

THE NEWS DEPARTMENT OF MATHEMATICS

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Math class teaches a computer to channel J.S. Bach

Story by Anne Manning

This past semester, 11 Colorado State University master's and Ph.D. students composed a suite of musical pieces that sound strikingly like they were written by J.S. Bach, the prolific German composer of the Baroque period.

These weren't music students, though. They were math students.

The course was Industrial Mathematics, and the students were challenged by their professor, Michael Kirby, to apply a mathematical theory to a practical problem: teaching a computer to compose music with specific style, rhythm and structure parameters. To do it, the students used a type of machine-learning algorithm familiar to any iPhone owner who uses Siri, Apple's voice recognition software.

What does composing music have to do with voice recognition software? It boils down to a type of neural network, called an LSTM – a long short-term memory network. Together, the class read an academic paper that explains the background of the LSTM algorithm and how it works, then Kirby asked them to reproduce the results. The students chose a Bach dataset, and created computer code to back up their results.

An LSTM is like a brain being trained by feeding it data – in this case, a repertoire of 129 chorales from the J.S. Bach canon. Unlike other neural networks, the LSTM has a series of gates that lets it learn relevant information and disregard what is irrelevant to the task at hand. Making predictions and being corrected over and over by the original dataset, the neural network learns, identifies and eventually corrects its own mistakes.

Learning like Siri

Patrick Rosse, a master's student in the class, explained that this type of neural network is what Apple uses in the Siri software, which takes into account previous words spoken and makes decisions about what was probably said. Each time the user talks to Siri, the recognition gets better and more accurate.

"Another example I've seen is that someone fed [an LSTM] a bunch of lyrics from the rapper Fabolous and it ended up writing a verse that retained his rhyming scheme," said Rosse, a former math teacher who is also studying LSTMs as part of his thesis.

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DISCOVERY BEGINS HERE

Message from the Chair



Hall. The former Calculus Center space is now occupied by a new upper division tutoring center.

As Scorpio, that scoundrel, is high in the evening skies, the fall semester must be upon us... time for our fall newsletter! Take a look and learn about some of our growth. Our Calculus Center, after only two years, has outgrown its home in Weber. To meet the increasing need for calculus tutoring, we partnered with the Institute for Learning and Teaching and moved the Calculus Center into TILT's Great

Our faculty continue to win accolades for their service. Jennifer Mueller received the School of Biomedical Engineering's Teaching Award, and Jess Hagman received the College of Natural Sciences Early Career Faculty Excellence in Teaching and/or Mentoring Award. We have also been busy on the hiring front this year. We will welcome two new faculty members to our department in the upcoming fall – please get to know them by browsing these pages!

Much of what we do could not be accomplished without the fantastic support of the friends of the Mathematics Department, and with our gratitude, we wish you all the best for fall!

Ken McLaughlin
Professor and Chair

Department Highlights

Department expands upper-division tutoring resources



The ever-increasing demand for calculus tutoring led to the expansion of the Calculus Center's services, which have moved from the basement of Weber to the Great Hall in the TILT building. The Great Hall (first the Reading Room in CSU's original stand-alone library, then the main recital hall during its Music Building tenure) is now a beautiful place, overlooking the oval, offering all-day calculus tutoring.

The expansion of the Calculus Center led to a vacancy of prime space in the basement of Weber. As valuable square footage cannot be wasted, the department developed daily upper-division Mathematics tutoring and mentoring where faculty, post-docs and undergraduates can come together and engage. For six or more hours each day, students are offered help with coursework led by senior faculty, including McLaughlin, in a space very familiar, inclusive and welcoming.

Undergraduate student recognized at hackCU invention marathon



Winning first place for Best Use of Typeform API, Derek Larkins and Kareem Youssef teamed with students from CU and Arizona State University to build PartyLink, an app that makes registering a party easier and less confusing. Each winning team member received a collector's edition of Makey Makey, an invention kit that allows users to connect everyday objects to computer programs.

[Read more on SOURCE.](#)

Summer program involves undergraduate students in original research



Summer may seem like a quiet time for CSU's campus, but not for a group of 16 busy mathematics undergraduates participating in CSU's first-ever summer math research program. The program was led by Professor of Mathematics, Rachel Pries, and Associate Professor and Undergraduate Director of Mathematics, Patrick Shipman, who together mentored three groups of students.

One group studied fractal patterns produced by dynamics of hyperbolic numbers. The other worked alongside chemistry Professor Stephen Thompson in the Laboratory for Mathematics in the Sciences, examining micro weather patterns and anthocyanins, a pigment found in fruits and plants. The third studied the properties of Hurwitz curves over finite fields, a topic with applications to cryptography.

The program was funded in part by the College of Natural Sciences and the Department of Mathematics, in addition to a National Science Foundation grant. The program was a part of a departmental initiative to get more mathematics undergraduates involved in original research, dispelling common misconceptions surrounding the lack of variety in careers in mathematics.

Many long days were spent poring over research papers and working on complex equations, teaching students in all groups to accentuate positive attributes in their fellow student's skills, thus creating a complex web of knowledge in which each student could contribute. The hard work led to lasting connections and published research. In January 2019, Pries' students presented their research at the largest mathematics meeting in the world, the Joint Math meeting, in which they were awarded the "outstanding poster" prize.

Department hosts Math Dat for high school students



On November 1, 2018, the Mathematics Department hosted Math Day for high school students with keynote speaker Lori Ziegelmeier. Ziegelmeier is an alumna of Colorado State University, having completed B.S. and B.A. degrees in Mathematics and Liberal Arts as well as an M.S. and Ph.D. in Mathematics. During the Math Day talk, Ziegelmeier spoke about the mathematics of digital images, incorporating plenty of cat photos to illustrate mathematical concepts and using projection and eigenimages to determine which of two people were more "cat-like".

Ziegelmeier became interested in image analysis as a first year graduate student when the Pattern Analysis Laboratory (PAL) was collecting a database of images for a facial recognition task. She started working to analyze the color space of natural imagery alongside leaders of PAL, Michael Kirby and Chris Peterson, who became her advisors. Her research program grew and now falls under the umbrella of Geometric and Topological Data Analysis. Loosely, this means finding the shape of a dataset and using it to extract meaning from data. Her research

has focused on developing and applying data analysis techniques and algorithms in order to uncover the structure of a wide variety of data sets ranging from hyperspectral images, to biological aggregations, to statistics of country development (such as life expectancy, gross domestic product per capita, infant mortality, population, etc.). Following her studies at Colorado State, Ziegelmeier went to the highly-selective liberal arts school Macalester College where she is currently an Assistant Professor. She enjoys working with undergraduate students on research projects and teaching classes at all levels.

Happy hundredth to Max Stein



Extending a special 100th birthday honor to distinguished alumni, Max Stein. Max was a force on the faculty, helping establish the master's and Ph.D. programs in mathematics and was the advisor to the first mathematics doctoral candidates. Stein is an emeritus professor, World War II veteran, and longtime CSU sports fan, who turned 100 on February 17.

[Read more on SOURCE.](#)

First data science major in the region launched by CSU



Our world now depends on big data – and the thoughtful analysis of it. From health care to finance to government to science, we rely every day on the study of truly massive troves of data. People trained in this skill are, however, in very short supply, which is one of the reasons data scientist has been the top-rated job in the U.S. for the past two years. To help the state and the world meet this ever-increasing need and to help shape the data-driven future, CSU is launching a new major in data science, the first of its kind in the Rocky Mountain region. Content for ten new courses have been developed by Professors of Mathematics, Michael Kirby, Henry Adams and Wolfgang Bangerth exclusively for data science and giving students a broad foundation in computer science, mathematics and statistics.

Data scientists have top earning potential, with an average salary of more than \$110,000. Experts estimate a shortage of more than 1 million data scientists, making people trained in this field in high demand.

The new program is housed as an interdisciplinary major in the College of Natural Sciences and has enrolled its first cohort of incoming student in fall 2018. The program has faculty mentors from all participating departments as well providing opportunities for research outside of the classroom.

[Read more on SOURCE.](#)

Faculty News

Mathematics faculty recognized for excellence in teaching



Pictured: Professor Jennifer Mueller (left), Assistant Professor Jess Hagman (right)

Professor Jennifer Mueller received the School of Biomedical Engineering (SBME) Teaching Award for the second year in a row. SBME provides trans-disciplinary education, research, and practical experiences throughout a full range of degree programs. The unique structure of the School involves four colleges, 14 departments, and over 70 faculty. Academic excellence across diverse fields converges into three primary areas of research: regenerative and rehabilitative medicine, imaging and diagnostics, and medical devices and therapeutics. SBME recognizes faculty that elevate the research and training environment in areas such as classroom instruction and classroom or faculty laboratories.

We are proud to announce Assistant Professor Jess Hagman was awarded an early Career Faculty Excellence in Teaching and/or Mentoring Award. Each year the College of Natural Sciences recognizes a pre-tenure track faculty member with the award, honoring those who have excellent performance in the classroom and/or evidence of high quality undergraduate research mentoring activity. They must have a deep commitment to and interest in the educational process beyond that required by their appointment.



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Department welcomes two new faculty members



Pictured: Dr. Maria Monks Gillespie (left), Dr. Emily J. King (right)

We are pleased to welcome Dr. Maria Monks Gillespie, who will be joining our department as a tenure-track assistant professor this fall! Dr. Gillespie, a former Hertz Fellow, Churchill Scholar, and winner of the Morgan Prize, is currently a National Science Foundation Postdoctoral Fellow and Krener Assistant Professor at UC Davis. Her research is in algebraic combinatorics, with applications to algebraic geometry and representation theory. Please join us in welcoming Maria!

We are also pleased to welcome Dr. Emily J. King, who will be joining our department as a tenure-track assistant professor this fall! Dr. King is currently a Junior Professor leading the group Computational Data Analysis at the University of Bremen, Germany. She was a Humboldt Postdoctoral Fellow in Osnabrück, Bonn, and Berlin. Before that she was an IRTA Postdoctoral Fellow at the National Institutes of Health and a Postdoctoral Research

Associate at the Norbert Wiener Center. Her research interests include pure & applied harmonic analysis, data analysis, frame theory (in particular algebraic, geometric, and combinatorial methods in frame theory), and signal and image processing. Please join us in welcoming Emily!



Remembering Rebecca Richards



The Mathematics department lost a great friend when Rebecca Richards passed away unexpectedly on June 4, 2019 while on vacation with her family in Mexico. Rebecca was a beam of light in the Mathematics office as an Academic Success Coordinator. She focused her energy on guiding each student in a way that was most meaningful to them specifically, ensuring they felt supported in their rigorous program of choice.

Before Mathematics, Rebecca was a key asset to the Registrar's office in the department of classroom scheduling. Students were her passion, and she was a treasure to all she worked with and supported.

In addition to being completely passionate about her work at CSU, she left behind the love of her life, Eugene Berta and their daughter, Ellen.

Support the Department

Your support of the department is incredibly valuable. Please consider making a difference to today's students, faculty, facilities, and programs at whatever level is right for you. Thank you!

For more information on giving, please contact Jill Higham, Managing Director of Development.

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