIC</td>
<td>Rich Representations for Parsing Visual Scenes</td>
<td>11/13/15</td>
</tr>
<tr>
<td>Matthew Stephens</td>
<td>University of Chicago</td>
<td>False Discovery Rates - a new deal</td>
<td>11/16/15</td>
</tr>
<tr>
<td>Tanya Berger-Wolf</td>
<td>University of Illinois at Chicago</td>
<td>Analysis of Dynamic Interaction Networks</td>
<td>12/14/15</td>
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<tr>
<td>Qixing Huang</td>
<td>TTIC</td>
<td>Dense Correspondences in the Era of Deep Learning</td>
<td>1/8/16</td>
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<tr>
<td>Gunnar Klau</td>
<td>Centrum Wiskunde &amp; Informatica, Amsterdam</td>
<td>Mining Gummi Bears in One and Two Jars</td>
<td>1/11/16</td>
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<tr>
<td>Mehrdad Mahdavi</td>
<td>TTIC</td>
<td>Stochastic optimization with exponentially concave losses: lower and upper bounds on the excess risk</td>
<td>1/15/16</td>
</tr>
<tr>
<td>John Wright</td>
<td>Carnegie Mellon University</td>
<td>Random Words, Longest Increasing Subsequences, and Quantum PCA</td>
<td>1/18/16</td>
</tr>
<tr>
<td>Michael Maire</td>
<td>TTIC</td>
<td>Affinity CNN: Learning Pixel-Centric Pairwise Relations for Figure/Ground Embedding</td>
<td>1/22/16</td>
</tr>
<tr>
<td>Dani Yogatama</td>
<td>Carnegie Mellon University</td>
<td>Learning to Represent Language: Embeddings and Optimization</td>
<td>1/25/16</td>
</tr>
<tr>
<td>Mert Gurbuzbalaban</td>
<td>Massachusetts Institute of Technology</td>
<td>Analyzing Complex Systems and Networks: Incremental Optimization and Robustness</td>
<td>1/27/16</td>
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<tr>
<td>Ayan Chakrabarti</td>
<td>TTIC</td>
<td>Architectures for Learning in Low-level Vision Applications</td>
<td>1/29/16</td>
</tr>
<tr>
<td>Bundit Laekhanukit</td>
<td>The Weizmann Institute of Science</td>
<td>Directed Network Design and Related Problems</td>
<td>2/1/16</td>
</tr>
<tr>
<td>Yajie Miao</td>
<td>Carnegie Mellon University</td>
<td>End-to-End Speech Recognition using Deep LSTMs, CTC Training and WFST Decoding</td>
<td>2/3/16</td>
</tr>
<tr>
<td>Boxin Shi</td>
<td>Nanyang Technological University</td>
<td>Camera Intelligence from Visual Computation and Sensor Innovation</td>
<td>2/4/16</td>
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<td>Karen Livescu</td>
<td>TTIC</td>
<td>Toward Neural Segmental Sequence Models</td>
<td>2/5/16</td>
</tr>
<tr>
<td>Xiaorui Sun</td>
<td>Columbia University</td>
<td>Efficient Density Estimation via Piecewise Polynomial Approximation</td>
<td>2/8/16</td>
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<tr>
<td>Ilya Razenshtein</td>
<td>Massachusetts Institute of Technology CSAIL</td>
<td>Locality-Sensitive Hashing and Beyond</td>
<td>2/10/16</td>
</tr>
<tr>
<td>Tandy Warnow</td>
<td>University of Illinois at Urbana-Champaign</td>
<td>New HMM-Based Methods in Sequence Alignment, Phylogenetics, and Metagenomics</td>
<td>2/12/16</td>
</tr>
<tr>
<td>Uri Shalit</td>
<td>New York University</td>
<td>Machine Learning for Observational Studies</td>
<td>2/17/16</td>
</tr>
<tr>
<td>Srikumar Ramalingam</td>
<td>Mitsubishi Electric Research Laboratories (MERL)</td>
<td>Towards Holistic Scene Understanding from a Single Image</td>
<td>2/18/16</td>
</tr>
<tr>
<td>Suriya Gunasekar</td>
<td>University of Texas at Austin</td>
<td>Mining Structured Matrices in High Dimensions</td>
<td>2/19/16</td>
</tr>
<tr>
<td>Carina Silberer</td>
<td>University of Edinburgh</td>
<td>Using Visual and Linguistic Information to Connect Language to the World</td>
<td>2/22/16</td>
</tr>
<tr>
<td>Kobbi Nissim</td>
<td>Ben-Gurion University and Harvard University</td>
<td>Differential Privacy for Data Analysis</td>
<td>2/23/16</td>
</tr>
<tr>
<td>Olga Russakovsky</td>
<td>Carnegie Mellon University</td>
<td>The Human Side of Computer Vision</td>
<td>2/24/16</td>
</tr>
<tr>
<td>Iman Hajirasouliha</td>
<td>Stanford University</td>
<td>Computational methods for characterizing large-scale human genome variations with applications to cancer</td>
<td>2/24/16</td>
</tr>
<tr>
<td>Dan Garber</td>
<td>TTIC</td>
<td>Fast and Simple PCA via Convex Optimization</td>
<td>2/26/16</td>
</tr>
<tr>
<td>Shmuel Weinberger</td>
<td>University of Chicago</td>
<td>Topological Sampling Problems</td>
<td>2/29/16</td>
</tr>
<tr>
<td>David Held</td>
<td>Stanford University</td>
<td>Using Motion to Understand Objects in the Real World</td>
<td>3/2/16</td>
</tr>
<tr>
<td>Mark Hallen</td>
<td>Duke University</td>
<td>Algorithms to Bring Realistic Modeling to Drug Design</td>
<td>3/4/16</td>
</tr>
<tr>
<td>Sameer Singh</td>
<td>University of Washington</td>
<td>Interactive Machine Learning for Information Extraction</td>
<td>3/7/16</td>
</tr>
<tr>
<td>Roy Frostig</td>
<td>Stanford University</td>
<td>Initialization and Dual Expressivity of Neural Networks</td>
<td>3/9/16</td>
</tr>
<tr>
<td>Mary Wootters</td>
<td>Carnegie Mellon University</td>
<td>Reed-Solomon Codes: from Theory to Practice.</td>
<td>3/10/16</td>
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<td>Liang Lu</td>
<td>University of Edinburgh</td>
<td>Deep Learning for End-to-End Speech Recognition</td>
<td>3/11/16</td>
</tr>
<tr>
<td>Mark Schmidt</td>
<td>University of British Columbia</td>
<td>Advances in Solving Structured Optimization Problems.</td>
<td>3/14/16</td>
</tr>
<tr>
<td>S. Matthew Weinberg</td>
<td>Massachusetts Institute of</td>
<td>Algorithms for Strategic Agents</td>
<td>3/16/16</td>
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<td>Technology</td>
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<tr>
<td>Zaid Harchaoui</td>
<td>New York University</td>
<td>Towards Deep Convolutional Methods without Supervision</td>
<td>3/28/16</td>
</tr>
<tr>
<td>Tuo Zhao</td>
<td>Johns Hopkins University</td>
<td>Compute Faster and Learn Better: Machine Learning via Nonconvex</td>
<td>3/30/16</td>
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<tr>
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<td>Model-based Optimization</td>
<td></td>
</tr>
<tr>
<td>Dhruv Batra</td>
<td>Virginia Tech</td>
<td>Towards Transparent Intelligent Systems: Diverse Predictions from</td>
<td>3/31/16</td>
</tr>
<tr>
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<td>Perception Modules</td>
<td></td>
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<tr>
<td>Devi Parikh</td>
<td>Virginia Tech</td>
<td>Words, Pictures, and Common Sense</td>
<td>4/1/16</td>
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<tr>
<td>Kevin Gimpel</td>
<td>TTIC</td>
<td>Learning Concise Representations of Textual Knowledge</td>
<td>4/8/16</td>
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<tr>
<td>Andreas Spanias</td>
<td>Arizona State University</td>
<td>An Introduction on the Activities at the SenSIP Center.</td>
<td>4/8/16</td>
</tr>
<tr>
<td>YangFeng Ji</td>
<td>Georgia Tech</td>
<td>Distributed Representation Learning for Discourse Processing</td>
<td>4/11/16</td>
</tr>
<tr>
<td>William Wang</td>
<td>Carnegie Mellon University</td>
<td>Scalable Learning and Reasoning for Large Knowledge Graphs</td>
<td>4/13/16</td>
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<tr>
<td>Kristen Grauman</td>
<td>University of Texas, Austin</td>
<td>Learning Image Representations from Unlabeled Video</td>
<td>4/18/16</td>
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<tr>
<td>Jiwei Li</td>
<td>Stanford University</td>
<td>Neural Dialogue Generation</td>
<td>4/20/16</td>
</tr>
<tr>
<td>Yuhuai Wu</td>
<td>University of Toronto</td>
<td>Architectural Complexity Measures of Recurrent Neural Networks</td>
<td>4/21/16</td>
</tr>
<tr>
<td>Yury Makarychev</td>
<td>TTIC</td>
<td>Satisfiability of Ordering CSPs Above Average</td>
<td>4/22/16</td>
</tr>
<tr>
<td>Gautam Dasarathy</td>
<td>Carnegie Mellon University</td>
<td>Learning Large Graphs from Compressed and Subsampled Data</td>
<td>4/27/16</td>
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<td>from Video: Methods for Unrestricted Recognition and Signer-Independence</td>
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<td>Mesrob Ohannessian</td>
<td>University of California, San</td>
<td>Handling and Harnessing Data Scarcity</td>
<td>4/29/16</td>
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<td>Diego</td>
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<tr>
<td>Christos Christodoulopoulos</td>
<td>University of Illinois at</td>
<td>Cognitive and Application-Driven Machine Learning for Natural</td>
<td>5/6/16</td>
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<td>Urbana-Champaign</td>
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<td>Saurabh Gupta</td>
<td>University of California, Berkeley</td>
<td>Scene Understanding from RGB-D Images</td>
<td>5/11/16</td>
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<td>Ofer Meshi</td>
<td>TTIC</td>
<td>Optimization and tightness of convex relaxations for structured output prediction</td>
<td>5/13/16</td>
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<tr>
<td>Sanjeev J. Koppal</td>
<td>University of Florida</td>
<td>Privacy Preserving Optics for Miniature Vision Sensors</td>
<td>5/16/16</td>
</tr>
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<td>Shayan Oveis Charan</td>
<td>University of Washington</td>
<td>Applications of strongly Rayleigh distributions in Algorithm Design</td>
<td>5/19/16</td>
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<td>Madhur Tulsiani</td>
<td>TTIC</td>
<td>On the Approximability of Constraint Satisfaction Problems</td>
<td>5/20/16</td>
</tr>
<tr>
<td>Nati Linial</td>
<td>Hebrew University</td>
<td>High-dimensional Permutations and Discrepancy</td>
<td>5/25/16</td>
</tr>
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<td>Alexander Razborov</td>
<td>TTIC</td>
<td>Complexity of Semi-Algebraic and Algebraic Proofs</td>
<td>5/27/16</td>
</tr>
<tr>
<td>Sanmi Koyejo</td>
<td>Stanford University</td>
<td>From Probabilistic Models to Decision Theory and Back Again</td>
<td>6/2/16</td>
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<tr>
<td>Qixing Huang</td>
<td>TTIC</td>
<td>Dense Correspondences in the Era of Deep Learning</td>
<td>6/3/16</td>
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<td>Brian Ziebart</td>
<td>University of Illinois, Chicago</td>
<td>Supervised Machine Learning as an Adversarial Game</td>
<td>6/6/16</td>
</tr>
<tr>
<td>John Lafferty</td>
<td>University of Chicago, TTIC</td>
<td>The Complexity of Minimizing Individual Convex Functions</td>
<td>6/10/16</td>
</tr>
<tr>
<td>Rayid Ghani</td>
<td>University of Chicago</td>
<td>Machine learning for Public Policy and Social Good: Case Studies, Challenges, and Opportunities</td>
<td>6/13/16</td>
</tr>
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<td>Lifu Tu</td>
<td>TTIC</td>
<td>Token Embeddings: Embedding Words in Context for Syntactic Tasks</td>
<td>6/27/16</td>
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Distinguished Lecture Series 2015-16

September 2015 through February 2016. (Location: TTIC)

Speakers included:

**Sanjeev Arora**
Charles C. Fitzmorris Professor of Computer Science, Princeton University.
Talk Title: Random walks on discourse spaces: A generative model approach to semantic word embeddings.

**William T. Freeman**
Professor of Electrical Engineering and Computer Science, Member of Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology.
Talk Title: A big world of tiny motions.

**Yoshua Bengio**
Professor of Computer Science and Operations Research, Canada Research Chair in Statistical Learning Algorithms, Universite de Montreal.
Talk Title: Deep Learning Theory.

**Tandy Warnow**
Professor of Computer Science and Bioengineering, The University of Illinois at Urbana-Champaign.

First Annual Midwest Robotics Workshop at TTIC

On March 17-18, 2016, TTIC hosted the first annual Midwest Robotics Workshop (MWRW). The workshop is intended to bring together roboticists from academia and industry in and around the Midwestern United States. It is an opportunity for researchers and practitioners to share their work and to network with one another, with the goal of creating a more cohesive and vibrant robotics community in the Midwest. The workshop featured invited talks by leading researchers, and an exciting collection of oral presentations and interactive poster sessions.

Workshop website: [http://www.ttic.edu/mwrw/](http://www.ttic.edu/mwrw/)
Midwest Vision Workshop

On April 14-15, 2016, TTIC once again hosted the Midwest Vision Workshop. This is a regular regional meeting of computer vision researchers, providing a forum for presenting recent work, informal discussion and exchange of ideas. The meeting, which included oral presentations and poster sessions, draws participants from TTIC, University of Chicago, University of Illinois at Urbana-Champaign, University of Michigan at Ann Arbor, Indiana University, Michigan State, Washington University in St. Louis, and other institutions. The two-day program included talks and poster presentations.
The PhD Program

The TTIC PhD Program is designed to prepare students for academic or research careers in computer science. To complete the program, a student must make an original and significant contribution to the field of computer science and this contribution must be described in a doctoral thesis. In addition to the thesis, there are course and examination requirements to complete the program. The main component of the program is the process by which the student learns to do research and becomes a part of the academic community.

As part of the associated partnership between TTIC and the University of Chicago, students of TTIC can take and receive credit for courses through the University of Chicago, and University of Chicago students can take advantage of classes TTIC offers as well. Students have taken full advantage of this opportunity. TTIC’s students have full access to the University of Chicago library system, athletic facilities, the student health center and transportation on campus. They may enjoy the benefits and great rewards of an intimate learning, study and research setting, exposure to state-of-the-art research, opportunities in the greater computer science community, and a shared and traditional experience that come with association with a large university.
TTIC student Jianzhu Ma, studying under Professor Jinbo Xu, successfully defended his theses this year and will receive his doctoral diploma in a ceremony in September 2016. This will be the seventh doctoral diploma to be awarded. Jianzhu Ma’s research interest is in bioinformatics. He is currently employed at the University of California, San Diego, Department of Medicine.

TTIC has several more PhD Candidates working on their theses and expects two more graduates by the end of summer 2016 to also participate in the September 2016 diploma ceremony.

Students Mrinalkanti Ghosh, Mohammadreza Mostajabi, Qingming Tang and Shubhendu Trivedi successfully fulfilled all requirements to complete the Master’s portion of the PhD Program, and received master’s diplomas from the Institute at the September 2015 diploma ceremony at the start of the academic year.
TTIC Curriculum Serving the University of Chicago

TTIC instructors serve the TTIC student population in in their courses, and under the TTIC-University of Chicago Agreement, University students may enroll in TTIC’s courses and receive credit through the University, and vice-versa. TTIC views this as part of serving the Education Mission of the Institute. The amount of University students who register for TTIC courses has been increasing the last several years. Course TTIC 31020: Introduction to Statistical Machine Learning, taught by Prof. Greg Shakhnarovich, had thirty-three attendees this Autumn Quarter 2015. Sixty-five percent of the course attendees were University of Chicago students. This is up from twenty-four registered students in the course the year before.

TTIC instructors are proud to offer a quality curriculum to its PhD students and share knowledge with the quality students from the University who enroll in Institute courses.

TTIC Student Awarded University of Chicago TA Prize

As part of TTIC and the University of Chicago’s agreements of engagement, both institutions share courses, services, and collaborate in many areas. As part of this, it is not uncommon for a TTIC student to assist with TAing a University course, or a University student TAing a TTIC course.

At the University annually, students are asked who they believe deserves the Department of Computer Science’s Teaching Assistant prize. These TAs stand out for dedication to students, and go above and beyond to help students gain an understanding of the concepts covered by a course.

TTIC PhD Candidate Shubhendu Trivedi was awarded the TA Prize for 2016 for his TA work in the course CMSC 25400/STAT 27725: Machine Learning. TTIC is very proud of Shubhendu’s dedication and talents in the classroom, and for his service to the greater campus community outside of TTIC.
Student Publications, Posters and Abstracts


He, Hua, **John Wieting**, Kevin Gimpel, Jinfeng Rao, and Jimmy Lin. "UMD-TTIC-UW at SemEval-2016 Task 1:


TTIC’s Largest Incoming Class

In the fall of 2004, TTIC matriculated its first three students. The 2015-16 academic year began with twenty-eight students, nine who were newly enrolled for Autumn 2015: the Institute’s largest incoming class to date.

Four students have been admitted and will enroll for the 2016-17 year.

Financial Support for Students

Full financial support is offered to all enrolled students in good standing, making progress towards their degree, guaranteed for four years. The tuition for an academic year is $30,000. All students at TTIC may expect to receive financial support that covers tuition, health services, health insurance and student life fees, and a scholarship to assist with living expenses, provided they remain full-time and in good academic standing.

Exchange Students

This year TTIC welcomed two exchange students from the Toyota Technological Institute located in Nagoya, Japan (TTIJ). Tomoaki Kondo and Chenxi Yang arrived in September 2015, took TTIC and University of Chicago courses, and returned to TTIJ in late December.

TTIC remains pleased with the exchange program with TTIJ, as the experience continues to be a positive success for all involved. Two new exchange students are scheduled to enroll on exchange at the institute for Autumn Quarter 2016.
INSTITUTE GOALS

Accreditation

On November 5, 2015, the Higher Learning Commission (HLC) Board reaffirmed TTIC’s Accreditation, placing the Institute on Standard Pathway. The reaffirmation letter of notice requires that TTIC:

- submit an October 2017 Interim Report to the Commission (marking progress on several key points),
- apply for a Substantive Change Application for the TTIC Master’s degree, and then
- be prepared for the normal 2019-20 four-year comprehensive visit, and the 2025-26 reaffirmation visit.

TTIC was pleased with this outcome, which came less than two months after TTIC attended a mandatory hearing with the Commission’s Institutional Actions Council (IAC) regarding the Commission’s on-site visit to TTIC from November 2014. The September 2015 hearing covered topics of Board autonomy, financial independence, assessment and student retention and completion. TTIC is thankful to the HLC for its partnership in working together to assist the institute, and the internal and external constituents who gave their time, support and energy to the accreditation process. TTIC is improved because of it.

In December 2015, TTIC submitted a Substantive Change Application to the HLC. As TTIC only admits PhD students, the PhD program as a whole was accredited. Until this point, this included the Master’s within the PhD portion, inside the program, but Master’s-within-the-PhD diplomas/degrees were somewhat of a gray area. The commission wanted a full review of the diploma requirements to determine if it met standards. In February 2016, TTIC was notified that there would be a Change Visit. The Change Visit was held June 20-21, 2016, at TTIC. Two HLC agents came to TTIC and met with leadership, faculty, students and administration, as well as Institute Trustees. They reviewed all requirements for the Master’s diploma. The agents have reported to TTIC that they will be recommending to the HLC Institutional Actions Council that TTIC be recognized to award the Master’s degree. That determination will be made in August 2016.
Board Strategy for Continued Improvements

The Board appointed three new distinguished Trustees in July of 2015:

- Dr. Eric Grimson, Chancellor for Academic Advancement, Massachusetts Institute of Technology; Executive Advisory Committee, TTIC
- Dr. Jim Merz, Frank M. Freimann Professor Emeritus of Engineering, Concurrent Professor of Physics, University of Notre Dame
- Dr. Richard Samuels, Ford International Professor, Dept. of Political Science, Massachusetts Institute of Technology; Director, MIT Center for International Studies; Founding Director, MIT Japan Program

The new Trustees are outstanding academic appointees, independent, and were selected via processes carried out by the Board Search Committee.

Changes were also approved to the Bylaws regarding the description of two Officer positions: Treasurer and Secretary to the Board, corresponding with Article 5, Sections 5.7 and 5.8. Changes included:

- The Treasurer’s reporting of investment will now be a responsibility of the Chairperson(s) of the Finance Committee.
- The Chief Financial Officer will be a staff administrator who reports day-to-day to the President, and acts under the direction of the Board; the CFO must be independent of any major donor.
- The CFO will invest funds at the direction of the President and the Board.
- TTIC will now have a President, Chief Financial Officer (CFO) and a Secretary of the Institute as Officers.
- The Board Chair will no longer be an Officer.
- Secretary of the Board becomes a Secretary of the Institute, falling under administration, supporting governance.
- The Secretary and CFO positions are now under a three-year appointment.

Committees received attention in 2015-16 as well. A new committee of the Board was created: the President’s Tenure Appointment Review Committee (PTAR). The committee shall review cases for faculty promotion and tenure, and make final recommendations to the President. It was approved by the full Board that committee service terms shall be three years, with an option for renewal. An independent majority of membership was also expanded in the Executive Committee.

The Board received its first TRIP (Total Return Investment Pool) Investment Report from the University of Chicago Investment Office since its initial endowment investment with the office. The Institute will be receiving quarterly reports. Report review will be a function of the Chief Financial Officer and the Finance Committee, reporting to the Board.

See p. 59 section Endowment Growth and Investment Collaboration with University of Chicago.
TTIC has been utilizing the External Advisory Committee (EAC) as a resource since the fall of 2004. This committee met on the Institute’s behalf once more in February 2016. The EAC was on-site February 15-16, met with institute leadership, discussed a tenure case with senior faculty including adjunct faculty, held a session with current students, and also held a session with current tenured and tenure-track faculty.

The current EAC membership includes:

- **Eric Grimson**, Chancellor for Academic Advancement, Massachusetts Institute of Technology
- **Takeo Kanade**, UA and Helen Whitaker Professor, Carnegie Mellon University
- **Richard Karp**, Professor of Electrical Engineering and Computer Science, University of California, Berkeley
- **Éva Tardos**, Jacob Gould Schurman Professor of Computer Science, Cornell University

Based on the visit, and supporting material supplied to the committee, the committee provided TTIC with a final report that outlined the EAC’s impression of TTIC’s state of progress, any areas of concern, and their general observations.

Their report noted areas of progress that the Institute has pursued: accreditation efforts, long-term financial stability, strong and committed service of the President, and a better-utilization of senior faculty.

The committee then made some recommendations for the Institute which touched on areas of expanding external funding, intellectual property policies, nurturing the growth of senior faculty and their service to the Institute and involvement in oversight, engagement of external faculty contributors, promoting and acting assertively on a strategy for gender diversification in faculty and student recruitment, student satisfaction, University of Chicago interaction at the student level, and the strategic plan of the institute. The Committee also discussed the transition of Chief Academic Officer and the exposure of faculty.

The report and guidance that the EAC provides to TTIC is invaluable. Their recommendations serve to direct TTIC in best practices regarding operational improvements, service to faculty and students, and quality insistence in all aspects. We thank them for their continued service on the committee and on behalf of the Institute’s mission and future.
Endowment Growth and Investment Collaboration with University of Chicago

In June 2015, the Toyota Motor Corporation (TMC) provided a donor agreement to TTIC stating:

TMC shall donate the sum of $85 million to TTIC’s endowment by the following three installments: 1st installment: $30 million by the end of June, 2015; 2nd installment: $30 million by the end of July, 2016; 3rd installment: $25 million by the end of July, 2017.

As approved by the Board of Trustees, in July of 2015, TTIC and the University of Chicago entered into an Agreement of Investment Management, which outlines the terms of investment in the University’s Total Return Investment Pool (TRIP) in which TTIC is investing $50 million of its endowment. The agreement was signed by President Sadaoki Furui and University of Chicago Vice President and Chief Investment Officer, Mark Shmid. The agreement remains valid until TTIC cashes out all TRIP funds, or with 180 days written notice by the Investment Office. The Board also approved further investment into TRIP by authorizing the investment of a portion of the $30 million contribution from Toyota Motor Corporation that will be received in July of 2016.

Computing Capacity Doubles in 2016

TTIC doubled its computing capacity in 2016. There now are sixty state-of-the-art GPUs (Graphics Processing Units) with a total of 684 Gigabytes of GPU memory and 520 CPU (Central Processing Unit) cores with a total of 4,416 Gigabytes of system memory. All of these computing resources are served by a total of 150 Terabytes of shared storage.

TTIC’s EAC members: (From top left to bottom right) Richard Karp, Eric Grimson, Eva Tardos, Takeo Kanade.
INTERNS AND VISITING SCHOLARS

TTIC maintains a steady number of interns and visiting scholars who engage in study and research on the premises. There were twenty-seven visiting scholars from other institutions in the U.S. and abroad who came to the Institute to work with TTIC faculty. These short-term visiting scholars bring interest, energy, and enthusiasm to our academic community, and allow TTIC students access to a broad range of specialties that outside researchers bring with them, along with ideas and culture brought from the visitors’ home institutions.

Deblin Bagchi, Ohio State University (K. Livescu)
Vijay Bhattiprolu, Carnegie Mellon University (M. Tulsiani)
Luka Borozan, University of Osijek, Croatia (S. Canzar)
Bharat Chandar, University of Chicago (M. Walter)
Arjun Chandrasekaran, Virginia Tech (M. Bansal)
Cha Chen, University of Chicago (M. Bansal, M. Walter)
Andrea F. Daniele, Sapienza University of Rome (M. Bansal, M. Walter)
Alex Gajewski, University of Chicago Lab School (M. Walter)
Arnab Ghosh, Indian Institute of Technology Kanpur (M. Bansal)
Wanjia He, University of Chicago (K. Livescu)
Dan Hendrycks, University of Chicago (K. Gimpel)
Dong Ki Kim, Cornell University (M. Walter)
Myungin Kim, University of Chicago (M. Bansal)
Aravind Srinivas Lakshminarayanan, Indian Institute of Technology Madras (M. Bansal)
Dian Li, University of Chicago (M. Bansal, M. Walter)
Zhen Li, University of Hong Kong (J. Xu)
Raci Lynch, Stanford University (K. Livescu)
Vivek Madan, University of Illinois, Urbana-Champaign (J. Chuzhoy)
Sepideh Mahabadi, Massachusetts Institute of Technology (J. Chuzhoy, Y. Makarychev)
Pasin Manurangsi, University of California, Berkeley (Y. Makarychev, M. Tulsiani)
Yixin Nie, University of Chicago (M. Bansal)
Manasvi Sagarkar, University of Chicago (K. Gimpel)
Ridwan Syed, University of Chicago (M. Tulsiani)
Trang Tran, University of Washington (M. Bansal, K. Gimpel, K. Livescu)
Igor Vasiljevic, University of Chicago (G. Shakhnarovich)
Yue Xu, California State University (J. Xu)
Xiaoming Zhao, University of Science and Technology of China (J. Xu)
Research Highlights

The Institute’s visiting students are working in a diverse range of research areas, including theory, machine learning, robotics, natural language processing, computer vision, computational biology, and speech technologies. Below are highlights of research projects with profiles of a few of the visiting students:

Andrea Daniele is a visiting student from the University of Rome, La Sapienza, where he has been studying Artificial Intelligence and Robotics Engineering. At TTIC, he is working with Matthew Walter and Mohit Bansal on natural language generation in the context of providing indoor route instructions, which is the problem of planning and synthesizing route instructions with the objective to allow people to easily navigate unknown environments. Andrea is broadly interested in research topics involving both NLP and Human-Robot interaction. He is from Petilia Policastro, a small village in Italy and likes to listen to Jazz and visit museums in his free time.

Dan Hendrycks is an undergraduate at the University of Chicago studying computer science. At TTIC he is working with Kevin Gimpel on the architecture of neural networks and practical deep learning security, including recognizing adversarial images and speech. Dan is from the rural town of Marshfield, Missouri, and enjoys advocating for various effective causes.

Sepideh Mahabadi is a PhD student at the theory of computation group at CSAIL, MIT. Her advisor is Piotr Indyk and her research interests mainly include high dimensional geometry, streaming algorithms, and graph algorithms. She is doing an internship at TTIC working with Julia Chuzhoy and Yury Makarychev on graph algorithms and embedding. She is from Tehran and did her undergraduate studies at Sharif University, Iran.

Trang Tran is a visiting student from the University of Washington, where she works on various speech and language processing projects. Her research ranges from modeling the language of online discussions to studying acoustic-prosodic features indicative of text difficulty. At TTIC, Trang is working with Karen Livescu, Kevin Gimpel, and Mohit Bansal on incorporating speech information to improve constituent parsing. Trang is broadly interested in research topics involving both speech and NLP, with a preference for applications in language disorders and social science. She is from Hanoi, Vietnam, and likes to run in her free time.
# Toyota Technological Institute at Chicago

## Statement of Financial Position

<table>
<thead>
<tr>
<th></th>
<th>June 30, 2016</th>
<th>June 30, 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash and cash equivalents</td>
<td>$ 2,120,090</td>
<td>$ 52,191,189</td>
</tr>
<tr>
<td>Grants receivable</td>
<td>510,413</td>
<td>413,378</td>
</tr>
<tr>
<td>Investment distribution receivable</td>
<td>2,120,670</td>
<td>-</td>
</tr>
<tr>
<td>Prepaid expenses and other current assets</td>
<td>83,696</td>
<td>4,898</td>
</tr>
<tr>
<td>Interest receivable</td>
<td>1,201,435</td>
<td>1,213,796</td>
</tr>
<tr>
<td>Investments (Note 3)</td>
<td>202,464,404</td>
<td>153,923,283</td>
</tr>
<tr>
<td><strong>Total current assets</strong></td>
<td>208,500,708</td>
<td>207,746,544</td>
</tr>
<tr>
<td><strong>Pledges Receivable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Note 5)</td>
<td>54,841,017</td>
<td>54,757,252</td>
</tr>
<tr>
<td><strong>Furniture and Equipment - Net</strong> (Note 4)</td>
<td>593,205</td>
<td>710,810</td>
</tr>
<tr>
<td><strong>Total assets</strong></td>
<td>$ 263,934,930</td>
<td>$ 263,214,606</td>
</tr>
</tbody>
</table>

## Liabilities and Net Assets

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liabilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade accounts payable</td>
<td>$ 143,984</td>
<td>$ 148,341</td>
</tr>
<tr>
<td>Due to TTI (Note 10)</td>
<td>39,425</td>
<td>-</td>
</tr>
<tr>
<td>Accrued expenses</td>
<td>491,929</td>
<td>457,557</td>
</tr>
<tr>
<td>Accrued lease liability</td>
<td>381,213</td>
<td>370,843</td>
</tr>
<tr>
<td>Deferred revenue</td>
<td>393,831</td>
<td>309,771</td>
</tr>
<tr>
<td><strong>Total liabilities</strong></td>
<td>1,450,382</td>
<td>1,286,512</td>
</tr>
</tbody>
</table>

## Net Assets

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestricted</td>
<td>97,968,896</td>
<td>100,532,214</td>
</tr>
<tr>
<td>Temporarily restricted</td>
<td>55,881,664</td>
<td>55,762,957</td>
</tr>
<tr>
<td>Permanently restricted</td>
<td>108,633,988</td>
<td>105,632,923</td>
</tr>
<tr>
<td><strong>Total net assets</strong></td>
<td>262,484,548</td>
<td>261,928,094</td>
</tr>
<tr>
<td><strong>Total liabilities and net assets</strong></td>
<td>$ 263,934,930</td>
<td>$ 263,214,606</td>
</tr>
</tbody>
</table>
# Toyota Technological Institute at Chicago

## Statement of Activities and Changes in Net Assets

<table>
<thead>
<tr>
<th>Revenue, Gains, and Other Support</th>
<th>2016</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unrestricted</strong></td>
<td><strong>Temporarily Restricted</strong></td>
<td><strong>Permanently Restricted</strong></td>
</tr>
<tr>
<td>Student tuition and fees</td>
<td>$750,000</td>
<td>$</td>
</tr>
<tr>
<td>Scholarship allowance</td>
<td>$(750,000)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Net tuition and fees</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Federal grants and contracts</td>
<td>1,566,643</td>
<td>-</td>
</tr>
<tr>
<td>Contributions (Note 10)</td>
<td>83,765</td>
<td>-</td>
</tr>
<tr>
<td>Net realized and unrealized gains and losses on investments</td>
<td>(522,793)</td>
<td>34,942</td>
</tr>
<tr>
<td>Interest income</td>
<td>4,662,159</td>
<td>-</td>
</tr>
<tr>
<td>Other interest</td>
<td>20,463</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total revenue, gains, and other support</strong></td>
<td>5,726,472</td>
<td>118,707</td>
</tr>
</tbody>
</table>

## Expenses

<table>
<thead>
<tr>
<th><strong>Unrestricted</strong></th>
<th><strong>Temporarily Restricted</strong></th>
<th><strong>Permanently Restricted</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational costs - Instruction</td>
<td>6,359,487</td>
<td>-</td>
<td>6,359,487</td>
</tr>
<tr>
<td>Management and general - Institutional support</td>
<td>1,930,303</td>
<td>-</td>
<td>1,930,303</td>
</tr>
<tr>
<td><strong>Total expenses</strong></td>
<td>8,289,790</td>
<td>-</td>
<td>8,289,790</td>
</tr>
</tbody>
</table>

## (Decrease) Increase in Net Assets

<table>
<thead>
<tr>
<th><strong>Unrestricted</strong></th>
<th><strong>Temporarily Restricted</strong></th>
<th><strong>Permanently Restricted</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,563,318)</td>
<td>118,707</td>
<td>3,001,065</td>
<td>556,454</td>
</tr>
<tr>
<td>(Decrease) Increase in Net Assets</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Net Assets - Beginning of year

<table>
<thead>
<tr>
<th><strong>Unrestricted</strong></th>
<th><strong>Temporarily Restricted</strong></th>
<th><strong>Permanently Restricted</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>100,532,214</td>
<td>55,762,957</td>
<td>105,632,923</td>
<td>261,928,094</td>
</tr>
</tbody>
</table>

## Net Assets - End of year

<table>
<thead>
<tr>
<th><strong>Unrestricted</strong></th>
<th><strong>Temporarily Restricted</strong></th>
<th><strong>Permanently Restricted</strong></th>
<th><strong>Total</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>$97,968,896</td>
<td>$55,881,664</td>
<td>$108,633,988</td>
<td>$262,484,548</td>
</tr>
</tbody>
</table>

## Net Assets - End of year

<table>
<thead>
<tr>
<th><strong>Unrestricted</strong></th>
<th><strong>Temporarily Restricted</strong></th>
<th><strong>Permanently Restricted</strong></th>
<th><strong>Total</strong></th>
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<td>105,632,923</td>
<td>261,928,094</td>
</tr>
</tbody>
</table>
The latest RNA-sequencing techniques create an avalanche of fragmented genetic data. TTIC’s Stefan Canzar leads a team using advanced algorithms to reassemble that information and detect missing patterns.

Accurately reconstructing the basic protein patterns in the genetic blueprints of life can help researchers understand cellular biology and identify specific patterns in genes that produce diseases. The preferred method of converting samples of cellular RNA into genetic data is RNA sequencing (RNA-seq), which creates hundreds of millions of small data fragments, known as reads.

Piecing together the resulting mass of highly fragmented data into the full-length molecular sequences, known as transcripts, is difficult. But a group of scientists from Toyota Technological Institute of Chicago (TTIC), Freie Universität Berlin, and Centrum Wiskunde & Informatica, have developed a way to use advanced algorithms to reconstruct RNA sequences more accurately and comprehensively than other current methods.

RNA stands for ribonucleic acid, a complementary molecule to DNA that’s found in all living cells. While every cell of the same organism contains the same DNA molecules, their genes are transcribed into different RNA sequences depending on cell type.

In RNA-seq, scientists break the content of a cell into tens of millions to hundreds of millions of short sequences of 100 to 150 bases, called reads. Reads can be pieced together to reconstruct an RNA transcript. But piecing the reads back together in correct combinations is difficult, because they often contain little information about where they belong.

“It is a big jigsaw puzzle,” says Stefan Canzar, a research assistant professor at TTIC. “You want to figure out the big picture—these RNAs—but you only have these small fragments, these puzzle pieces.” Further complicating matters, one subgroup of transcripts is particularly hard to reconstruct. When transcripts are rare in the sample, key data about the connectivity of basic informational blocks that make up transcripts, known as exons, may not be evident from RNA sequencing. The researchers call these “invisible transcripts.” Existing methods being used to reassemble RNA ignore such transcripts for computational reasons.

The technique pioneered by Canzar and his colleagues, Comprehensive Isoform Discovery and Abundance Estimation, or CIDANE, mixes techniques from machine learning and combinatorial optimization to reconstruct transcripts.

CIDANE can also use existing information from known, and experimentally validated, gene structures to improve the accuracy of the RNA assembly. While such information is not necessary, CIDANE can use any existing data to improve its ability to reconstruct RNA.

“Any prior knowledge can help in piecing together the genetic puzzle,” says Canzar. CIDANE is also able to reassemble the elusive invisible transcripts, detecting patterns that other techniques miss, Canzar says. Using a technique from large-scale optimization, CIDANE can discover those transcripts using an optional stage of the algorithm that kicks in on-demand when invisible transcripts appear to be involved. While the importance of invisible transcripts is still uncertain, by recognizing them, CIDANE gives genetics researchers more and better information about their existence and value.

Ultimately, CIDANE is more accurate than all existing reconstruction methods, Canzar says. The most sensitive reassembly technique after CIDANE, when applied to human blood and monocyte samples, correctly pieced together 11,473 and 11,117 transcripts respectively. CIDANE correctly predicted 14,885 and 14,254, which is 80 to 90 percent more transcripts than the third most sensitive, and most widely used, reassembly technique.

TTIC’s Julia Chuzhoy studies complicated graphs, aiming to create faster and more accurate algorithms.

Finding the best driving route, connecting with friends on Facebook, buying a cheap airline ticket—all of these rely on what computer scientists call “graphs” or networks, the mathematical term for a sets of nodes connected by edges.

Because graphs are used so widely, better understanding their structures leads to superior algorithms, and to better and faster computer programs. TTIC’s Julia Chuzhoy is trying to deepen our understanding of graphs by looking for hidden structures lurking in complex networks.

Imagine routing traffic across a graph, which could represent the streets of a city or a corporate computer network. “We would like to find pathways for traffic to follow, while keeping the load on the graph edges as low as possible,” says Chuzhoy.

Take a city such as Phoenix, which typically closes some roads in the spring for construction and sets up detours. How should the city reroute traffic so that vehicles continue to efficiently move through the network?

In graphs such as the one formed by Phoenix’s road system, there is a hidden structure: a grid. In Phoenix, a good number of roads run either North to South or East to West. The street intersections are the grid nodes, and the road segments connecting the intersections are its edges. Grid graphs are among the simplest to analyze, but they are still rich in interconnections, so routing traffic on them is easy and convenient. The larger the grid, the more traffic it can carry.

Mathematicians Neil Robertson of the Ohio State University and Paul D. Seymour of Princeton famously showed in 1986 that any graph that’s complex enough contains a grid. But the grids they found were too tiny to be useful when routing large amounts of traffic across a network. Since then, the question of whether complex graphs contain large grids has remained a central open question in graph theory.

This represented a huge step forward in understanding network routing, but it left open the bigger question of whether another kind of crossbar—a large grid—exists in complex graphs. “While any crossbar would work for routing problems, grids have many more known uses, so they are in some sense ‘universal’ or ‘all-purpose’ crossbars,” Chuzhoy says.

In a follow-up work with Chandra Chekuri, a colleague from University of Illinois, Chuzhoy shows that the tree-of-sets system helps not only with routing, but also with finding large grids, answering a question that had been open for almost 30 years. The grids that Chuzhoy and Chekuri find are quite close in size to the best one could hope for. This result sheds new light on the structure of complex graphs and creates far more powerful tools for using them. For example, it’s already led to better and much faster algorithms for many graph-based problems.

While theoretical, Chuzhoy’s research could ultimately be used to help design algorithms that make communication and transportation networks more reliable and solve an array of other practical problems—from finding more efficient designs for electronic circuitry, for instance, to planning complex maneuvers of swarming robots.


Can computers learn to color?

A machine-learning system developed by TTIC researchers can accurately colorize black-and-white images.

Human imagination is adept at instilling color into a black-and-white photograph. Our familiarity with the visual world is so ingrained that a child completing a coloring book understands what makes a realistic palette. Sky is usually blue, but other objects, such as a car, could be any one of many colors. In pursuit of building machines that can interpret the visual world as well as humans, some researchers see color as a starting point. Gustav Larsson, a PhD student in computer science at the University of Chicago, and TTIC’s Michael Maire and Gregory Shakhnarovich, have found a way to teach machines to accurately predict colors using new machine-learning techniques based on artificial neural networks.

This new method could be used to automatically colorize historical images and films, and create computer graphics tools for artists. But ultimately, the work could lead to a method of priming a robot’s artificial visual system so it could recognize and navigate its environment. “Automatic colorization also serves as a proxy measure for visual understanding,” the researchers write.

Rather than start from scratch, Larsson, Maire, and Shakhnarovich began with an existing neural network that could recognize 1,000 different types of objects. They then focused on modifying this network to predict a color for every pixel in a grayscale image - even if the pixel was part of an unrecognized object. To do so, they trained the network using a database of 1.2 million color photos. Converting each to grayscale enabled them to present the network with example pairs of a grayscale input image and corresponding desired color output image.

Teaching the network proceeded via a routine of learning from mistakes. The researchers used a network with a deep architecture: one layer of neurons is connected to the input, while a second layer of neurons is connected to the first layer. This pattern repeats for many layers, the last of which is treated as the output. The strength of each connection is a parameter that can be adjusted. The network contained a total of almost 150 million such parameters, and as a whole those parameters determined the network’s behavior. Learning from each example involved tweaking the parameters so that the network’s output became more similar to the actual color image. This required propagating parameter adjustments backwards through the network, from last to first layer. After taking a week to iterate through all 1.2 million examples 10 times, the network was well tuned to the task of colorization.

The researchers point to two custom aspects of their architecture design that were key to accurate colorization. First, they added shortcut connections from intermediate layers of the network to deeper layers. For vision tasks, neurons in early layers typically learn to respond to local image structures, such as edges and corners. As one moves to subsequent layers, neurons respond to a larger context and increasingly abstract concepts: textures, object parts, objects, and scenes. When deciding on a color, the shortcut connections “allowed the network to combine the ‘what’ and ‘where’ aspects of image understanding,” says Shakhnarovich.

Second, the network’s predictions appeared in the form of color histograms, rather than as exact color values. This allowed the system to hedge its bets, especially for objects such as clothes or flowers that typically occur in different colors. As a side benefit, the system’s histogram output made it possible for it to automatically generate several different plausible colorizations - a potential boon to artists wanting to manipulate their work with different color palettes.
According to quantitative measures of color accuracy, the researchers’ method works significantly better than those of its predecessors. Many earlier attempts also required users to advise the computer, either by scribbling some suggested colors on the image and having the system fill in the rest, or by presenting related photos from which to transfer colors onto the target image. Outperforming these approaches, while being fully automatic, means the method vastly reduces the human labor required to achieve accurate colorization.

With a working system in place, the researchers went back to the start in order to expand their goals: could they remove the requirement to first know about 1,000 objects? To pick colors, the network must have identified many uncategorized objects - the set of 1,000 objects only provided a head start. If the colorization task alone could teach the network about the visual world, their system would succeed without this head start. To test this hypothesis, the researchers repeated their training procedure starting from a network with connection strengths that were randomly chosen, rather than borrowed from a network that already knew about objects.

The resulting trained network was able to colorize images just as well as the original network, proving that it wasn’t necessary to start with object knowledge. The next test was to probe what the network actually knew about the visual world. “We want to see if learning to correctly predict the color makes it easier to learn about different types of objects in images,” Shakhnarovich says. They gave the colorization-trained network the additional task of labeling pixels according to object category (for example, car, person, chair, or table).

The colorization network proved capable of labeling objects, performing better at this than a baseline network that had not been first taught to colorize. This result suggests colorization is a gateway to building other systems that understand images. And for colorization, the learning process itself can be automated with an endless supply of color images on the Internet. The researchers hope that future machine vision systems will learn on their own, like a child playfully exploring without any instruction from parents.

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President, Toyota Technological Institute at Chicago
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Professor, Academy for Global Leadership, Tokyo Institute of Technology
Former Director of University Library, Tokyo Institute of Technology
Former Dean of Graduate School of Information Science and Engineering, Tokyo Institute of Technology
Former Director of Furu Research Laboratory, NTT Human Interface Laboratories, Japan
Former Director of Speech and Acoustics Laboratory, NTT Human Interface Laboratories, Japan
*Trustee since April 2013*

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Bernard Gordon Chair of Medical Engineering at MIT
Lecturer on Radiology at Harvard Medical School and at Brigham and Women's Hospital
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*Trustee since July 2015*
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Chair and Chief Executive Officer, New Ventures, LLC
Appointed by President Jimmy Carter, became the youngest director of the Women's Bureau in the history of the Labor Department
US 23rd Secretary of Labor and first African American to lead the US Department of Labor
Former member of the National Economic Council
Serves on the boards of: Cummins Inc., Entergy Inc., MGM Mirage, Coca-Cola Company
Former chairwoman of the Coca-Cola Company’s Human Resources Task Force
Board member of the Clinton Bush Haiti Fund
Trustee since October 2012

Masanori Kashiwara
Executive Advisor, Toyota Technological Institute
Member of the Board of Directors, Toyota School Foundation
Former Chief Administrative Officer, Toyota Technological Institute
Former Vice President, Toyota Motor North America, Inc.
Former Secretary and Treasurer, Toyota Motor Corporate Services of North America, Inc.
Trustee since October 2009

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Member, Enrico Fermi Institute
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Emeritus Director, International Computer Science Institute
Former Editor-in-chief of Speech Communication
Fellow of the IEEE and of the International Speech Communication Association (ISCA)
Trustee since April 2015

Hiroyuki Sakaki
President, Toyota Technological Institute
Professor Emeritus in 2007, Institute of Industrial Science, University of Tokyo
Former Vice President of Toyota Technological Institute (Nagoya, Japan) in 2007 and promoted to President in 2010
Awarded the National Recognition as a Person of Cultural Merit, Japan Academy Award, Leo Esaki Award, Heinrich Welker Award, Medal of Purple Ribbon from the Emperor of Japan, IEEE David Sarnoff Award, Fujiwara Prize, Japan IBM Science Award, and the Hattori-Hoko Award
Trustee since October 2010

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Ford International Professor, Dept. of Political Science, Massachusetts Institute of Technology
Director, MIT Center for International Studies
Founding Director, MIT Japan Program
Former head of the MIT Political Science Department, Vice-Chair of the Committee on Japan of the National Research Council, and chair of the Japan-US Friendship Commission.
Trustee since July 2015
Toshiaki Taguchi
Advisor, Toyota Motor Corporation
Former President and CEO, Toyota Motor North America, Inc.
Former Executive Vice President, Toyota Motor Corporation
Former Board of Directors of Japan Society, the Japanese Chamber of Commerce and Industry of New York and the Nippon Club
Trustee since October 2002

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Chairman of the Board of Trustees, Toyota Technological Institute at Chicago
Chairman of the Board of Directors & the Board of Trustees, Toyota School Foundation
Special Advisor, Toyota Central R&D Labs., INC.
Former Executive Vice President, Toyota Motor Corporation
Trustee since October 2011

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Anna Ruffolo, Director of Operations
Chendi Wu, Senior Accountant

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TTIC, in admissions, employment and access to programs, considers all faculty, staff and students on the basis of individual merit and without regard to race, color, religion, sex, sexual orientation, national or ethnic origin, age, disability, or any other legally protected status.
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The Toyota Technological Institute (Nagoya, Japan)