IACS ANNUAL REPORT 2017-2018
STUDENT WORK FROM CAPSTONE RESEARCH COURSE:
Content-Based Generation of Spotify Playlists
Omar Abboud, S.M. '17, Sonu Mehta, S.M. '17, and Laura Ware, S.M. '18

Developing novel processes for curating successful Spotify playlists based on data about songs that constitute that playlist.

STUDENT WORK FROM CAPSTONE RESEARCH COURSE: Probabilistic Survey Design
Rohan Thavarajah, M.E. '18

Considering the effects of fatigue and insight in crowdsourcing a labeling task.
In 2017-18, the Institute for Applied Computational Science welcomed its fifth cohort of master’s students in computational science and engineering, admitted its first cohort of students to a new Master of Science in Data Science degree program, expanded community-building efforts, and continued to strengthen the vision of its founders – to be an intellectual home for faculty and students applying computational methods to major challenges in science and the world.

**DATA SCIENCE AT HARVARD**

The new Master of Science in Data Science degree program is administered by the IACS and under the joint academic leadership of Statistics and Computer Science. The three-semester program allows students to take a technical core of four courses in data science, computer science, and statistics, a capstone research project course, and a new course on critical thinking in data science, which will explore the non-technical aspects of data science and their impact on the world.

The Harvard Data Science Initiative, a broader effort at Harvard to promote learning and scholarship in data science, which launched in 2017, has collaborated successfully with IACS this past year on seminars, industry engagement, and the development of an online certificate program in business analytics with Harvard Business School and the Statistics department.

**EXPANDING COLLABORATIONS**

Students taking the IACS capstone research project course, now in its fourth year, worked closely with partner organizations from industry, government, and science including Google, Spotify, BASF, the MBTA, the Center for Clinical Data Science (Mass. General/Brigham &Women’s Hospitals), and the Harvard T. Chan School of Public Health.

IACS continued its partnership with MIT’s Institute for Data, Systems, and Society, Stanford University, and Microsoft Research New England, hosting a day-long Women in Data Science (WiDS) conference in Kendall Square, Cambridge with sponsorship from the Harvard Data Science Initiative. More than 240 academic leaders, industry professionals and students attended the event, which was one of more than 150 WiDS events held simultaneously around the world. Local technology leaders discussed research in such areas as deep learning applications in oncology, data science tools for pollution monitoring, and the challenges of preventing bias in algorithms.

**A GROWING COMMUNITY**

With 33% more students expected on campus in Fall 2018, more faculty and Ph.D. students from across the University involved in the programs, and more than 130 alumni working in industry (technology, finance, data-driven consumer companies, and startups) and a few going on to doctoral programs, IACS and its community have grown significantly. We look forward to a successful year and a celebration of the fifth year reunion of our pioneering first class of master’s students in Spring 2019.

Sincerely,

*Catherine A. Chute*
*Executive Director, IACS*
*SEAS Assistant Dean for Professional Programs*

*Efthimios Kaxiras*
*Director, IACS*
*John Hasbrouck Van Vleck Professor of Pure and Applied Physics*
CONTINUED INTEREST IN THE PROGRAM REFLECTS STUDENT DEMAND

The Computational Science and Engineering master’s program admissions yield is 68%, the second-highest in a six-year span. The Data Science master’s program, in its first year, has an admissions yield of 54%.
2018-19 STUDENT COHORT

NATIONALITY OF ENROLLED STUDENTS

<table>
<thead>
<tr>
<th>Country</th>
<th>CSE</th>
<th>DS</th>
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<tbody>
<tr>
<td>US</td>
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<td>China</td>
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<tr>
<td>Belgium</td>
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<tr>
<td>Canada</td>
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<td>Hong Kong</td>
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<td>Thailand</td>
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<tr>
<td>UK</td>
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YEARS SINCE UNDERGRADUATE DEGREE

<table>
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<tr>
<th>Years</th>
<th>CSE</th>
<th>DS</th>
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<tr>
<td>0 yrs</td>
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<tr>
<td>1-3 yrs</td>
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<td>4+ yrs</td>
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UNDERGRADUATE MAJORS

Note: Includes students who completed double majors.
HANDS-ON LEARNING

CAPSTONE PROJECT COURSE

Students work in small groups to identify a complex and open-ended problem and work with the instructor, mentors, and industry partners to propose a solution in the form of a software package, a set of recommendations in a report, or a research paper.

THE ASSOCIATED PRESS TAGGING SERVICE

Anjali Fernandes, A.B. ’17, Andrew Lund, S.M. ’17, Divyam Misra, S.M. ’17, Nripsuta Saxena, S.M. ’17

For a news organization like the Associated Press (AP), the accuracy of metadata tags on articles is vital, since web searches drive a great deal of traffic to the AP website.

A team of students spent the spring semester working with the AP to increase metadata accuracy. The students developed a mostly automated metatagging system that uses named entity extraction to identify and isolate people, places, organizations, companies, and other proper nouns in a piece of text. The students’ tool smartly sorts tags by their prominence within an article. The students also developed a user interface that shows the tags identified by the AP’s current system and tags identified by their tool and enables users to upvote or downvote tags and save that feedback.

Going forward, the AP may integrate the students' work into a tool they are currently developing, or work with CSE students next year to produce an unsupervised system that will dynamically change the sorting of tags based on users' upvotes and downvotes.
SQUARE: INTERPRETABILITY AND FAIRNESS OF MACHINE-LEARNING MODELS

Paul Blankley, S.M. ’18, Camilo Fosco, M.E. ’19, Ryan Janssen, S.M. ’18, and Donghun Lee, M.E. ’19

Working on a semester-long project with Square Capital, IACS students tackled the issue of fairness in financial lending by utilizing statistical tests that compared the decisions the model made for the general population with the decisions it made for a certain protected class of individuals.

The students combined the tools they developed into a dashboard, Exigo, that enables users to input a machine-learning model and a dataset, then receive a report grading the model’s fairness and listing the top features that were most significant in the algorithms’ determinations. The dashboard is model agnostic, so it can be used with any machine-learning algorithm and data set. Distilling the complexity of a machine-learning algorithm into a simple, single-page report will enable users to better understand what is happening inside the “black box” of a machine-learning model.

Since loan companies are now required by law to give a reason to applicants for a rejected loan, the reports produced by this dashboard could prove instrumental in providing transparency in decision-making. In addition to helping a company like Square determine fairness, the dashboard could also serve as an effective debugging tool for algorithms used in any number of different situations.
WHERE STUDENTS GO AFTER GRADUATION

CSE graduates go on to work across a variety of industry sectors or choose to pursue further studies at leading graduate business or doctoral programs. IACS collaborates with the Harvard Office for Career Services to expose students to a diverse range of companies — through the Data Analytics and Technology Fair (attended by nearly 100 employers), and individual company tech talks or tech treks.

INFORMATION FROM THE GRADUATING CLASSES OF 2013-2018

TECHNOLOGY

Afiniti
Akamai
Alibaba
Amazon
Bose
Facebook
GCP Applied Technologies
Google
Houzz
Hubspot
Hudl
Lyft
Microsoft
PlusAI
QRI
Salesforce
SquareSpace
Tencent
TripAdvisor
Uber
Wayfair
Yelp

INVESTMENT/FINANCE

Acacia Global Investors
Accadian Asset Management
Arrowstreet Capital
Axovant Sciences
Balyasny Asset Management
Bank of America
Merrill Lynch
Bloomberg
BridgeWater Associates
Capital One
China Asset Management
Citadel
Goldman Sachs
JP Morgan
Man Numeric
Maquarie Group
Moneylion
Morgan Stanley
OnDeck
The Thasos Group
Vitu Financial
Weiss Asset Management
Wellington Management

FURTHER GRADUATE STUDIES

Applied Physics PhD
Architecture Technology PhD
Biostatistics PhD
Computer Science PhD
MBA
MD/PhD
Mechanical Engineering PhD
Statistics PhD

START-UPS

Beacon Athlete Tracking
DrivenData
Perceptive Automata
Referio
Unnamed AI startup

ACADEMIA

Harvard Ash Center
Harvard Center for Astrophysics
Harvard Center for Clinical Data Science
Harvard IACS
Johns Hopkins Applied Physics Lab
MIT research
National Cheung Kung University

GOVERNMENT/MILITARY/NATIONAL LABS

GovTech Singapore
MIT Lincoln Laboratory
Singapore Military
U.S. Coast Guard
U.S. Navy

ADVERTISING/MARKETING

Accenture
Interactive
Pypestream
Tribe Dynamics
Yieldmo

OTHER

BCF Associates d'Affairs
BookXChange
Legendary Entertainment
McKinsey & Company

TYPICAL JOB TITLES: DATA SCIENTIST | DATA ENGINEER | SOFTWARE ENGINEER | PRODUCT MANAGER | DATA ANALYST | QUANTITATIVE STRATEGIST

STUDENTS REPORTED STARTING SALARIES BETWEEN $80,000 – $140,000.
CSE ALUMNI PROFILES

OMAR ABBOUD, S.M. ’17
Data Scientist at Squarespace

A data scientist by day and concert pianist by night, Omar Abboud unravels complexity, whether he is sitting at a keyboard or behind the keys of a baby grand. After earning a bachelor's degree in operations research, Abboud enrolled in the CSE program to leverage his technical training with practical applications in business and academia.

In his day job as a data scientist at Squarespace, he examines different forms of advertising media the company uses to help leaders make strategic decisions about how to deploy media and allocate the marketing budget. But he finds that flexing his creative muscles through music makes him a better data scientist. Abboud, who has been playing the piano since age 4, continues to play with a chamber trio in New York City, and has performed at Carnegie Hall, the Italian Academy, Symphony Space, and Lincoln Center.

RYAN LEE, A.B./S.M. ’15
Chief Data Scientist at Tribe Dynamics

As chief data scientist at digital marketing startup Tribe Dynamics, Ryan Lee helps lifestyle brands use social media to reach influencers and amplify their marketing efforts.

But digital marketing is not a career path he considered when he was an undergraduate chemistry concentrator at Harvard. His chemistry focus shifted towards bioinformatics, and he decided to earn a computational science master's degree to expand his data science skillset. The program prepared him well for his role at Tribe, where he oversees a team of four data scientists who develop data-driven solutions for the company's marketing products, analyze data to answer client questions, and create data visualizations and other marketing materials. He enjoys the excitement of watching trends appear and seeing brands go viral, and the opportunity to apply his data science skills in an industry with so much passion and color.

avery faller, s.m. ’16
Senior Machine Learning Engineer at Perceptive Automata

Though he majored in architecture as a Yale undergrad, Avery Faller’s experience coding apps at a student-led tech startup piqued his interest in computer science. Seeking more exposure to research and cutting edge techniques, he completed the CSE program.

Since graduation, Faller has stayed in the fast-paced world of startups, now as senior machine learning engineer at Perceptive Automata, where he uses machine learning to improve the safety of autonomous vehicles and advanced driver-assistance systems. He and his teammates are working to help autonomous vehicles understand human body language and movement cues, in an effort to help prevent potentially fatal accidents. Though he plays jack-of-all-trades at this young startup, Faller enjoys working with various sensors and different data types on such new problems that he and his teammates sometimes wonder if they are even solvable.
SECONDARY FIELD PROGRAM ATTRACTS STUDENTS FROM A WIDE VARIETY OF DISCIPLINES

Open to Ph.D. students in the Graduate School of Arts and Sciences, the Computational Science and Engineering (CSE) Secondary Field (Harvard’s term for a minor) equips students across disciplines with an understanding of rigorous computational methods for approaching scientific questions. In 2018, 12 Ph.D. students graduated with their Secondary Field in CSE.

MAJOR FIELD OF STUDY FOR CSE SECONDARY FIELD STUDENTS

<table>
<thead>
<tr>
<th>SCIENCES</th>
<th>STATISTICS</th>
<th>SOCIAL SCIENCES</th>
<th>SCHOOL OF ENGINEERING AND APPLIED SCIENCES (SEAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy</td>
<td>Biostatistics</td>
<td>Economics</td>
<td>Applied Math</td>
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<tr>
<td>Biological and Biomedical Sciences</td>
<td>Population Health Sciences</td>
<td>Health Policy</td>
<td>Applied Physics</td>
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<td>Biophysics</td>
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<td>Sociology</td>
<td>Engineering Sciences</td>
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<td>Environmental Science and Engineering</td>
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<tr>
<td>Earth and Planetary Sciences</td>
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<tr>
<td>Molecular and Cellular Biology</td>
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<tr>
<td>Organismic and Evolutionary Biology</td>
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<tr>
<td>Physics</td>
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<tr>
<td>Systems Biology</td>
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42 STUDENTS IN THE PROGRAM

8 SEAS Sciences
26 Social Sciences
6 Statistics
2 Statistics

STEM: 8 SEAS Sciences
Social Sciences: 26 Social Sciences
IACS FELLOWSHIP PROGRAM

Thanks to the generosity of an anonymous donor, IACS has been able to offer fellowships to a small group of students in the Computational Science and Engineering (CSE) program. For academic year 2017-2018, one student in the master of engineering program and one student in the secondary field program were awarded funds to cover their tuition and continue their research.

MASTERS OF ENGINEERING RECIPIENT
Nicholas Hoernle, M.E. ‘18

Nicholas’ research aims to assist educators with the difficult task of interpreting student exploration of a large scale immersize, interactive ecosystem. Representing the system dynamics that result from student actions with a complex time series, Nicholas utilized switch based models to decompose the time series into individual periods that target interpretability for teachers.

SECONDARY FIELD RECIPIENT
Rodrick Kuate Defo, Ph.D. candidate

Rodrick’s research in Computational Materials Science had led him to study the impact of temperature on the movement of defects in crystal lattices. Knowing how temperature changes will affect these defects is essential in designing quantum devices. Using methods that he learned from his secondary field courses, Rodrick was able to develop a code for simulating hundred of defects in a reasonable time frame.

IACS RESEARCH ASSOCIATES

Cecilia Garraffo will be joining IACS in 2018-19. She received her Ph.D. in Physics from the University of Buenos Aires where she specialized in gravitational field theories and extension of General Relativity. She has been a post-doctoral fellow at the High Energy Astrophysics division of the Harvard- Smithsonian Center for Astrophysics. She will collaborate with IACS Scientific Program Director Pavlos Protopopapas on his research and also support educational activities of IACS.

Marios Mattheakis, who will also join IACS, received his Ph.D. in Applied Computational Physics from the University of Crete focusing on computational electromagnetics, optical materials science, and statistics of wave flows. Recently, in the Kaxiras group at Harvard, he has been involved in innovative computational and mathematical approaches focusing on graphene and other two-dimensional materials. At IACS, he will conduct research with IACS/SEAS faculty and support graduate student research projects.

WeiWei Pan, who has a Ph.D. in pure mathematics from Wesleyan University, will continue to work with Professor Finale-Doshi Velez on developing principled methods for addressing non-identifiability in machine learning models, and also continue with IACS mentoring students on research projects and master's theses.
For the second year, Harvard, MIT, and Microsoft Research New England partnered with Stanford University to bring the Women in Data Science (WiDS) conference to Cambridge, Massachusetts. The one-day technical conference brought together over 240 local academic leaders, industrial professionals, and students to hear about the latest data science-related research, learn how leading-edge companies are leveraging data science for success, and connect with potential mentors, collaborators, and others in the field.

**THE WIDS DATATHON**

Women data scientists of all levels analyzed data collected by InterMedia with the goal of helping the world’s poorest people take advantage of widely available mobile phones and other digital technology to access financial tools and participate more fully in their local economies. The competition sought to encourage women data scientists to engage in social impact solutions by participating in a predictive analytics challenge.

**THE DATA WORKSHOP**

The Data Workshop oriented participants to the competition and provided insights into the challenge of data exploration/visualization, data cleaning, feature engineering, and modeling. Led by Weiwei Pan from Harvard Institute of Applied Computational Sciences and Anastasiya Belyaeva from MIT Institute of Data, Systems and Society, attendees started the evening with an introductory workshop and applied exercises. Attendees then broke off for a working dinner, where they formed teams, networked, and started to develop their solutions for the datathon.
ComputeFest, an annual program of knowledge- and skill-building activities in computational science and engineering, welcomed over 500 participants across Harvard and the greater Boston community. This year’s topic was *The Digital Doctor: Health Care in an Age of AI and Big Data*.

**SYMPOSIUM**

*The Digital Doctor: Health Care in an Age of AI and Big Data* attracted nearly 500 attendees. Organized by Francesca Dominici of the Harvard T.H. Chan School of Public Health, Isaac Kohane of Harvard Medical School, and Margo Seltzer of SEAS in affiliation with IACS Associate Brian Hayes, symposium topics ranged from reinforcement learning in health care to precision medicine, electronic health records, patient therapies, immunotherapy and neuroscience. See page 17 for a full list of topics and speakers.

**SKILL-BUILDING WORKSHOPS**

ComputeFest workshop attendees gained hands-on skills in advanced Python, Deep Learning with Image Classification, Microsoft Azure ML, H2O, Domino, Stan, Tableau, and Deep Learning with NVIDIA.

**STUDENT DATA CHALLENGE**

The inaugural Student Data Challenge: Disrupting Healthcare through Machine Learning provided students with healthcare insurance claims data and challenged them to detect fraudulent insurance claims, which cost taxpayers billions of dollars each year.
Three students traveled to Chile this January to participate in the fifth year of a Harvard research and education collaboration with Chilean researchers and scientists. The students conducted collaborative astronomical research projects with students and faculty from the University of Chile, Universidad de Concepción, and Pontifica Universidad Católica de Chile. Working in teams with astronomers, mathematicians, and fellow computer scientists, students utilized machine learning to classify and then visualize supernovae.

Students developed a machine-learning algorithm that could be trained to classify a supernova as data is received, refining that classification as additional data becomes available.
MILAN DATA SHACK PROGRAM

As part of the Applied Computation 297r Capstone Project Course, eight students, four from Harvard and four from Italy, joined together under the supervision of Harvard and Politecnico di Milano faculty to solve problems within the data science context. The group first met in Cambridge in January, then again in Como, Italy, in March. In between visits the students collaborated virtually on two projects:

TRIBE DYNAMICS
IACS, Harvard University: Andrea Porelli, Srivatsan Srinivasan
Politecnico di Milano: Alessandro Bianchi, Ginevra Terenghi

Tribe Dynamics is a San Francisco-based consulting company that measures social media engagement for beauty, fashion and lifestyle brands and uses these engagement metrics to suggest better social media marketing strategies. In this process, they use text classifiers to perform natural language understanding to decipher whether or not a particular post is talking about a brand. As the company expands across the globe, their classifier faces challenges in understanding posts in Non-English languages. In this project, students target developing classifier models that scale well across languages. The new models are able to transfer knowledge garnered in one language onto the other, allowing Tribe Dynamics to strongly leverage the data and model’s core strengths in English.

EMPORIO SIRENUSE
IACS, Harvard University: Kimia Mavon, Karan Rajesh Motwani
Politecnico di Milano: Francesca Morini, Moreno Raimondo Vendra

Le Sirenuse Positano is a luxury 5 star hotel located in Positano, on the Amalfi Coast. The Emporio Sirenuse store stands in front of the hotel. The goal of this project is to improve the online presence of the clothing brand by leveraging social media platforms, while protecting its heritage.

In this project, students analyzed how a luxury brand may utilize a growing digital economy using big data, while maintaining its heritage. Their proposed tool used a human-in-the-loop model to identify relevant communities and suggest a post’s text, hashtags, and images. The system is housed in an interactive visualization interface designed for intuitive analysis.
## 2017-18 SEMINARS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Presenter</th>
<th>Institution</th>
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<tbody>
<tr>
<td>Big Data Software: What's Next?</td>
<td>Mike Franklin</td>
<td>University of Chicago</td>
</tr>
<tr>
<td>Machine Learning for Small Business Lending</td>
<td>Thomson Nguyen</td>
<td>Square Capital</td>
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<tr>
<td>Theory Methods to Describe Transport and Dynamics in Quantum Materials</td>
<td>Prineha Narang</td>
<td>Harvard University</td>
</tr>
<tr>
<td>Reinforcement Learning for Healthcare</td>
<td>Finale Doshi-Velez</td>
<td>Harvard University</td>
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<tr>
<td>Adventures in Analytics</td>
<td>Bob Rogers</td>
<td>Intel</td>
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<tr>
<td>Extreme Scale Computing, Big Data Science and Web of Life Network Science</td>
<td>Manju Manjunathaiah</td>
<td>Harvard University</td>
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<tr>
<td>Using Knockoffs to Find Important Variables with Statistical Guarantees</td>
<td>Lucas Janson</td>
<td>Harvard University</td>
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<tr>
<td>Geometric Deep Learning on Graphs and Manifolds: Going Beyond Euclidean Data</td>
<td>Michael Bronstein</td>
<td>Radcliffe Institute, Università della Svizzera italiana, and Tel Aviv University</td>
</tr>
<tr>
<td>Challenges and Considerations in Search Quality</td>
<td>Isabelle Stanton</td>
<td>Google</td>
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<tr>
<td>Data Science Toward Understanding Human Learning and Improving Educational Practice</td>
<td>Ken Koedinger</td>
<td>Carnegie Mellon University</td>
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<tr>
<td>Data Science and Our Environment</td>
<td>Francesca Dominici</td>
<td>Harvard University</td>
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<tr>
<td>Taking the Universe’s Baby Picture</td>
<td>David Spergel</td>
<td>Princeton University, CCA &amp; Flatiron Institute</td>
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<tr>
<td>Interactive Visual Discovery in Event Analytics: Electronic Health Records and Other Applications</td>
<td>Ben Shneiderman</td>
<td>University of Maryland-College Park</td>
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<tr>
<td>Topic</td>
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<tr>
<td>Reinforcement Learning in Healthcare: Challenges and Promise</td>
<td>Finale Doshi-Velez</td>
<td>Harvard University</td>
</tr>
<tr>
<td>The Algorithm for Precision Medicine</td>
<td>Matt Might</td>
<td>University of Alabama at Birmingham</td>
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<tr>
<td>Optimizing the patient journey with AI</td>
<td>John Brownstein</td>
<td>Harvard University and Boston Children's Hospital</td>
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<tr>
<td>Phenomics is the New Genomics</td>
<td>Marzyeh Ghassemi</td>
<td>Google's Verily and MIT</td>
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<tr>
<td>Challenges and Opportunities for Machine Learning in Cancer Immunotherapy</td>
<td>Jennifer Chayes</td>
<td>Microsoft New England Research and New York City</td>
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<tr>
<td>Deciphering the Dynamics of the Anesthetized Brain: A Case Study in Statistical and Mathematical Modeling”</td>
<td>Emery Brown</td>
<td>MIT</td>
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<tr>
<td>Panel Discussion: Opportunities and Challenges</td>
<td>Margo Seltzer with Emery Brown, Jennifer Chayes, Finale Doshi-Velez, and Matt Might</td>
<td>Harvard University</td>
</tr>
</tbody>
</table>
MEMBERS OF THE IACS ADVISORY BOARD


STANDING COMMITTEE ON THE CSE PROGRAM


STANDING COMMITTEE ON THE DATA SCIENCE PROGRAM


ADMINISTRATIVE AND TEACHING STAFF

Efthimios Kaxiras Faculty Director, IACS and John Hasbrouck Van Vleck Professor of Pure and Applied Physics  ■  Cathy Chute Executive Director  ■  Pavlos Protopapas Scientific Program Director and Lecturer  ■  Daniel Weinstock Associate Director of Graduate Studies and Lecturer  ■  Sheila Convey Program Manager  ■  Natasha Baker Administrative Coordinator  ■  Ignacio Llorente Visiting Professor  ■  Sauro Succi Visiting Professor  ■  Rahul Dave Lecturer  ■  David Sondak Lecturer  ■  Niv Dayan Postdoc  ■  Harikrishna Narasimhan Postdoc  ■  WeiWei Pan Postdoc

RESEARCH STUDENTS AND VISITORS

Marouan Belhaj Student Researcher  ■  Brian Hayes Associate  ■  Rafael Mayo Garcia Visiting Scholar  ■  Javier Machin Matos Visiting Scholar  ■  Karim Pichara Associate  ■  Rosalind Reid Fellow  ■  Nicholas Ruta Student Researcher  ■  Mauricio Santillana Associate  ■  Sameen Wajid Student Researcher  ■  Alexander Wissner-Gross Associate  ■  Giulia Zerbini Student Researcher