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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. 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.
During 2018-2019, 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.

Seven new non-tenure track faculty members arrived at the start of the 2018-19 academic year. We had 225 applications to our PhD program this year, up from 207 last year (and 135 the year before). We gave offers to 26 students, most of whom have many other top offers, and 9 students accepted. 20% of applicants and 23% of students given offers were female (these were 17% and 23% respectively last year).

In recognition of his outstanding research, professional stature, and contributions to TTIC, Yury Makarychev has been promoted to Full Professor. Two PhDs will be awarded this fall, bringing the total number of TTIC’s alumni to 19, and 8 Masters within the PhD degrees will also be awarded this Fall.

The level of recognition and impact of research at TTIC continues to steadily increase, the latest examples being the following noteworthy awards: In terms of paper awards, Jinbo Xu received RECOMB 2019 Test-of-Time Award for the 2007 publication, and two PhD students received Best Students Award at COLT 2019: (1) Omar Montasser with Research Assistant Professor Steve Hanneke and Professor Nathan Srebro, and (2) Blake Woodworth with a visiting student, two visiting alumni, a PhD alumnus, and Professor Nathan Srebro. Blake Woodworth also received the Google Fellowship.

TTIC faculty gave many invited, distinguished, and keynote talks also this academic year. Nathan Srebro lead a plenary session on Distributed Learning at ITA 2019. Karen Livescu was an invited speaker at the ICERM Workshop on Theory and Practice in Machine Learning and Computer Vision, and will be a Keynote speaker at the Natural Language, Dialog and Speech (NDS) Symposium later this year. Avrim Blum gave an IAM-PIMS distinguished lecture at the University of British Columbia. I gave invited talks on AI at JTEKT in Nagoya, at the Riken Center for Advanced Intelligence Project Symposium in Tokyo and at the Asia Pacific Signal and Information Processing Association conference in Hawaii. The faculty actively pursued federal research grants, with tenured and tenure-track faculty being awarded three grants totaling over $3.7 million.
In terms of the accreditation renewal process, the next HLC visit will be February 2020. We are currently drafting the Self-Study Report and compiling evidence documents/exhibits to support the report, which will be submitted to HLC at the beginning of January 2020.

Our relationship with Toyota Technological Institute in Nagoya (TTIJ) continues to strengthen. Several TTIJ faculty spent a couple of days at TTIC for conducting joint research with TTIC faculty, and the 2nd TTIJ student enrolled in the TTIC’s PhD program in autumn 2018. The institute’s relationship with the University of Chicago remains strong, both with respect to various kinds of administrative aid, student support and with respect to the potential for collaborative research and academic endeavors. TTIC courses remain popular with University of Chicago students, with over 80% of enrollment consisting of students from the University. Total enrollment experienced a modest drop compared to last year (279 down from 366 last year) due in part to a slightly different mix of courses in alternate years as well as Julia Chuzhoy being on sabbatical.

As of June 30, 2019, I will step down from the role of TTIC President after 6 years and 3 months of service. The Presidential Search Committee set up by the TTIC Board and a search firm conducted screening and interviews with candidates, and the Committee finally recommended Dr. Matthew Turk to the Board as my successor. The recommendation was unanimously approved, and we are excited to welcome Dr. Turk on July 1. During my term, TTIC has made significant growth in terms of size and status; e.g., number of tenure and tenure-track faculty has increased from 8 to 12, number of students has increased from 22 to 35, number of student applications has increased from 66 to 225, number of PhD alumni has increased from 3 to 17, number of admin staff has increased from 7 to 10, annual budget has increased from $7 million to $10 million, and total amount of endowment has increased from $110 million to $225 million. Faculty and students have received many scientific awards, and faculty have been awarded many federal grants. I had a fantastic time at TTIC!

I hope TTIC will continue its growth and to mature as an institution, under the new President. We are committed to further improvement of academic excellence and enhancing the already strong relations with our academic partners.

Sadaoki Furui
President
NOTE FROM THE CHIEF ACADEMIC OFFICER

It has been another fantastic year for academics at TTIC, so let me begin with a little bragging. This year both Best Student Paper awards at COLT 2019 went to papers authored by TTIC researchers: Steve Hanneke, Omar Montasser, and Nati Srebro received the award for their paper, “VC Classes are Adversarially Robustly Learnable, but Only Improperly”, and Nati Srebro, Blake Woodworth and co-authors received the award for their paper, “The Complexity of Making the Gradient Small in Stochastic Convex Optimization”. Jinbo Xu received the RECOMB Test of Time Award for his 2007 publication, “Pairwise Global Alignment of Protein Interaction Networks by Matching Neighborhood Topology.” And Arturs Backurs received the 2019 EATCS Distinguished Dissertation Award.

TTIC faculty were also selected for a number of high-profile research leadership positions: Karen Livescu served as Program Co-Chair for ICLR 2019, Julia Chuzhoy was selected as Program Chair for STOC 2020, and many TTIC faculty served as Area Chairs for top conferences.

Departures are always bittersweet, but we are very proud of the successes of our departing Research Assistant Professors. Allyson Ettinger joined the University of Chicago as an Assistant Professor in the Linguistics Department, Suriya Gunasekar joined Microsoft Research as a Research Scientist, Mark Hallen co-founded a bio-medical startup Gavilan Biodesign, Aly Khan joined the University of Chicago in the Department of Pathology, Mesrob Ohannessian joined the University of Illinois at Chicago as an Assistant Professor of Electrical and Computer Engineering, and Karl Stratos joined Rutgers as an Assistant Professor of Computer Science. Congratulations and good luck to all!

Finally, congratulations to 2018 PhD graduates Haris Angelidakis, Heejin Choi, and Shubhendu Trivedi, and 2019 PhD graduate Mohammadreza Mostajabi!

This past year was a busy one. We had our first ever Industry Open House, hosted the Midwest Speech and Language Days, took part in the AI Driving Olympics, had another successful and well-attended Summer Workshop Series, hosted a large number of summer visiting students, and had many exciting colloquium speakers. We also welcomed three new adjoint faculty: Sanjeev Khanna from the
University of Pennsylvania, David Chiang from Notre Dame, and Richard Lipton from Georgia Tech.

Our PhD program continues to grow. We had 225 applicants to our PhD program this past year (a new record), and next year our student body will for the first time exceed 40 students. So, we might be a little crowded this coming year, but I am sure we can handle it, and the energy will be invigorating.

Let me conclude by thanking my friend and colleague Sadaoki Furui for his fantastic service as president of TTIC over the past 6 years, and welcoming our new president Matthew Turk. Sadaoki was instrumental in helping TTIC blossom and grow. He advocated for TTIC’s core mission of fundamental research and education, and ensured that TTIC’s faculty and students had the resources they needed to do great things and fulfill that mission, always in his quiet way looking out for the good of TTIC. Thank you, Sadaoki, for all you have done for TTIC. And we are greatly excited to have Matthew Turk as our new incoming president. Matthew is a highly accomplished researcher in the areas of computer vision, augmented reality, HCI, and AI more generally, who will help lead TTIC to new heights of excellence in research and education.

TTIC is a special place. There is a wonderfully collaborative atmosphere, an intense research focus, and the highest standards of scholarship and integrity. Everyone I speak to who has spent time here tells me they carry TTIC in their hearts. For alumni and others reading this, we welcome you back (or here) anytime.

Avrim Blum
Chief Academic Officer
INSTITUTE OVERVIEW

Faculty and Staff

<table>
<thead>
<tr>
<th>Position</th>
<th>Count</th>
</tr>
</thead>
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<tr>
<td>Professors</td>
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<tr>
<td>Associate Professors</td>
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<tr>
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<tr>
<td>Research Assistant Professors</td>
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<tr>
<td>Adjoint Faculty</td>
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</tr>
<tr>
<td>Administrative Office Staff and IT</td>
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<tr>
<td>Postdocs</td>
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PhD Program

<table>
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<tr>
<th>Category</th>
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<tbody>
<tr>
<td>Students Enrolled for 2018-19</td>
<td>35</td>
</tr>
<tr>
<td>Master’s within the PhD Program Degrees Awarded</td>
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</tr>
<tr>
<td>PhD Degrees Awarded</td>
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<tr>
<td>Applicants for the 2019-20 Academic Year</td>
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<tr>
<td>Admitted</td>
<td>27</td>
</tr>
<tr>
<td>Enrolled</td>
<td>9</td>
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</table>

AWARDS AND HONORS

2019 July  Arturs Backurs

Prof. Arturs Backurs will be awarded the Distinguished Dissertation Award at EATCS 2019, the 46th International Colloquium on Automata, Languages and Programming (ICALP 2019), the main European conference in Theoretical Computer Science and annual meeting of the European Association for Theoretical Computer Science (EATCS).

2019 June  Omar Montasser, Steve Hanneke, Nati Srebro,
Blake Woodworth and Karthik Sridharan

At the 32nd Conference on Learning Theory (COLT), held in Phoenix, Arizona, in June 2019, both Best Student Paper awards went to TTIC PhD students. TTIC PhD student Omar Montasser for the paper, "VC Classes are Adversarially Robustly Learnable, but Only Improperly" with TTIC Research Assistant Prof. Steve Hanneke and TTIC Prof. Nati Srebro. TTIC PhD student Blake Woodworth and Ayush Sekhari (TTIC visiting student) for the paper, "The Complexity of Making the Gradient Small in Stochastic Convex Optimization" with Dylan Foster, Ohad Shamir, (TTIC visiting student alumnus), Karthik Sridharan (TTIC PhD alumnus), and TTIC Prof. Nati Srebro.
Prof. Karen Livescu was Program Co-Chair for the International Conference on Learning Representations (ICLR) 2019. ICLR is the premier gathering of professionals dedicated to the advancement of the branch of artificial intelligence called representation learning, but generally referred to as deep learning.

ICLR is globally renowned for presenting and publishing cutting-edge research on all aspects of deep learning used in the fields of artificial intelligence, statistics and data science, as well as important application areas such as machine vision, computational biology, speech recognition, text understanding, gaming, and robotics.

Prof. Jinbo Xu, together with Professor Bonnie Berger of Massachusetts Institute of Technology and Dr. Rohit Singh, will be receiving the Test of Time Award at the RECOMB 2019 conference in Washington D.C. this May 2019, for the 2007 publication, “Pairwise Global Alignment of Protein Interaction Networks by Matching Neighborhood Topology.” RECOMB 2019 conference is the 23rd edition of a series of algorithmic computational biology conferences bridging the areas of computational, mathematical, statistical and biological sciences and is one of the top two conferences in Computational Biology. Professor Xu has also received the Best Paper award in RECOMB 2014 for his work entitled, “MRFalign: Protein Homology Detection through Alignment of Markov Random Fields” and the Best Poster award in RECOMB 2009 for his work entitled, “Boosting Protein Threading Accuracy”.

TTIC PhD Candidate Blake Woodworth is awarded the Google PhD Fellowship. Google PhD Fellowship students are a select group recognized by Google researchers and their institutions as some of the most promising young academics in the world. The Fellowships are awarded to students who represent the future of research.

Julia Chuzhoy was selected Program Chair for the 52nd ACM Symposium on Theory of Computing (STOC) 2020, to be held in Chicago IL in June 2020.
NEW FACULTY

Research Assistant Professors

Arturs Backurs | PhD - Massachusetts Institute of Technology
Allyson Ettinger | PhD - University of Maryland, College Park
Steve Hanneke | PhD - Carnegie Mellon University
Sepideh Mahabadi | PhD - Massachusetts Institute of Technology
Thatchaphol Saranurak | PhD - KTH Royal Institute of Technology
Sam Wiseman | PhD - Harvard University
Michael Yu | PhD - University of California, San Diego

Adjoint Professors

Sanjeev Khanna
Professor, University of Pennsylvania | PhD - Stanford University

David Chiang
Associate Professor, University of Notre Dame | PhD - University of Pennsylvania

Richard Lipton
Professor and Frederick G. Storey Chair (emeritus), Georgia Institute of Technology | PhD - Carnegie Mellon University
Beginning in June 2018, TTIC held an open search for a new President to succeed Dr. Sadaoki Furui, who informed the Board of Trustees he would step down in the summer of 2019. The Board appointed a President Search Committee: Dr. Eric Grimson (Chair) Dr. Sadaoki Furui, Dr. Rocky Kolb, Dr. Nelson Morgan, and Dr. Hiroyuki Sakaki. The committee worked with the firm WittKieffer to conduct an extensive search.

Dr. Sadaoki Furui served as President from April 2013, and concluded his term on June 30, 2019. Under the six years of President Furui’s tenure, TTIC received its first full accredited status by the Higher Learning Commission. The student body grew from 21 students to 35, and the President attended the graduations of 14 PhD program graduates. (Only 3 students graduated prior to the 6-year term of President Furui.)

In November 2018, the Board made an appointment offer to Dr. Matthew Turk, which was accepted. Dr. Turk is a full professor at the University of California, Santa Barbara. His primary appointment is in the Department of Computer Science, where he serves as Department Chair since 2017. He holds a secondary appointment in Media Arts and Technology, where he served as Chair from 2005 to 2010. He also had affiliate appointments in Electrical and Computer Engineering and the Dynamical Neuroscience Program and was involved in several interdisciplinary organizations across campus.

A farewell reception was held for President Furui on June 28, 2019. Offering gratitude to Dr. Furui for his service and contributions, speakers at the event included:

Avrim Blum, Chief Academic Officer
Karen Livescu, Associate Professor
David McAllester, Professor
Chrissy Novak, Administrative Director of Graduate Studies
Shubham Toshniwal, PhD Candidate

Dr. Furui, a long-time flutist, played at the ceremony with his wife accompanying him on the piano.

Dr. Turk will begin his President tenure on July 1, 2019, with an investiture ceremony scheduled for October 2019. Dr. Turk relayed the following message to TTIC constituents, “I am deeply...
honored and thrilled to have the opportunity to serve as the next president of the Toyota Technological Institute at Chicago, and I am grateful to the TTIC Board of Trustees for giving me the chance to serve in this capacity. In its short history, TTIC has become a world-class computer science institute with a distinctive research profile and a dynamic and collaborative culture. The Institute is well-positioned to accelerate its momentum and surpass the impressive strides it has already achieved in its mission of international impact through research and education. I look forward to working closely with the Board and the entire TTIC community – faculty, students, staff, and partners – to further the mission, explore new opportunities for excellence and impact, and support TTIC’s unique scholarly community. I am particularly excited to get to know the people of TTIC, learn more about their recent and planned research, and to explore the wonderful city of Chicago.”
FACULTY PROMOTION AND TENURE

At the April 2019 meeting of the Board of Trustees, upon recommendation of the President, the Trustees approved Yury Makarychev for promotion to full Professor.

Yury Makarychev received his MS degree in Mathematics from Moscow State University in 2001 and his PhD in Computer Science from Princeton University in 2008. He spent the following two years as a Postdoctoral Researcher at Microsoft Research in Redmond, WA and Cambridge, MA.

Yury's research interests include combinatorial optimization, approximation algorithms, semi-definite programming, and low-distortion metric embedding. He has recently worked on developing approximation algorithms for unique games, constraint satisfaction, graph partitioning, and vertex ordering problems, investigating tradeoffs between local and global properties of metric spaces, and studying lift-and-project hierarchies of mathematical relaxations.

Yury advised 2018 PhD alumnus Haris Angelidakis, who is currently employed at Eidgenössische Technische Hochschule Zürich (ETH Zurich).

In addition, the Board approved new President, Dr. Matthew Turk's tenure, that when his appointment as President concludes, he will transition to tenured Professor duties.
FACULTY BY AREA

Algorithms & Complexity
Backurs, Arturs
Blum, Avrim
Chuzhoy, Julia
Mahabadi, Sepideh
Makarychev, Yury
Saranurak, Thatchaphol
Tulsiani, Madhur

Machine Learning
Bhojanapalli, Srinadh
Gunasekar, Suriya
Hanneke, Steve
McAllester, David
Ohannessian, Mesrob
Srebro, Nathan

Computational Biology
Hallen, Mark
Khan, Aly
Xu, Jinbo
Yu, Michael

Robotics
Walter, Matthew

Computer Vision & Computational Photography
Shakhnarovich, Greg

Speech and Language Technologies
Ettinger, Allyson
Gimpel, Kevin
Livescu, Karen
Stratos, Karl
Wiseman, Sam

POST-DOCS
Lin, Meishan
Wang, Sheng
Nguyen, Son
Research Philosophy

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, adjoin professors and postdocs encompassing many areas of research interests, and from many countries and 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 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 met 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.

Arturs Backurs
Research Assistant Professor
www.ttic.edu/backurs

PUBLISHED/SUBMITTED PAPERS

TALKS
"Efficient Density Evaluation for Smooth Kernels." Talk given at the University of Chicago, IL, November 2018.
"Efficient Density Evaluation for Smooth Kernels." Talk given at the University of Michigan, Ann Arbor, November 2018.

IN Volvement
Conference Reviews: FOCS, ICALP, ICML, ITCS, MFCS, SODA, STACS, STOC
Journal Reviews: Algorithmica, Transactions on Algorithms
Grant Reviews: ERC Starting Grant, the Israel Science Foundation
HONORS/AWARDS
EATCS Distinguished Dissertation Award, 2019
George M. Sprowls Award for Best PhD Thesis in Computer Science, MIT, 2018

Avrim Blum
Chief Academic Officer
www.ttic.edu/blum

PUBLISHED/SUBMITTED PAPERS
Blum, Avrim, Vladimir Braverman, Ananya Kumar, Harry Lang, and Lin F. Yang. “Approximate Convex Hull of Data Streams.” International Colloquium on Automata, Languages and Programming (ICALP), Prague, Czech Republic, July 2018.

TALKS
"Some results on algorithmic fairness in online decision making." IAM-PIMS Distinguished Lecture Talk given at the University of British Columbia, Vancouver, BC, November 2018.
"Algorithmic fairness in online decision-making." Gerald M. Masson Distinguished Lecture Talk given at the Department of Computer Science at Johns Hopkins University, Baltimore, MD, April 2019.
"Algorithmic fairness in online decision-making." Talk given at UChicago & TTIC ML Seminar, April 2019.

INVolvEMENT
Program Chair, ITCS 2019
Committee Chair, ACM Knuth Prize
Editorial board: Journal of the ACM
Steering Committee, FOCS
Scientific Advisory Board, Simons Institute for the Theory of Computing
Technical Advisory Board, Microsoft Research India
60th Anniversary Celebration Committee, FOCS 2019

RESEARCH FUNDING AWARDS

CLASSES/SEMINARS
TTIC 31010 - Algorithms (CMSC 37000): This is a graduate level course on algorithms with the emphasis on central combinatorial optimization problems and important methods for algorithm design and analysis. Topics covered include greedy algorithms, dynamic programming, network flow, linear programming, NP-completeness, approximation algorithms, randomized algorithms and probabilistic methods, and online algorithms.

MISCELLANEOUS
Advisor, Kevin Stangl (TTIC)
Thesis Committee: Colin White (CMU), Keerthiram Murugesan (CMU), Kent Quanrud (UIUC)
Hosted summer interns Neha Gupta (Stanford) and Paul Golz (CMU)
Julia Chuzhoy  
Professor  
www.ttic.edu/chuzhoy

PUBLISHED/SUBMITTED PAPERS

TALKS

ININVOLVEMENT
Program Committee Chair, STOC 2020  
Editorial Board Member, SIAM Journal on Computing  
Steering Committee Member, SODA

HONORS/AWARDS
Best Paper Award, Workshop on Representation Learning for NLP at ACL, 2016.

RESEARCH FUNDING AWARDS
NSF 1616584, AF: small: “Graph routing, vertex sparsifiers, and connections to graph theory.” Sept 1 2016 – August 31, 2020. $449,720. I am the PI.

MISCELLANEOUS
Advisor: Rachit Nimavat (TTIC) and Zihan Tan (UChicago)

Sepideh Mahabadi  
Research Assistant Professor  
www.ttic.edu/mahabadi

PUBLISHED/SUBMITTED PAPERS

TALKS
"Diversity Maximization over Large Data Sets." Invited Talk given at Midwest Theory Day Workshop, Purdue University, West Lafayette, IN, April 2019.
"Nonlinear Dimension Reduction via Outer Bi-Lipschitz Extension." Invited Talk given at Metric
Yury Makarychev
Associate Professor
www.ttic.edu/makarychev

PUBLISHED/SUBMITTED PAPERS

TALKS
“k-means and k-medians under dimension reduction.” Talk given at Workshop on Robust and High-Dimensional Statistics, Simons Institute, Berkeley, CA, November 2018.
“Nonlinear Dimension Reduction via Outer Bi-Lipschitz Extensions.” Talk given at AMS Meeting, Hartford, CT, April 2019.

INVOLVEMENT
Organizing Committee Member, STOC 2020

RESEARCH FUNDING AWARDS
NSF Award CCF-1718820, $449,986 (2017–2020)

CLASSES/SEMINARS
TTIC 31100 / CMSC 39010-1 Computational and Metric Geometry: The course covers fundamental concepts, algorithms and techniques in computational and metric geometry. Topics covered include: convex hulls, polygon triangulations, range searching, segment intersection, Voronoi diagrams, Delaunay triangulations, metric and normed spaces, low–distortion metric embeddings and their applications in approximation algorithms, padded decomposition of metric spaces, Johnson—Lindenstrauss transform and dimension reduction, approximate nearest neighbor search and locality–sensitive hashing.
Thatchaphol Saranurak
Research Assistant Professor
www.ttic.edu/saranurak

PUBLISHED/SUBMITTED PAPERS


TALKS
"Dynamic Spanning Forest: Techniques and Connections." Talk given at Theory Seminar, University of Chicago, IL, November 2018.

"Dynamic Spanning Forest: Techniques and Connections." Talk given at Theory Seminar, University of Illinois at Urbana-Champaign, November 2018.

"Dynamic Spanning Forest: Techniques and Connections." Talk given at Theory Seminar, University of Michigan, Ann Arbor, November 2018.


"Breaking Quadratic Time for Small Vertex Connectivity." Talk given at DIMAP Workshop on Advances in Modern Graph Algorithms, Venice, Italy, April 2019.

"Breaking Quadratic Time for Small Vertex Connectivity." Talk given at Theory Seminar, University of Chicago, IL, April 2019.


"Expander Decomposition." Talk given at Highlights of Algorithms (HALG), University of Copenhagen, June 2019.


INVOLVEMENT
Journal Review: Theoretical Computer Science (Elsevier)
PUBLISHED/SUBMITTED PAPERS

TALKS
“CSPs and Expansion.” Talk given at the ITCSC-CSE Joint Seminar, Chinese University of Hong Kong, June 2019.
“(In)Approximability of Matrix Norms.” Talk given at the Banff workshop Analytic Techniques in Theoretical Computer Science, Alberta, Canada, August 2018.

ININVOLVEMENT
Managing Editor, Theory of Computing
Editor Board Member, Algorithmica
Program Committee Member, ITCS 2018
Local Organizer, STOC 2020
Conference Reviews: STOC, APPROX, SODA, ICALP, COLT

CLASSES/SEMINARS
TTIC 31150 - Mathematical Toolkit: Autumn 2018. The goal of this class is to introduce key concepts in linear algebra and probability, while also providing an exposure to a somewhat rigorous and abstract style of reasoning. In addition to being a required class for all TTIC, it now also satisfies certain requirements for CS students at UChicago.
Theory Reading Group: Autumn 2018. The reading group in the autumn quarter was focused on understanding fine-grained approximation and hardness for problems solvable in polynomial time. We discussed papers on distributed PCPs and fast approximation algorithms.
Sum of Squares Reading Group: Winter and Spring 2019. Mostly organized by Aaron Potechin, this reading group covered various recent papers related to approximation and the sum-of-squares SDP hierarchy. Towards the end of the spring quarter, I also offered a series of four lecture on the recent breakthrough proof of the 2-to-2 conjecture.
High Dimensional Expanders Reading Group: Spring 2018. Primarily organized by UChicago student Fernando Granha Jeronimo, this reading group met weekly at TTIC to discuss recent works in the newly emerging area of High-Dimensional Expanders.

MISCELLANEOUS
Advisor: Mrinalkanti Ghosh (TTIC), Shashank Srivastava (TTIC); Fernando Granha Jeronimo (UChicago), Goutham Rajendran (UChicago), Radhika Patodia (Masters student at UChicago), also working with Dylan Quintana from UChicago (not formally co-advised)
Interns: Vedat Levi Alev (University of Waterloo)
Thesis Committees Member: Blake Woodworth (TTIC), Leonardo Nagami Coregliano (UChicago), Vijay Bhattiprolu (CMU)
Industrial Affiliate Policy Committee Member, TTIC
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.

Mark Hallen
Research Assistant Professor
www.ttic.edu/hallen

PUBLISHED/SUBMITTED PAPERS

TALKS
"PLUG (Pruning of Local Unrealistic Geometries) Removes Restrictions on Biophysical Modeling for Protein Design." Talk given at Duke University, Durham, NC, July 2018.

IN INVOLVEMENT
Conference Review, PLoS Computational Biology
Co-organizer, festschrift for Bruce Donald at Duke University

Jinbo Xu
Professor
www.ttic.edu/xu

PUBLISHED/SUBMITTED PAPERS


TALKS
“Progress on protein structure prediction by deep learning.” Keynote talk given at the 3DSIG of Intelligent Systems for Molecular Biology (ISMB), Basel, Switzerland, July 2019.


“Progress on protein structure prediction by deep learning.” Talk given at the First Year Advisory Board (FAB), Carnegie Mellon University, Pittsburgh, PA, October 2018.

“Progress on protein structure prediction by deep learning.” NIH Cancer Institute

“Progress on protein structure prediction by deep learning.” University of Washington (keynote)

“Progress on protein structure prediction by deep learning.” Talk given at the University of Chicago, IL, July 2019.

“Progress on protein structure prediction by deep learning.” Colorado State University

“Progress on protein structure prediction by deep learning.” Tsinghua University

“Progress on protein structure prediction by deep learning.” Fudan University

“Progress on protein structure prediction by deep learning.” Shanghai Jiaotong University

“Progress on protein structure prediction by deep learning.” Hong Kong Chinese University

INVOLVEMENT
Associate Editor: Bioinformatics, Journal of Computational Biology
Panelist: NSF Bio, NIH MSFD

HONORS/AWARDS
RECOMB 2019 Test-of-Time Award

RESEARCH FUNDING AWARDS
NIH/NIGMS 1R01GM089753-06A1. New Computational Methods for Data-Driven Protein Structure Prediction. 9/1/2015-9/30/2019, no-cost extension, total cost ~$300k/year.


CLASSES/SEMINARS
TTIC 31160 - Topics in Bioinformatics: This class will focus on the application of mathematical models and computer algorithms to studying structure biology, in particular, protein, RNA and DNA molecule structures.
Computer Vision and Computational Photography

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.

Greg Shakhnarovich
Associate Professor
www.ttic.edu/gregory

PUBLISHED/SUBMITTED PAPERS


TALKS
"Style transfer by Relaxed Optimal Transport and Self-Similarity." Talk given at Weizmann Institute of Science, Chicago, IL, December 2018.

"Diverse Indoor-Outdoor Dense Depth dataset." Poster presented at the MADLab Workshop, University of Wisconsin, Madison, May 2018.

"Style transfer by Relaxed Optimal Transport and Self-Similarity." Invited Talk given at the Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, February 2019.
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. This includes 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.
Suriya Gunasekar  
Research Assistant Professor  
www.ttic.edu/gunasekar

PUBLISHED/SUBMITTED PAPERS

Nacson, Mor Shpigel, Suriya Gunasekar, Jason D. Lee, Nathan Srebro, and Daniel Soudry.  
“Lexicographic and Depth-Sensitive Margins in Homogeneous and Non-Homogeneous  
(ICML), Long Beach, CA, June 2019.

Nacson, Mor Shpigel, Jason D. Lee, Suriya Gunasekar, Pedro H. P. Savares, Nathan  
Srebro, and Daniel Soudry. “Convergence of Gradient Descent on Separable Data.”  
Paper presented at the International Conference on Artificial Intelligence and Statistics  
(AISTATS), Okinawa, Japan, April 2019.

Blum, Avrim, Suriya Gunasekar, Thodoris Lykouris, and Nathan Srebro. “On preserving  
non-discrimination when combining expert advice.” Paper presented at the Conference on  

Gunasekar, Suriya, Jason Lee, Daniel Soudry, and Nathan Srebro. “Implicit Bias of Gradient  
Descent on Linear Convolutional Networks.” Paper presented at the Conference on  

Soudry, Daniel, Elad Hoffer, Mor Shpigel Nacson, Suriya Gunasekar, and Nathan Srebro.  
“The Implicit Bias of Gradient Descent on Separable Data.” Journal of Machine Learning  

TALKS

“Implicit Bias of Optimization in Learning.” Talk given at the Center for Applied Mathematics  

“Implicit Bias of Optimization in Learning.” Invited Talk given at INFORMS Annual Meeting,  
Catonsville, MD, November 2018.

“Optimization bias in linear convolutional networks.” Talk given at the MIFODS Workshop on  
Non-convex Optimization and Deep Learning, Massachusetts Institute of Technology  
(MIT), Cambridge, January 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Microsoft Research,  
Redmond, WA, January 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Northwestern University,  
Evanston, IL, January 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at the University of Wisconsin  
Madison, February 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at the University of  
Massachusetts at Amherst, February 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Johns Hopkins University,  
Baltimore, MD, February 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at the University of Michigan at  
Ann Arbor, February 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Columbia University, New  
York, February 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Princeton University, New  
Jersey, February 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Georgia Institute of  
Technology, Atlanta, February 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at New York University, March  
2019.

“Rethinking the Role of Optimization in Learning.” Talk given at McGill University, Canada,  
March 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Ecole Polytechnique  

“Rethinking the Role of Optimization in Learning.” Talk given at ETH Zurich, Switzerland,  
March 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at Duke University, Durham,  
NC, March 2019.

“Rethinking the Role of Optimization in Learning.” Talk given at the University of British
Columbia, Canada, April 2019.
"Rethinking the Role of Optimization in Learning." Talk given at the University of Illinois Urbana-Champaign, April 2019.
"Rethinking the Role of Optimization in Learning." Talk given at the University of Washington at Seattle, April 2019.
"Rethinking the Role of Optimization in Learning." Talk given at the University of California at San Diego, April 2019.

IN_INVOLVEMENT
Conference Reviews: ICML 2018, NeurIPS 2018, ICLR 2018

MISCELLANEOUS
Long-term visitor at Simons Institute for the Theory of Computing, University of California, Berkeley. Special program on Foundations of Deep Learning
Ongoing long-term collaborations with Jason Lee (USC, Los Angeles) and Daniel Soudry (Technion, Israel), and Mor Schpigel (Technion, Israel)
Other collaborators: Thodoris Lykouris (Cornell)

Steve Hanneke
Research Assistant Professor
www.ttic.edu/hanneke

PUBLISHED/SUBMITTED PAPERS
Zhivotovskiy, Nikita, and Steve Hanneke. "Localization of VC Classes: Beyond Local Rademacher Complexities."* Theoretical Computer Science*
vol. 742 (September 2018):27-49.

TALKS
“Principles of Active Learning.” Talk given at Theory Seminar, University of Illinois at Chicago, IL, November 2018.

**TALKS**
“Maximum Mutual Information Predictive Coding.” Talk given at the University of Washington, Seattle, November 2018.

**INVOLVEMENT**
Conference Reviews: ICLR, ACL, EMNLP

**CLASSES/SEMINARS**
TTIC 31230: Fundamentals of Deep Learning. Introduction to fundamental principles of deep learning. Although deep learning systems are evolving rapidly, this course attempts to teach material that will remain relevant and useful as the field changes. The course emphasizes theoretical and intuitive understanding to the extent possible.
Nathan Srebro
Professor
www.ttic.edu/srebro

PUBLISHED/SUBMITTED PAPERS


Nacson, Mor Shpigel, Nathan Srebro, and Daniel Soudry. “Stochastic Gradient Descent on Separable Data: Exact Convergence with a Fixed Learning Rate.” Paper presented at the International Conference on Artificial Intelligence and Statistics (AISTATS), Okinawa, Japan, April 2019.


Woodworth, Blake, Suriya Gunasekar, Jason Lee, Daniel Soudry, and Nathan Srebro. “Kernel


TALKS


INVolVEMENT
Action Editor, Journal of Machine Learning Research
Special Issue Editor, Journal on Selected Areas in Information Theory
Senior Area Chair, ICML 2018, ICML 2019, NIPS 2019
Area Chair, AISTAT 2019
Program Committee, COLT 2018
Steering Committee Member, Fairness, Transparency and Accountability (ACM FAT)
Co-Organizer: IMA Workshop on “Recent Themes in Resource Tradeoffs;” ICML Workshop on “Generalization in Deep Learning”
Advisory Board Member, Midwest Machine Learning Symposium

HONORS/AWARDS


RESEARCH FUNDING AWARDS
Robotics

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
Dai, Zhongtian, and Matthew R. Walter, “Finite time analysis of potential-based reward shaping.” Poster presented at the Multi-Disciplinary Conference on Reinforcement...
Learning and Decision Making (RLDM), Montreal, Canada, July 2019.

TALKS
"Jointly Optimization over Robot Motion and Control." Talk given at the International Workshop on Symbolic-Neural Learning, Tokyo, Japan, July 2019.

INvolvement
Area Chair, Robotics: Science and Systems (RSS)
Organizer, 2018 Robotics: Science and Systems Workshop on Models and Representations for Human-Robot Communication
Steering Committee, Northeast Robotics Colloquium
Panelist: NSF Smart and Autonomous Systems, NSF Graduate Research Fellowship Program, European Research Council Starting Grant
Czar: TTIC Young Researcher Seminar Series, TTIC Industry Affiliates Program
Contributor, AI Driving Olympics (AI-DO), International Conference on Robotics and Automation (ICRA), 2019
Volunteer Staff, Duckietown Foundation
Senior Program Committee, National Conference on Artificial Intelligence (AAAI)
Program Committee: EMNLP, ACL, NeurIPS, EACL, AISTATS, Language Grounding for Robotics (RoboNLP)
Conference Reviews: CoRL, ICRA, IROS, HRI

Research Funding Awards
Army Research Laboratory (ARL), Robotics Collaborative Task Alliance (RCTA), “Language Generation as a Means of Resolving Gaps in Situational Awareness,” $100,000.

Classes/Seminars
TTIC 31170: Robot Learning and Estimation: This course concerned with fundamental techniques in robotics and artificial intelligence (AI), with an emphasis on probabilistic inference, learning, and planning under uncertainty. The course will investigate the theoretical foundations underlying these topics as rigorous mathematical tools that enable solutions to real-world problems drawn broadly from robotics and AI. The course will cover topics that include: Bayesian filtering (Kalman filtering, particle filtering, and dynamic Bayesian networks), simultaneous localization and mapping, planning, Markov decision processes, partially observable Markov decision processes, reinforcement learning, and graphical models.
Introduction to Duckietown, RoboCup 2019 Workshop

Miscellaneous
Qualifying Exam Committee Member: Ankita Pasad (TTIC), Sudarshan Babu (TTIC), Pedro Pamplona Savarese (TTIC), Mingda Chen (TTIC)
Senior Member, IEEE
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 relies heavily 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.

Kevin Gimpel
Assistant Professor
www.ttic.edu/gimpel

PUBLISHED/SUBMITTED PAPERS


TALKS
“From Paraphrase Modeling to Controlled Generation.” Distinguished Lecture Talk given at the Allen Institute for Artificial Intelligence (AI2), Seattle, WA, September 2018.

“From Paraphrase Modeling to Controlled Generation.” Talk given at LANS Informal Seminar, Argonne National Laboratory, Lemont, IL, October 2018.

**IN Volvement**
- Editorial Board Member, *Computational Linguistics*
- Area Chair, Semantics, NAACL-HLT 2019
- Publications Co-Chair (Advisory), ACL 2019
- Journal Reviews: JMLR, JAIR
- Conference Reviews: ICLR, ACL, *SEM, EMNLP*
- Workshop Reviews: RepL4NLP, MRQA, WiNLP, NAACL SRW, Workshop on Structured Prediction for NLP
- Organizer, Midwest Speech and Language Days 2017 at TTIC

**Published/Submitted Papers**

**InvolveMent**
- Editorial Board Member, *Computational Linguistics*
- Area Chair, Semantics, NAACL-HLT 2019
- Publications Co-Chair (Advisory), ACL 2019
- Journal Reviews: JMLR, JAIR
- Conference Reviews: ICLR, ACL, *SEM, EMNLP*
- Workshop Reviews: RepL4NLP, MRQA, WiNLP, NAACL SRW, Workshop on Structured Prediction for NLP
- Organizer, Midwest Speech and Language Days 2017 at TTIC

**Research Funding Awards**
- Amazon Research Award, "Structured Prediction Energy Networks for Neural Machine Translation." $60,000 + $10,000 in AWS promotional credits.

**Classes/Seminars**
- TTIC 31210: Advanced Natural Language Processing; Spring 2019. This course is a follow-up to TTIC 31190, going into more depth in fundamentals of natural language processing (NLP) and covering a broader range of applications. The class is organized around classes of methods for NLP, including representation learning, deep neural networks, Bayesian modeling, unsupervised learning, and structured prediction.
- Co-facilitator of Speech and Language at TTIC (SL@TTIC) reading group

**Miscellaneous**
- Advisor: Mingda Chen (TTIC), Lingyu Gao (TTIC), Freda Shi (TTIC/Co-advised with Karen Livescu), Lifu Tu (TTIC), Davis Yoshida (TTIC); Zewei Chu (UChicago), Xiaoan Ding (UChicago), Yuanzhe Pang (UChicago)
- PhD Dissertation Committee Member: Pramod Kaushik Mudrakarta (UChicago), Aynaz Taheri (UIC), Shubhendu Trivedi (TTIC)
- TTIC Website Committee Member
- TTIC Faculty Coordinator of Visiting Student Program

Karen Livescu
Associate Professor
www.ttic.edu/livescu

PUBLISHED/SUBMITTED PAPERS


TALKS
"(How) should we use domain knowledge in the era of deep learning? (A perspective from speech processing)." Talk given at LTI Colloquium, Carnegie Mellon University, Pittsburgh, PA, November 2018.
"Acoustic (and acoustically grounded) word embeddings." Invited Talk given at SLT, Athens, Greece, December 2018.
"Acoustic (and acoustically grounded) word embeddings." Talk given at Sound Understanding Seminar, Google, Mountain View, CA, March 2019.

INVOLVEMENT
Technical chair, ASRU 2019
Program chair, ICLR 2019
Area chair: ICLR 2020, EMNLP 2018
Standing review committee member, Transactions of the ACL
Organizing committee member: Midwest Speech and Language Days 2019, Workshop for Young Female Researchers in Speech Science and Technology 2018-2019 (Interspeech satellite workshops)
Co-organizer, Workshop on Automatic Recognition and Analysis of American Sign Language, Chicago, 2019
Conference reviews: ICASSP 2019
Workshop reviews: ACL SIGMORPHON 2019
Journal reviews: Journal of Machine Learning Research; IEEE Transactions on Audio, Speech, and Language
Other reviews: NSF Career Award reviewer

RESEARCH FUNDING AWARDS
CLASSES/SEMINARS
TTIC 31220: Unsupervised Learning and Data Analysis: This course will introduce concepts and techniques for analyzing and learning from unlabeled data. Unsupervised methods are used, for example, for visualization, data generation, and representation learning. The course motivates settings in which unsupervised methods are needed or useful, and discusses the relationships between unsupervised and supervised methods. Topics will include fixed feature representations such as Fourier methods and count-based features; linear and nonlinear dimensionality reduction; clustering; density estimation, mixture models, and expectation maximization; and semi-supervised/distant-supervision settings. Linear, kernel, and deep neural network-based methods will be included. Assignments will include theoretical and practical exercises.

MISCELLANEOUS
Steering Committee member, UChicago Center for Data and Computing
TTIC thesis committee member, Reza Mostajabi
UChicago MS thesis committee member, Bowen Wang
Mid-term PhD committee member: Marcely Zanon Boito, Université Grenoble Alpes, France
Visiting students advised: Shuning Jin (U. Minnesota / U. Maryland), Yushi Hu (UChicago), Jack Huang (UChicago), Yang Chen (UChicago)
Internal TTIC service: Colloquium organizer, web site committee member, president search support team member, student support coordinator, student workshop faculty advisor, faculty mentor to Sam Wiseman

Karl Stratos
Research Assistant Professor
www.ttic.edu/stratos

PUBLISHED/SUBMITTED PAPERS

TALKS
“Low-Dimensional Structures in Unlabeled Text.” Talk given at Toyota Technological Institute at Chicago, IL, January 2019.

IN VolVEMENT
Conference Reviews: ACL, NAACL, NeurIPS, ICML, ICLR, AAAI, CoNLL, TACL, JMLR

CLASSES/SEMINARS
TTIC 41000 - Special Topics - Spectral Techniques for Machine Learning: A spectral technique refers to a technique that makes use of the eigenvalues of a matrix. Thanks to the rich theory underlying linear algebra and matrix perturbation, these techniques can offer a precise and satisfying understanding of a wide class of problems such as dimensionality reduction and model estimation. Moreover, the existence of powerful algorithms for computing eigenvalues makes the approach also practical, with applications ranging from robotics to natural language processing. This seminar-like course will first supply an inventory of mathematical tools to understand and derive spectral techniques used in modern machine learning. It will apply these tools to examine some of the most recent developments in the literature. In the latter part of the
course, the course will “flip” and students will take turns to present a paper on recent research in this area. A student can choose any relevant work under this topic, but personal guidance and references will be provided.

MISCELLANEOUS
Co-advisor, with Kevin Gimpel: Zewei Chu (UChicago), Mingda Chen (TTIC)

VISITING FACULTY and NON-RESIDENT ADJOINT FACULTY

David Chiang  Adjoint Professor, TTIC
Associate Professor, University of Notre Dame
PhD - University of Pennsylvania

David Forsyth  Adjoint Professor, TTIC
Professor, University of Illinois at Urbana-Champaign
PhD - Balliol College, Oxford

Sanjeev Khanna  Adjoint Professor, TTIC
Professor, University of Pennsylvania
PhD - Stanford University

John Lafferty  Adjoint Professor, TTIC
Professor, Yale
PhD - Princeton University

Richard Lipton  Adjoint Professor, TTIC
Professor and Frederick G. Storey Chair (emeritus),
Georgia Institute of Technology
PhD - Carnegie Mellon University

Seiichi Mita  Adjoint Professor, TTIC
Senior Research Scholar, TTI-Japan
PhD - Kyoto University

Robert Nowak  Adjoint Professor, TTIC
Professor, University of Wisconsin-Madison
PhD - University of Wisconsin-Madison

Yutaka Sasaki  Adjoint Professor, TTIC
Professor, TTI-Japan
PhD - University of Tsukuba

Shanghua Teng  Adjoint Professor, TTIC
Professor, University of Southern California
PhD - Carnegie Mellon University

Stephen Wright  Adjoint Professor, TTIC
Professor, University of Wisconsin-Madison
PhD - University of Queensland
László Babai  
George and Elizabeth Yovovich Professor, Departments of Computer Science and Mathematics, University of Chicago  
PhD - Hungarian Acad. Sci., Budapest

Michael Franklin  
Liew Family Chair of Computer Science, University of Chicago  
PhD - University of Wisconsin

Mladen Kolar  
Associate Professor of Econometrics and Statistics, Booth School of Business, University of Chicago  
PhD - Carnegie Mellon University

Risi Kondor  
Assistant Professor, Departments of Computer Science and Statistics, University of Chicago  
PhD - Columbia University

Michael Maire  
Assistant Professor, Department of Computer Science, University of Chicago  
PhD - University of California, Berkeley

Janos Simon  
Professor and Director of Graduate Studies, Department of Computer Science, University of Chicago  
PhD - Cornell University

Rebecca Willett  
Professor, Departments of Statistics and Computer Science, University of Chicago  
PhD - Rice University
COLLABORATION and COOPERATION

Arturs Backurs is working with Steve Hanneke (TTIC) on relations between VC dimension and teaching dimension.

Arturs Backurs is working with Kyriakos Axiotis (MIT), Ce Jin (Institute for Interdisciplinary Information Sciences, Tsinghua University, China), Christos Tzamos (University of Wisconsin-Madison) and Hongxun Wu (Institute for Interdisciplinary Information Sciences, Tsinghua University, China) on the modular subset sum problem.

Arturs Backurs has worked with Piotr Indyk (MIT) and Tal Wagner (MIT) over the last year on a project about the space complexity of the kernel density evaluation problem.

J Chuzhoy Collaborated with Sanjeev Khanna from University of Pennsylvania on dynamic algorithms for shortest paths problem and on vertex-capacitated flow and cut problems.

J Chuzhoy Collaborated, together with Zihan Tan (UChicago student) with Merav Parter from Weizmann Institute of Science on graph-theoretic problems with applications to distributed computation

J Chuzhoy Collaborated, together with Thatchaphol Saranurak (RAP at TTIC) with Parinya Chaipermsook from Aalto University, Finland on algorithms and lower bounds for Binary Search Trees.

Kevin Gimpel served as a research advisor for four students from the Department of Computer Science at the University of Chicago: PhD students Zewei Chu, Xiaoan Ding, and Pramod Kaushik Mudrakarta, and undergraduate Yuanzhe Pang.

Kevin Gimpel collaborated with Aynaz Taheri and her advisor Tanya Berger-Wolf at the University of Illinois at Chicago on representation learning for graphs.

Kevin Gimpel collaborated with John Wieting, a PhD student in the Language Technologies Institute at Carnegie Mellon University, and his advisors, Graham Neubig from Carnegie Mellon and Taylor Berg-Kirkpatrick from the University of California, San Diego, on computing semantic similarity between two sentences and using such similarity measures to improve machine translation.

Kevin Gimpel collaborated with researchers from Stony Brook University (Jun Seok Kang and Niranjan Balasubramanian), the University of California, Irvine (Robert L. Logan IV, Dheeru Dua, and Sameer Singh), and the University of Chicago (Zewei Chu and Yang Chen) on datasets and methods for knowledge-backed, entity-based text generation. This project began at the TTIC 2018 summer workshop on collaborative and knowledge-backed generation.

Kevin Gimpel, Karen Livescu, and TTIC student Haoyue (Freda) Shi have collaborated with Jiayuan Mao of Tsinghua University on learning natural language syntax from captioned images.

Karen Livescu has continued to collaborate with University of Edinburgh and Stellenbosch University researchers (Sameer Bansal, Herman Kamper, Sharon Goldwater, and Adam Lopez) on low-resource speech translation.

Karen Livescu and TTIC student Shubham Toshniwal have collaborated with Shinji Watanabe at Johns Hopkins University and Tomoki Hayashi, Tomoki Toda, and Kazuya Takeda of Nagoya University, on text-to-speech synthesis enhanced with pre-trained text embeddings.

Karen Livescu and TTIC student Shane Settle have continued to collaborate with Michael Picheny and
Kartik Audhkhasi at IBM Research, on automatic speech recognition models that map directly from acoustics to words.

**Karen Livescu, Greg Shakhnarovich,** and TTIC students **Ankita Pasad** and **Bowen Shi** have collaborated with researchers at Stellenbosch University (Herman Kamper and Aristotelis Anastassiou) on learning visually grounded models of speech.

**Karen Livescu, Greg Shakhnarovich,** and TTIC student **Bowen Shi** have continued collaboration with colleagues in the University of Chicago linguistics department (Diane Brentari, Aurora Martinez Del Rio, and Jonathan Keane) on a project to automatically transcribe portions of American Sign Language videos, as part of an NSF-funded collaborative grant.

**Greg Shakhnarovich** and **Karen Livescu** are part of the Machine, Algorithms, and Data Lab (MADLab) in collaboration with University of Wisconsin-Madison and University of Chicago researchers. MADLab is headed by Rob Nowak at University of Wisconsin and is funded by the U.S. Air Force Office of Sponsored Research.

**Jinbo Xu** is collaborating with scientists at Illumina Inc. to develop deep learning algorithms that may predict the clinical impact of human mutations.

**Jinbo Xu** and Prof. Tao Pan of the University of Chicago Biosciences are collaborating on the analysis of RNA sequencing data.

**Jinbo Xu** and Prof. Tobin Sosnick of the University of Chicago Pritzker School of Molecular Engineering collaborate on protein folding.
TALKS, SEMINARS AND WORKSHOPS

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 allow students to be exposed to ideas and researchers that may play a role in shaping their academic views, research direction, or even career. Talks and seminars play an important role in establishing the level of intellectual activity and influx of innovative ideas at an institution: research is more likely to be productive in an active environment with significant interaction between researchers.

The table below lists (in order of appearance) 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 advisers, and for the general TTIC and University of Chicago communities interested in hearing what their colleagues are currently involved in. The Young Researcher Seminar Series features 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. 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 accessed from the main website: www.ttic.edu

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<tr>
<th>Year</th>
<th>Number of Speakers</th>
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<td>2017-18</td>
<td>89 speakers</td>
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<td>2016-17</td>
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<td>2014-15</td>
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<td>Shang-Hua Teng</td>
<td>University of Southern California</td>
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<td>Gal Chechik</td>
<td>Bar-Ilan University, Google</td>
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<td>Indian Institute of Science</td>
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<td>Mari Ostendorf</td>
<td>University of Washington</td>
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<td>Avrim Blum</td>
<td>TTIC</td>
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<td>Brian Ziebart</td>
<td>University of Illinois at Chicago</td>
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<td>Thomas Howard</td>
<td>University of Rochester</td>
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<td>Maithra Raghu</td>
<td>Cornell University</td>
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<td>Sewoong Oh</td>
<td>University of Illinois at Urbana-Champaign</td>
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<td>Mark Hallen</td>
<td>TTIC</td>
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<tr>
<td>Nikhil Bansal</td>
<td>Eindhoven University of Technology</td>
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2018 TTIC Summer Workshop Program

TTIC held its first annual Summer Workshop Program over the summer of 2018. There were four exciting week-long workshops organized by researchers around the country (and globe) and held at TTIC. All four workshops involved a lively exchange of ideas, and TTIC looks forward to hosting the workshop series again in summer 2019.

Collaborative Writing with Language Generation Systems  [July 23-27, 2018]

The goal of this workshop is to promote research in collaborative and knowledge-backed language generation. Neural approaches have led to improvements in a range of generation tasks including translation, summarization, and poetry/story generation. These advances have led to systems that can generate locally coherent sentences. Neural approaches also allow us to easily introduce additional information to enable knowledge-backed generation. We now have the building blocks to start investigating collaborative and knowledge-backed writing systems.

Organizers: Niranjan Balasubramanian, Stony Brook University  |  Kevin Gimpel, TTIC

Data Center Scheduling from Theory to Practice  [July 30-August 2, 2018]

This workshop will bring together a team of researchers with complementary skills, both from theoretical computer science and systems with the ultimate goal of designing scheduling and resource allocation policies for the next generation of Data center Resource Management Systems (DRMS). While there is a huge scheduling literature in theory community, the success of translating the theoretical results to real systems have been limited. On one hand, a deeper understanding within the theory community of the real issues and constraints facing system builders and designers and building models for better modeling modern applications is required. On the other hand, system builders need to consider a more principled approach of tackling scheduling problems and using optimal, or close to optimal strategies that can significantly impact the design of heuristics used in resource management.

The workshop gives a unique opportunity to both the communities to spend a week together, identify the major issues, start collaboration and solve challenging technical questions. Data center scheduling is a complex problem, and many scheduling questions that we consider solved in theory needs to be revisited in light of it.

Organizers: Leana Golubchik, University of Southern California  |  Samir Khuller, University of Maryland  |  Barna Saha, University of California Berkeley  |  Cliff Stein, Columbia University
Computational Efficiency and High-Dimensional Robust Statistics [August 13-17, 2018]

The notion of robustness lies at the core of machine learning. The first objective of the workshop will be to introduce the local machine learning community to the new insights and techniques in the exciting area of algorithmic robust statistics. During the last couple of years, several algorithmic techniques have been developed for robust high-dimensional estimation by various groups of researchers. There are intriguing connections between these techniques and the relations between them can only be drawn when presenting all of them together. By bringing a number of experts together, we expect to foster collaboration and open exchange of ideas that will significantly push the boundary of the field. This includes both circumventing technical obstacles and discussing new directions and opportunities for future work. Specifically, we will examine the following concrete questions: What are the limits of current algorithmic techniques, and can we develop new techniques that yield efficient robust estimators for richer families of problems and models? Is there a formal connection between adversarial robustness and other notions of algorithmic stability, such as differential privacy, and adaptive data analysis? Can we leverage insights from the theory of robustness to improve the security of machine learning systems against adversarial attacks?

Organizers: Ilias Diakonikolas, University of Southern California | Daniel Kane, University of California, Santa Barbara

Learning in the Presence of Strategic Behavior [August 20-22, 2018]

The main goal of this workshop is to address current challenges and opportunities that arise from the presence of strategic behavior in machine learning. This workshop aims at bringing together members of different communities, including machine learning, economics, theoretical computer science, and social computing, to share recent results, discuss important directions for future research, and foster collaborations.

Organizers: Nika Haghtalab, Carnegie Mellon University | Yishay Mansour, Tel Aviv University | Tim Roughgarden, Stanford University | Vasilis Syrgkanis, Microsoft Research | Jenn Wortman Vaughan, Microsoft Research
Distinguished Lecture 2019

Talks were held at TTIC, and speakers included:

April 11, 2019

Christos Papadimitriou  Columbia University
Talk Title: “Computation in the Brain”

May 7, 2019

Ran Raz  Princeton University
Talk Title: “Learning Fast Requires Good Memory: Time-Space Tradeoff Lower Bounds for Learning”

Industry Open House

[Oct 12, 2018 at TTIC] TTIC hosted an Industry Open House to introduce companies and organizations to the research conducted at TTIC and to establish relationships with faculty and students. The Open House included presentations by several TTIC faculty members, an interactive poster session, and a working lunch to explore opportunities for collaboration. It concluded with break-out sessions to allow for more detailed discussions between participants and individual faculty members.
3rd Annual TTIC Student Workshop 2019

[February 8, 2019, at TTIC] TTIC held its third annual student workshop in the winter of 2019. The annual event aims to help students develop professionally and be better prepared for a career in academia or industry. The workshop was all-day and had two parts:

Student Symposium: This included 9 research talks and two poster presentation sessions by students working at TTIC (enrolled or not). Students submitted abstracts and gave a talk or poster presentation. This is intended to accustom the students to presenting their research and also create an awareness for the research being done by students at TTIC to the greater community. A committee consisting of faculty members awarded best talk and best poster awards at the conclusion of the symposium.

Panel discussion: A discussion with a panel comprised of various TTIC faculty and a University of Chicago faculty guest. Students are encouraged to ask questions they have about preparing for careers in academia and industry, or general academic best practices. The 2019 panel featured: Allyson Ettinger, David McAllester, Greg Shakhnarovich, Rebecca Willett.

Awards for the 2019 Student Workshop went to:

**Best Talk:** Pedro Savarese, “How do infinite-width, bounded-norm ReLU networks look in function space?”

**Omar Montasser,** “Adversarially Robust Learnability.”

**Best Poster:** Shubham Toshniwal

Organizing Committee: Erica Cocom, Karen Livescu, Shubham Toshniwal, Madhur Tulsiani and Blake Woodworth

Talk Award Committee: Sam Wiseman, Steve Hanneke, Mesrob Ohannessian

Poster Award Committee: Michael Yu, Arturs Backurs
Midwest Speech and Language Days

[May 2-3, 2019 at TTIC] Midwest Speech and Language Days (MSLD) is a two-day meeting that continues and expands upon the tradition of Illinois Speech Day and the Midwest Computational Linguistics Colloquium. Presenters and attendees come from Midwest universities and research institutions. The goal is to increase awareness of speech and language research going on in the region and to foster collaboration among sites. The event is held at TTIC every other year, and another university the years between.
TTIC Robotics group held a robot ability demonstration for the Chicago Museum of Science and Industry's *Robotics Week*.
The PhD Program

The TTIC PhD Program is designed to prepare students for modern 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, conducting high-level, responsible and original research that culminates in a doctoral thesis which can be successfully defended in a public forum and published. In addition to the thesis, there are course, experiential and examination requirements to complete the program. The main component of the program is the process by which the student learns to do quality 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 enroll in classes TTIC offers, for credit. Students of both institutions have taken full advantage of this opportunity. TTIC students have full access to the University of Chicago library system, athletic facilities, the student health center and transportation on campus. TTIC students 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 may experience the shared and traditional experiences that come with a large university.
Graduates and Diplomas

TTIC awarded three doctoral diplomas at the diploma ceremony in September 2018 to:

- **Haris Angelidakis**, studied under Professor Yury Makarychev, research interest is in Approximation Algorithms. Haris is currently employed at Eidgenössische Technische Hochschule Zürich (ETH Zurich).
- **Heejin Choi**, studied under Professor Nati Srebro, research interest is in Machine Learning.
- **Shubhendu Trivedi**, studied under Professor Greg Shakhnarovich, research interest is in Machine Learning and Computer Vision. Shubhendu is currently employed at the Institute for Computational and Experimental Research in Mathematics (Brown University), and ICERM’s Computer Vision program.

TTIC expects one PhD Candidates to be eligible for doctoral degrees in the September 2019 diploma ceremony.

Students Mingda Chen, Pedro Savarese, Chip Schaff, Shane Settle and Bowen Shi 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 2018 diploma ceremony at the start of the academic year.
Quality Curriculum

TTIC instructors deliver the course curriculum for the TTIC student population, 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 sharply increasing the last several years in almost every course.

TTIC instructors are proud to offer a quality curriculum to its PhD students and share rigorous courses with the quality students from the University who take part. The increase in course enrollments and with that, course delivery demands, is a consideration as TTIC moves forward in its space needs planning.

Financial Support for Students

Full financial support is offered to all enrolled students in good academic standing, in residence, making progress in the program, guaranteed for up to five 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 (which provide student privileges on campus), and a stipend paid for research or teaching assistance, provided they remain full-time and in good academic standing.
New Course

A Special Topics course was offered for the first time at TTIC in autumn quarter 2018, instructed by Research Assistant Professor, Karl Stratos.

TTIC 41000: Special Topics: Spectral Techniques for Machine Learning
Prof. Karl Stratos

A spectral technique refers to a technique that makes use of the eigenvalues of a matrix. Thanks to the rich theory underlying linear algebra and matrix perturbation, these techniques can offer a precise and satisfying understanding of a wide class of problems such as dimensionality reduction and model estimation. Moreover, the existence of powerful algorithms for computing eigenvalues makes the approach also practical, with applications ranging from robotics to natural language processing. This seminar-like course will first supply an inventory of mathematical tools to understand and derive spectral techniques used in modern machine learning. It will apply these tools to examine some of the most recent developments in the literature. In the latter part of the course, the course will “flip” and students will take turns to present a paper on recent research in this area. A student can choose any relevant work under this topic, but personal guidance and references will be provided.

Audience and prerequisites: The course is designed to encourage students to start doing research in this area. Thus the expected audience is graduate students with relevant background, for example a PhD student in machine learning theory/application who is comfortable with proofs and has some basic knowledge of linear algebra (but not familiar with the techniques considered in this course). Both TTIC and UofC students are qualified to take this course, possibly the former getting priority if necessary. Class size is 10-20.

The goals of taking this course are:

1. Achieving an understanding of the foundational concepts and tools used in modern spectral methods
2. Obtaining an ability to accurately evaluate new works in this area at conferences
3. Finding new research projects that persist beyond this course and result in publications.


Sun, Yuqi, Haoyue Shi, and Junfeng Hu. “Implicit Subjective and Sentimental Usages in Multi-sense Word Embeddings.” Paper presented at the Workshop on Computational Approaches to Subjectivity, Sentiment & Social Media Analysis, Brussels, Belgium, November 2018.


Student Admissions and Student Body Growth

In the fall of 2004, TTIC matriculated its first three students. The 2018-19 academic year began with thirty-five students, eight who enrolled as new students for Autumn 2018.

Nine students were admitted and plan to enroll for the 2019-20 year.

PhD program applicants continue to increase year after year, with its highest jump coming in the admissions season 2018.

Dr. Greg Shakhnarovich is the Director of Admissions and together, with the Office of Admissions, continues improving TTIC’s outreach strategy, student visit days, and application review and selection processes. The Admissions Office continues to strive for the selection of the most promising applicants, a quality admission experience, and placing high value on diversity in the student population.

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INSTITUTE GOALS

The Board of Trustees appointed a new President, to begin on July 1, 2019. Dr. Matthew Turk will be the 3rd President of TTIC since the institute was founded in 2003, and the first to be full-time. The Board and President Search Committee had an expanded vision for the role of the next President, described in the Leadership Profile which was used in the search process:

- Accelerate TTIC's momentum. The president will work with the Board, sponsors and the faculty to determine the niche for TTIC in the computer science ecosystem and develop a plan to garner the resources to get there. It is essential for the new president to maintain the Institute’s trajectory and to enhance the pace of its progress.

- Execute the Strategic Plan: grow the faculty, ensure robust student demand, maintain and enhance key relationships: keep them strong and grow more productive over time.

- Plan for and execute space planning to match TTIC’s growth

- Raise the visibility of the Institute. Seize the opportunity to identify and engage with additional partners. Enhance collaboration, including research laboratories, corporations, academic institutions or even local or regional governments.

- Ensure financial stability and health. Expand support for the Institute beyond the founding donors. Begin to cultivate the Institute’s alumni future giving, and seek philanthropic investment from currently unaligned prospects with a deep interest in the Institute’s work. The president should explore and pursue other means to increase the income, such as commercialization of IP, cooperative research arrangements with industry and support from relevant foundations.

- Professionalize the institutional infrastructure and build a sense of community. Work across the institution to ensure that the work environment is optimal for all and is typified by respect and collegiality, and that faculty and staff are engaged effectively in institutional decision-making.

A President Investiture ceremony is planned for October, 2019.
Accreditation Planning with Leadership Transitions

TTIC is accredited by the Higher Learning Commission (HLC) and was granted accreditation reaffirmation in November 2015 with an interim reporting requirement for 2017. The next scheduled comprehensive visit by the HLC will be February 3-4, 2020. A lot of preparation work is required for a comprehensive visit involving institute leadership, faculty, students, and partners.

Between the 2015 reaffirmation and the 2020 comprehensive visit, TTIC will have:

- a new president (July 2019)
- a new Chief Academic Officer (2017)
- a new Chief Financial Officer (2016)
- grown the student body by 54% (from 28 students to 43)
- graduated 11 more PhDs (for a total of 17)
- grown the administrative support staff by 67% (from 6 to 10) to accommodate increased support of all areas: research, academic and operational functions.

With TTIC experiencing success and acknowledgement of its strong research and the contributions of its students and graduates, while continuing to grow in size and impact, Institute leadership has been working to sync institute actions, plans, strategy and finances, and keep the momentum going. There is an effort to incorporate the best of what TTIC has been doing, the foundation of where it has been, with new ideas, fresh personnel and talent, aimed at propelling TTIC into its next phase of development.
In FY 2018-2019 TTIC tenured and tenure-track faculty were awarded three federal research grants from 17 submitted proposals: Two from the National Science Foundation (NSF) and one Department of Defense (DOD) award totaling over $3.7 million. The DOD award includes TTIC’s first outgoing sub-award.

TTIC’s current grants portfolio of $10 million includes:

- 16 NSF basic and collaborative research awards,
- 2 NSF Graduate Research Fellowship awards,
- 1 National Institute of Health award,
- 3 DOD awards, and
- Corporate awards from Microsoft, Google, Adobe, Facebook, Bloomberg and Amazon.

Federal grant expenditures continued to increase totaling $1.9 million in FY 2018-2019.
The Institute Mission was updated in April 2019 with an expanded section on Diversity, Inclusion and Equity, and the addition of a section on People.

The new section on Diversity, Inclusion and Equity was added, as success in the research and education missions of TTIC requires a diverse faculty and student body and strong interactions with the multicultural, international academic computer science community. To serve society well in an age of lightning-speed technological advancement, TTIC must make full use of the intellectual abilities of all segments of society, to benefit the advancements being made. Additionally, progress is limited and society is under-served when segments of the population are underrepresented and discouraged from participating in an area such as computer science. TTIC recognizes the intrinsic value of diversity and inclusiveness, and understands that equity in services and support can foster advancements and creativity in the faculty, staff, and student body.

TTIC also identifies that its most valuable resource is people: who devote themselves to the institute, the mission, and the program and research being carried out at TTIC. Each person at TTIC is important and the institute aims to provide all its members with the tools and support they need to do their part in advancing the institute’s mission. The Mission document now reflects this.
This fiscal year was exciting as we made significant progress in our plans for growth, related to both our infrastructure and financial assets.

TTIC is close to full-capacity in its current space, which includes approximately 27,000 square feet on two floors in a building on University of Chicago’s campus. With the planned growth in faculty and students, additional space and administrative support will be needed to accommodate this growth in the academic program. With the approval of the Board, we engaged Gensler, an architectural firm, in the summer of 2018 to develop a renovation plan. As part of the design process, Gensler had individual feedback sessions with all constituents – faculty, staff, and students – to ascertain the vision for TTIC’s future. The focus of the renovation is to have space for the increased headcount, additional collaboration space, improved classrooms, and another robotics lab.

After months of discussion, in April 2019 the University of Chicago agreed to lease TTIC an additional 5,000 square feet in the same building as our existing space. We are currently working with Gensler to refine the renovation design with hopes of beginning construction in the summer of 2020.

An increase in headcount and space translates to the need for additional revenue. Since investment return currently represents 80% of operating revenue, this our first area of focus for increasing revenue. During the April 2019 board meeting, the Board agreed with the Finance Committee’s proposal to engage the services of an investment consultant. The goal is to work with an investment consultant to develop an investment strategy designed with a tolerable level of risk and targeted level of return necessary to fund TTIC’s long-term growth plans and operations while preserving purchasing power of our investments. The investment consultant will work with the Finance Committee, the President, and me to develop an investment policy statement that sets parameters for asset allocation, risk tolerance, and liquidity. The goal is for this project to be completed in spring 2020.

Operating Results

TTIC’s primary source of revenue is investment return. Operating revenue exceeded budget by 5%, primarily due to an increase in grant revenue.
revenue presents approximately 20% of revenue. Of the over $7 million available in grant funds available for spending, 80% were awarded by the National Science Foundation and the Department of Defense.

Also, for the first time in the history of the partnership, TTIC collected tuition from University of Chicago for instructing their undergraduates. We are currently renegotiating the Teaching Agreement with University of Chicago, which will detail the tuition University of Chicago will pay to TTIC to continue to teach its students.

TTIC operating expenses were 7% less than budgeted. We had budgeted for the fiscal year assuming TTIC would have a full roster of 14 Research Assistant Professors and a newly hired tenure-track faculty member. The decrease in operating expenses in comparison to budget represents salary, benefits, and research spending due to the lack of hiring.

Overall, TTIC ended the year with an operating surplus. TTIC has over $64 million in unrestricted financial assets available for spending within one year. Given the liquidity and positive operating results, TTIC is in a strong financial position with more than enough resources to support its operations and planned growth.

Jessica Johnston
Chief Financial Officer
# Toyota Technological Institute at Chicago

## Statement of Financial Position

**June 30, 2019 and 2018**

<table>
<thead>
<tr>
<th></th>
<th>2019</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash and cash equivalents</td>
<td>$5,384,737</td>
<td>$5,940,183</td>
</tr>
<tr>
<td>Receivables:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous receivable</td>
<td>120,387</td>
<td>20,115</td>
</tr>
<tr>
<td>Grants receivable</td>
<td>602,271</td>
<td>785,151</td>
</tr>
<tr>
<td>Due from TTI (Note 10)</td>
<td>1,559</td>
<td>1,646</td>
</tr>
<tr>
<td>Interest receivable</td>
<td>1,268,401</td>
<td>1,384,271</td>
</tr>
<tr>
<td>Investment distribution receivable</td>
<td>4,035,253</td>
<td>3,300,935</td>
</tr>
<tr>
<td>Prepaid expenses and other current assets</td>
<td>28,310</td>
<td>82,786</td>
</tr>
<tr>
<td>Investments (Note 4)</td>
<td>254,134,213</td>
<td>245,162,211</td>
</tr>
<tr>
<td>Furniture and Equipment - Net (Note 5)</td>
<td>706,704</td>
<td>619,188</td>
</tr>
<tr>
<td><strong>Total assets</strong></td>
<td><strong>$266,279,835</strong></td>
<td><strong>$257,276,486</strong></td>
</tr>
<tr>
<td><strong>Liabilities and Net Assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounts payable</td>
<td>$429,029</td>
<td>$361,552</td>
</tr>
<tr>
<td>Accrued expenses</td>
<td>738,377</td>
<td>663,502</td>
</tr>
<tr>
<td>Accrued lease liability (Note 8)</td>
<td>329,775</td>
<td>360,953</td>
</tr>
<tr>
<td>Deferred revenue</td>
<td>922,607</td>
<td>588,420</td>
</tr>
<tr>
<td><strong>Total liabilities</strong></td>
<td>2,419,788</td>
<td>1,964,427</td>
</tr>
<tr>
<td><strong>Net Assets (Note 6)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without donor restrictions</td>
<td>65,272,026</td>
<td>62,275,497</td>
</tr>
<tr>
<td>With donor restrictions</td>
<td>198,588,021</td>
<td>193,038,562</td>
</tr>
<tr>
<td><strong>Total net assets</strong></td>
<td><strong>263,860,047</strong></td>
<td><strong>255,312,059</strong></td>
</tr>
<tr>
<td><strong>Total liabilities and net assets</strong></td>
<td><strong>$266,279,835</strong></td>
<td><strong>$257,276,486</strong></td>
</tr>
</tbody>
</table>
### Toyota Technological Institute at Chicago

#### Statement of Activities and Changes in Net Assets

**Years Ended June 30, 2019 and 2018**

<table>
<thead>
<tr>
<th></th>
<th>2019 Without Donor Restrictions</th>
<th>2019 With Donor Restrictions</th>
<th>2018 Without Donor Restrictions</th>
<th>2018 With Donor Restrictions</th>
<th>Total</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenue, Gain, and Other Support</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student tuition and fees</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scholarships</td>
<td>(1,050,000)</td>
<td>$ 1,135,848</td>
<td>$ 1,135,848</td>
<td>$ 900,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total student tuition and fees</td>
<td>$ 85,848</td>
<td>$ 85,848</td>
<td>$ 85,848</td>
<td>$ 2,109,344</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Federal grants and contracts</td>
<td>2,355,406</td>
<td>2,355,406</td>
<td>2,109,344</td>
<td>2,109,344</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other interest</td>
<td>38,317</td>
<td>38,317</td>
<td>29,087</td>
<td>29,087</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net realized and unrealized gain (loss) on investments</td>
<td>2,889,883</td>
<td>8,020,961</td>
<td>10,910,844</td>
<td>(1,839,196)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment (loss) income, net of investment fees</td>
<td>(163,320)</td>
<td>4,801,728</td>
<td>4,636,406</td>
<td>234,948</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net assets released from restrictions</td>
<td>7,271,228</td>
<td>(7,271,228)</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total revenue, gain, and other support</td>
<td>$ 12,477,362</td>
<td>$ 5,551,459</td>
<td>$ 18,028,821</td>
<td>$ 533,781</td>
<td>$ 4,408,454</td>
<td>$ 4,942,235</td>
</tr>
<tr>
<td><strong>Expenses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Educational expenses - Instruction</td>
<td>7,378,567</td>
<td>7,378,567</td>
<td>6,859,627</td>
<td>6,859,627</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management and general expenses - Institutional support</td>
<td>2,102,266</td>
<td>2,102,266</td>
<td>2,099,744</td>
<td>2,099,744</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total expenses</td>
<td>9,480,833</td>
<td>9,480,833</td>
<td>8,859,371</td>
<td>8,859,371</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Increase (Decrease) in Unrestricted Net Assets - Before transfers</strong></td>
<td>2,996,529</td>
<td>5,551,459</td>
<td>8,547,986</td>
<td>(8,425,590)</td>
<td>4,408,454</td>
<td>(4,017,136)</td>
</tr>
<tr>
<td><strong>Transfers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Increase (Decrease) in Net Assets</strong></td>
<td>2,996,529</td>
<td>5,551,459</td>
<td>8,547,988</td>
<td>(11,321,871)</td>
<td>7,304,735</td>
<td>(4,017,136)</td>
</tr>
<tr>
<td><strong>Net Assets - Beginning of year</strong></td>
<td>62,275,497</td>
<td>193,036,562</td>
<td>255,312,059</td>
<td>69,159,915</td>
<td>190,169,280</td>
<td>259,329,195</td>
</tr>
<tr>
<td><strong>Net Assets - End of year</strong></td>
<td>$ 85,272,026</td>
<td>$ 198,888,021</td>
<td>$ 263,860,047</td>
<td>$ 87,838,044</td>
<td>$ 197,474,015</td>
<td>$ 265,312,069</td>
</tr>
</tbody>
</table>

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INTERNS AND VISITING SCHOLARS

TTIC maintains a steady number of interns and visiting scholars who engage in study and research on the premises. Summer 2019 had seventeen visiting scholars from other institutions in the U.S. and abroad who came to the Institute to work on research projects in collaboration with TTIC faculty and students over the summer months. This summer, project topics include computational biology, computer vision, machine learning, natural language processing, robotics, and theoretical computer science.

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.

Visiting students from eleven universities, listed below (faculty hosts in parentheses):

Cristian Cabada, Lindblom Math and Science Academy (M. Walter)
Julian Coward, Lindblom Math and Science Academy (M. Walter)
Mina Dalirrooyfard, MIT (J. Chuzhoy, Y. Makarychev)
Xiaoan Ding, University of Chicago (K. Gimpel)
Paul Gölz, Carnegie Mellon University (A. Blum)
Neha Gupta, Stanford University (A. Blum)
Linyang He, Fudan University (A. Ettinger)
Shuning Jin, University of Minnesota Duluth (K. Livescu, K. Stratos, S. Wiseman)
Jason Li, Carnegie Mellon University (J. Chuzhoy, Y. Makarychev)
Dongpeng Liu, University of Missouri (J. Xu)
Tianyu Liu, Peking University (K. Gimpel, S. Wiseman)
Alonso Morales, Lindblom Math and Science Academy (M. Walter)
Jonathan Padua, Lindblom Math and Science Academy (M. Walter)
Zachary Robertson, University of Chicago (M. Walter)
Bobby Shi, University of Chicago (M. Walter)
Kathy Wu, Thomas Jefferson High School for Science and Technology (J. Xu)
Shanyi Zhang, Beihang University (G. Shakhnarovich)

Those interested in joining TTIC as a visiting student may apply online on the TTIC website. Students also visit during other times of the year, and some students maintain long-standing collaborations with TTIC faculty.
TTIC partnered with the Chicago Public Schools (CPS) program Career and Technical Education (CTE), which gives high school students the chance to get a head start on preparing for college and careers. In CTE programs, students learn how core school subjects like math, science and writing are used in real-life. CTE students have the opportunity to participate in hands-on training and gain real world experience through job shadows and internships. Students may even have the opportunity to earn nationally recognized certifications used to get a job, help pay for college, or make students career-ready straight out of high school.

TTIC’s Prof. Matt Walter hosted a Job Shadow Day in December 2018, and offered a six-week summer internship for four Lindblom Math & Science Academy students in summer 2018.
In late June through mid-July 2018, successive heavy downpours in southwestern Japan resulted in widespread, devastating floods and mud-flows. More than 200 people lost their lives in those regions with many people reported as 'still missing.' More than 70,000 troops and emergency workers were dispatched to distribute supplies and dig through debris to search for the missing. At the end of July, more than 10,000 people remained in evacuation centers, unable to return home.

Workers and volunteers who descended on the region to help clean up and rebuild soon faced another risk: heatstroke. Following the rains were two weeks of record high temperatures, going up to 106 degrees. In one week alone, the Fire and Disaster Management Agency reported 22,000 people were taken by ambulance to receive care, displaying symptoms of heatstroke.

The JCCC (Japanese Chamber of Commerce and Industry of Chicago) Foundation has launched a disaster relief campaign on behalf of the Chicago community to collect donations to assist the people of West Japan in rebuilding their lives. All donations go to Japanese Red Cross Society.

TTIC matched all pledges made by faculty, students and staff, and made a total donation of $1700.
GOVERNANCE

Board of Trustees

Robert Barnett
Partner, Williams & Connolly LLP
Ranked Number One, Washingtonian Magazine’s list of “Washington’s Best Lawyers.”
Executive Committee Member, Williams & Connelly LLP
Senior Counsel, Board of Trustees of the John F. Kennedy Center for the Performing Arts. (President-appointed member.)
Trusted since April 2006

Sharon Darling
President and Founder, National Center for Family Literacy
Frequent keynote speaker: Businessweek Fortune 500 Forum and the National Governors Association
Recipient of the 2002 National Humanities Medal awarded by President and Mrs. George W. Bush, and the Albert Schweitzer Prize for Humanitarianism from Johns Hopkins University
Serves on the boards of: the Barbara Bush Foundation for Family Literacy, the National Fund for Excellence in American Indian Education, Corporation for Public Broadcasting’s Ready to Learn, and the Heart of America Foundation
Trusted since April 2007

Robert A. Fefferman
Max Mason Distinguished Service Professor, Division of the Physical Sciences, University of Chicago
Former Dean, Division of the Physical Sciences, University of Chicago
Former Chairman, Department of Mathematics, University of Chicago
Recipient, Quantrell Award for Excellence in Undergraduate Teaching, and University of Chicago Sloan Foundation Fellow
Trusted since October 2003

Sadaoki Furui
President, Toyota Technological Institute at Chicago
Professor Emeritus, Tokyo Institute of Technology
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 Furui Research Laboratory, NTT Human Interface Laboratories, Japan
Former Director of Speech and Acoustics Laboratory, NTT Human Interface Laboratories, Japan
Trusted since April 2013

Eric Grimson
Chancellor for Academic Advancement, Massachusetts Institute of Technology
Bernard Gordon Chair of Medical Engineering at MIT
Lecturer on Radiology at Harvard Medical School and at Brigham and Women’s Hospital
Former Education Officer for the Dept. of Electrical Engineering and Computer Science at MIT; Associate Department Head; Head of the Dept. of Electrical Engineering and Computer Science.
Trusted since July 2015
Alexis Herman
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

Edward ‘Rocky’ Kolb
Dean, Division of Physical Sciences, University of Chicago
Arthur Holly Compton Distinguished Service Professor
Member, Enrico Fermi Institute
Board Member, Giant Magellan Telescope, 2010-present; Adler Planetarium, 2010-present
Trustee since October 2013

Charles Isbell
Professor and Executive Associate Dean, College of Computing, Georgia Institute of Technology
Co-Chair, Computing Research Association's Subcommittee on Education
Co-leader of the Threads reform of the undergraduate computing curriculum: a successful, comprehensive restructuring of the computing curriculum that provided a cohesive, coordinated set of contexts for teaching and learning computing skills.
Recipient of: Modern Day Technology Leader Award (Black Engineer of the Year Award, 2009); Scholar of Note (Black Issues in Higher Education, 2004); One of the 50 Most Important African American Technologists (Soul of Technology, eAccess Corp, 2009)
Committed mentor of young minority faculty
Trustee since October April 2018

Yoshihiko Masuda
Chairman of the Board of Trustees, Toyota School Foundation
Advisor, Toyota Central R&D Labs, Inc. and Toyota Motor
Recipient of Society of Automotive Engineers (SAE) Fuel and Lubricant Paper Award (1997) and JSAE Technological Contribution Award (2017)
Trustee since October 2017

Jim Merz
Fellow, American Physical Society; Fellow, IEEE; Fellow Materials Research Society
Emeritus Professor of Electrical and Computer Engineering, University of California, Santa Barbara
Emeritus Director, NSF Science and Technology Center “Quest”, UCSB
Emeritus Vice President for Research, Graduate Dean, and Interim Dean of Engineering, Notre Dame
Trustee since July 2015

Nelson Morgan
Professor-in-residence (emeritus) Electrical Engineering and Computer Science Dept., University of California, Berkeley
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
Angela Olinto
Dean of the Physical Sciences Division, University of Chicago
Albert A. Michelson Distinguished Service Professor, Department of Astronomy and Astrophysics; Enrico Fermi Institute; and the College, University of Chicago
Principal Investigator of the POEMMA (Probe of Extreme Multi-Messenger Astrophysics) space mission
Member of the Pierre Auger Observatory
Fellow, American Physical Society and the American Association for the Advancement of Science
Received the Chaire d'Excellence Award of the French Agence Nationale de Recherche, 2006
Received the Llewellyn John and Harriet Manchester Quantrell Award for Excellence in Undergrad Teaching, 2001
Received the Faculty Award for Excellence in Graduate Teaching, University of Chicago, 2015
Trustee since October 2018

Mari Ostendorf
Endowed Professor of System Design Methodologies and Associate Vice Provost for Research, University of Washington
Fellow of IEEE and ISCA and a 2013-2014 IEEE Signal Processing Society Distinguished Lecturer
Has had 260 publications and recipient of two paper awards, the 2010 IEEE HP Harriett B. Rigas Award, and the 2018 IEEE James L. Flanagan Speech and Audio Processing Award
Served as Editor of IEEE Transactions on Audio, Speech and Language Processing and Computer Speech and Language, as VP Publications on IEEE Signal Processing Society, and served as a member of the IEEE Periodicals Review and Advisory Committee
Trustee since October 2017

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, Fujisara Prize, Japan IBM Science Award, and the Hattori-Hoko Award
Trustee since October 2010

Ivan Samstein
Vice President and Chief Financial Officer, University of Chicago
Leads integrated strategic financial planning and oversight for the execution of the University’s work in financial analysis and functions, information technology and human resources
Former Chief Financial Officer for Cook County, 2012-2016
Former Director of public finance department, Bank of America Merill Lynch, 2004-2011
Trustee since April 2018

Masatami Takimoto
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

Mark Hogan
Advisor to the Board
Director, Toyota Motor Corporation
President, Dewey Investments, LLC

Mitsuru Nagasawa
President Emeritus
Trustee Departures
Ms. Sharon Darling: Service of April 2007 - June 2019
Dr. Robert Fefferman: Service of Oct 2003 - Oct 2018
Dr. Rocky Kolb: Service of Oct 2013 - Oct 2018

Trustee Appointments
Dr. Angela Olinto: Appointed Oct 2018

LEADERSHIP
Sadaoki Furui, President
Jessica Johnston, Chief Financial Officer
Avrim Blum, Chief Academic Officer
Chrissy M. Novak, Secretary of the Institute

ADMINISTRATION
Adam Bohlander, Director of Information Technology
Rose Bradford, Manager of Research Administration
Erica Cocom, Student Services and Admissions Administrator
Jessica Johnston, Chief Financial Officer
Deree Kobets, Controller
Ava Lindsey, Office Manager
Mary Marre, Administrative Assistant
Alicia McClarin, Administrative Assistant
Amy Minick, Director of Human Resources and International Affairs Office, Title IX Coordinator
Chrissy M. Novak, Administrative Director of Graduate Studies and Publications, Accreditation Liaison Officer, Deputy Title IX Coordinator
Latrice Richards, Events and Facilities Manager
Equal Opportunity Statement

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.
SPECIAL THANKS

The External Advisory Committee
Eric Grimson, Chancellor and Professor of Computer Science and Engineering, Massachusetts Institute of Technology
Takeo Kanade, UA and Helen Whitaker University Professor, Robotics Institute, 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

The University of Chicago greater community
Booth School of Business
Chicago Center for Teaching
Computation Institute
Department of Computer Science
Department of Mathematics
Department of Statistics
English Language Institute
Faculty and Administration of the Division of Physical Sciences
Office of the Bursar
Office of International Affairs
Office of Investments
Office of the Registrar
Physical Science Division
PSD Graphic Arts
Staff of the Regenstein and Eckhart Libraries
Student Health and Counseling Services
University Research Administration
University IT Services
The professionals at the 6045 S. Kenwood Avenue building

The professionals at the Higher Learning Commission
The Toyota Central R&D Labs, Inc.
Toyota Motor Corporation
Toyota Technological Institute (Nagoya, Japan)

Distinguished Speakers at the 2017 CAO Installation Event
Pedro Felzenszwalb, Professor of Engineering and Computer Science, Brown University
Steve Smale, Professor Emeritus of Mathematics, UC Berkeley
Yishay Mansour, Professor of Computer Science, Tel-Aviv University
Lance Fortnow, Professor and Chair, School of Computer Science, Georgia Tech College of Computing
Éva Tardos, Jacob Gould Schurman Professor of Computer Science, Cornell University
Robert Fefferman, Max Mason Distinguished Service Professor in Mathematics, University of Chicago
Tom Mitchell, E. Fredkin University Professor, Machine Learning Department, School of Computer Science, Carnegie Mellon University
Adam Kalai, Principal Researcher, Microsoft Research Cambridge