對外合作組織與機構動態報導

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SMALL BRAIN, BIG DATA

大腦小，數據很大

By John Spizzirri • September 11, 2017

A neuroscientist and a computational scientist walk into a synchrotron facility to study a mouse brain… Sounds like a great set-up for a comedy bit, but there is no punchline.

報告摘要(KEY INFORMATION)

1. 「基本上，我們的目標簡單明確—希望能產生腦中所有神經元之成像—但由 X 光及電子顯微鏡觀察的數據資料相當龐大，已經是兆級甚至千兆級的程度；所以我們希望能運用 Theta 建立建立一套軟體及資料庫去分析這樣的數據。」阿岡先進光子源的計算科學家表示。
2. 人類製造出的噪音如重金屬樂團的嘶吼等，可能高達 130 分貝——會造成聽力損害的程度；然而樂團再吵也無法與噴射引擎的噪音相提並論。明尼蘇達大學與阿岡的研究學者以具有高可信度的電腦模擬系統，探討噴射引擎產生噪音的原理，期待終有一天該領域的業者能使用更安靜的引擎設計。
3. 在歐洲，一振奮人心的專案即將展開：有關在具碳收集儲存能力場址，由天然氣產生零CO_2排放之氫氣並以氫氣火力發電廠發電的可能性。其後續發展仍須持續關注。
4. 8 月 4 日，美國向聯合國提交協議申請，以討論如何使其儘早合法退出巴黎協定。然而，根據美國國務院一新聞稿指出，美國仍將持續參與全球氣候變遷相關之協商及會談，以保障美國利益並確保所有未來政策選項對當局而言保持開放。美國最早得以在 2020 年 11 月 4 日，也就是下屆美國總統大選後，退出巴黎協定。
5. 科技正改變我們工作的模式。以線上工作而言，雇主和員工都面對新的挑戰。如果雇主無法在聘用員工前確認其工作能力，就不會開出良好待遇；而若沒有良好待遇，員工也不願費盡心力。因此，史丹佛管理科學學者正研究建立一可評比受雇者資歷、並能使受雇者團結爭取權益之平臺，希望能為雇傭雙方創造雙贏局面。

The result is cutting-edge science that can only be accomplished in a facility as scientifically integrated as the U.S. Department of Energy's (DOE) Argonne National Laboratory.

At a casual, or even a more attentive glance, Doga Gursoy and Bobby Kasthuri would seem at opposite ends of the research spectrum. Gursoy is an assistant computational scientist at Argonne's Advanced Photon Source (APS), a DOE Office of Science User Facility; Kasthuri, an Argonne neuroscientist.

But together, they are using Argonne's vast arsenal of innovative technologies to map the intricacies of brain function at the deepest levels, and describing them in greater detail than ever before through advanced data analysis techniques.

Gursoy and Kasthuri are among the first group of researchers to access Theta, the new 9.65 petaflops Intel-Cray supercomputer housed at the Argonne Leadership Computing Facility (ALCF), also a DOE Office of Science User Facility. Theta's advanced and flexible software platform supports the ALCF Data Science Program (ADSP), a new initiative targeted at big data problems, like Gursoy and Kasthuri's brain connectome project.

ADSP projects explore and improve a variety of computational methods that will enable data-driven discoveries across all scientific disciplines.

"By developing and demonstrating rapid analysis techniques, such as data mining, graph analytics and machine learning, together with workflows that will facilitate productive usage on our systems for applications, we will pave the way for more and more science communities to use supercomputers for their big data challenges in the future," said Venkat Vishwanath, ALCF Data Sciences Group Lead.

All about the connections

This new ADSP study of connectomes maps the connections of every neuron in the brain, whether human or mouse. Determining the location of every cell in the brain and how they communicate with each other is a daunting task, as each cell makes thousands of connections. The human brain, for example, has some 100 billion neurons, creating 100 trillion connections. Even the average mouse brain has 75 million neurons.

"This ALCF award targets big data problems and our application of brain imaging does just that," said Gursoy, assistant computational scientist in the X-Ray Science Division of Argonne's Advanced Photon Source. "The basic goal is simple — we would like to be able to image all of the neurons in the brain — but the datasets from X-rays and electron microscopes are extremely large. They are at the tera- and petabyte scales. So we would like to use Theta to build the software and codebase infrastructure in order to analyze that data."

This research was supported by the U.S. Department of Energy's Office of Science. A portion of the work was also supported by Argonne's Laboratory-Directed Research and Development (LDRD) program.

The process begins with two imaging techniques that will provide the massive sets of data for analysis by Theta. One is at the APS, where full brains can be analyzed at submicron resolution — in this case, the brain of a petite shrewmouse — through X-ray microtomography, a high-resolution 3-D imaging technique. Argonne's X-ray Sciences Division of the APS provides the expertise for the microtomography research. Much like a CT scanner, it produces images as micro-thin slices of a material whose structure can be meticulously scrutinized. While this resolution provides a detailed picture of blood vessels and cell bodies, the researchers aim to go still deeper.

That depth of detail requires the use of an electron microscope, which transmits a short-wavelength electron beam to deliver resolution at the nanometer scale. This will allow for the capture of all the synaptic connections between individual neurons at small targeted regions guided by the X-ray microtomography.

For years, scientists at the APS have used these techniques to deepen our understanding of a wide variety of materials, from soil samples to new materials to biological matter," said Kamel Fezzaa from sector 32-ID at the APS. "By coordinating our efforts with Argonne high-speed computing capabilities for this project, we are able to provide some truly revolutionary images that could provide details about brain functions that we have never before been able to observe."

Both techniques can produce petabytes of information a day and, according to the researchers, the next generations of both microscopes will increase that amount dramatically.

Images produced by these datasets have to be processed, reconstructed and analyzed. Through the ADSP, Gursoy and Kasthuri are developing a series of large-scale data and computational steps — a pipeline — that integrates exascale computational approaches into an entirely new set of tools for brain research.

Taming of the shrew

The first case study for this pipeline is the reconstruction of an entire adult shrewmouse brain, which, they estimate, will produce one exabyte of data, or one billion gigabytes. And the studies only get bigger from there.

"Machine learning will go through these datasets and help come up with predictive models. For this project, it can help with segmentation or reconstruction of the brain and help classify or identify features of interest," said Vishwanath.

Lessons learned from the smaller shrewmouse brain will be applied to a large mouse brain, which constitutes a 10-fold increase in volume. Comparisons between the two will reveal how organizational structures form during development, from embryo to adult, and how they evolve. The reconstruction of a non-human primate brain, with a volume 100 times larger than a mouse brain, is being considered for a later study.

A neuroscientist and a computational scientist leave a synchrotron facility with studies from a mouse brain . . . armed with new techniques to analyze this data. The images produced by their work will provide a clearer understanding of how even the smallest changes to the brain play a role in the onset and evolution of neurological diseases, such as Alzheimer's and autism, and perhaps lead to improved treatments or even a cure.

THE SUBLIME CHALLENGE OF JET NOISE

噴射機噪音大挑戰

By John Spizzirri • September 18, 2017

Humans make a lot of noise. The riffs of heavy metal bands like Metallica and Kiss have soared to levels in the 130-decibel range, levels sure to lead to auditory damage.

But try as they might, bands just can't compete with the decibel ranges produced by jet engines. They are, said Joe Nichols, among the loudest sources of human-made noise that exist.

An assistant professor of Aerospace Engineering and Mechanics at the University of Minnesota, Nichols is fascinated by sound and its ability to find order in chaos – and by applying that understanding to the development of new technologies that can reduce noise in aircraft.

Nichols is working with the Argonne Leadership Computing Facility (ALCF), a U.S. Department of Energy (DOE) Office of Science User Facility within the DOE's Argonne National Laboratory, to create high-fidelity computer simulations to determine how jet turbulence produces noise. The results may lead to novel engineering designs that reduce noise over commercial flight paths and on aircraft carrier decks. "Noise tells you something about the fundamental nature of turbulence, because noise reveals order that is otherwise hidden in complex, highly nonlinear, chaotic phenomena," he said.

That is why jet noise presents both a challenging and a beautiful problem for Nichols.

Taming the roar of the engine

Jet engines produce noise in different ways, but mainly it comes from the high-speed exhaust stream that leaves the nozzle at the rear of the engine. And planes are loudest when they move slowly, such as at takeoff or at landing. As the exhaust stream meets relatively still air, it creates tremendous shear that quickly becomes unstable. The turbulence produced from this instability becomes the roar of the engine.

Aeronautic engineers incorporate chevrons, broken eggshell-shaped patterns, into exhaust nozzle designs to change the shape of the jet as it leaves the engine. The idea is to reduce the noise by changing the pattern of the turbulence. But much of the design work remains a guessing game.

Working with ALCF computational scientist Ramesh Balakrishnan and Argonne's supercomputer Mira, Nichols and his team are applying computational fluid dynamics to remove some of that guesswork. They start by conducting high-fidelity large eddy simulations that accurately capture the physics of the turbulence that is making the noise.

From those simulations they extract reduced-order, or more concise, models that explain what part of the turbulence actually makes the sound. In addition to improving scientific understanding of jet noise, these reduced-order models also provide a fast, yet accurate, means for engineers to evaluate new designs.

Simulating complex geometries like jet turbulence requires the use of an unstructured mesh — a non-uniform 3-D grid — to represent the dynamics involved. In this case, one simulation could have 500 million grid points. Multiply that by five to account for pressure, density and three components of velocity to describe the flow at every grid point. That equates to billions of degrees of freedom, or the number of variables Mira uses to simulate jet noise.

"But what if inside the jet turbulence there is a skeleton of coherent flow structures that we can describe with just 50 degrees of freedom," suggested Nichols. "Which aspects are most important to the jet noise production? How do the flow structures interact with each other? How closely can the skeleton model represent the high-fidelity simulation?"

This work, published last year in the journal *Physics of Fluids*, could help engineers more precisely direct the modeling of jet engine nozzle geometries by determining, for instance, the ideal number and length of chevrons.

"What distinguishes Joe's work from those of the other computational fluid dynamics projects at ALCF is that it involves the development of a method that could mature into becoming a design tool for aero-acoustics," said ALCF's Balakrishnan. "His project leverages computational data with what he calls input-output analysis, which reveals the origins of jet noise that are otherwise hidden in direct run-of-the-mill forward simulations, or even experiments."

Simulating waves of aviation

One of the leading ways to predict the instability waves that create sound inside of turbulence is through methods based on a type of computational tool called parabolized stability equations. But while they're good at predicting supersonic sound sources, they have a hard time predicting all the components of subsonic jet noise, especially in the sideline direction, or perpendicular to the exhaust stream.

The University of Minnesota team developed a new method based on input-output analysis that can predict both the downstream noise and the sideline noise. While it was thought that the sideline noise was random, the input-output modes show coherent structure in the jet that is connected to the sideline noise, such that it can be predicted and controlled.

Nichols also uses a variation on the input-output analysis to study noise produced by impingement, where a jet blast is directed at a flat surface, such as aircraft taking off from or hovering over an aircraft carrier deck.

Like decibel-breaking guitar licks, impingement produces a feedback loop when the turbulence hits a flat surface and accelerates outward. As the noise loops back towards the jet nozzle, new turbulence is triggered, creating extremely large tones that can reach into the 170-decibel range and do structural damage to the aircraft in question.

The team turned to Mira to conduct a high-fidelity simulation of an impinging jet without any modifications, and then measured the noise it produced. When compared to ongoing experiments, they predicted those same tones very accurately. A reduced-order model of the simulations helped Nichols more precisely predict how to change the jet configuration to eliminate feedback tones. Another simulation of the modified jet showed that the tones were almost completely gone.

"The simulations play a crucial role because they let us see spatio-temporally resolved fluid motions that would be impossible to measure experimentally, especially if you're talking about a hot exhaust moving at Mach 1.5," noted Nichols.

This research, says Balakrishnan, is still a work in progress, but the results are encouraging. While it still needs some refinement, it holds the promise of becoming a design tool that jet engine manufacturers may one day use to help quiet the skies.

For electric guitar makers Fender and Gibson, on the other hand, perhaps not so much.

UPDATE ON HYDROGEN ENERGY AND CCS IN EUROPE

歐洲的氫能與碳收集儲存之近期發展

Yoshiaki Shibata

On July 27, the Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD) was established in Japan. The Association is scheduled to conduct a demonstration test on an international hydrogen supply chain in 2020, in which hydrogen is transported and stored using methylcyclohexane between Japan and Brunei. The test is in line with a technical demonstration of the ocean transport of liquefied hydrogen also scheduled for 2020, to be conducted by the CO_2-free Hydrogen Energy Supply-Chain Technology Research Association (HySTRA) established last year. The test is another step toward establishing a CO_2-free hydrogen supply chain, on which efforts began with NEDO's demonstration a few years ago. Both programs aim to supply large amounts of CO_2-free hydrogen primarily for hydrogen-fired power plant, which could help significantly decarbonize electricity.

Japan is working to establish a CO_2-free hydrogen supply chain ahead of other countries, but similar efforts may now start in Europe.

In July, three companies, namely Statoil, Vattenfall and Gasunie, signed an MOU to evaluate the possibility of converting an existing natural gas-fired thermal power plant into a hydrogen-fired power plant. The target natural gas thermal power plant is Vattenfall's three 440 megawatt-unit combined cycle plant in Eemshaven, Holland. The hydrogen will be produced by steam reforming natural gas, and the carbon dioxide produced in the process will be captured and stored by CCS. The MOU also includes a study on the infrastructure, large-scale hydrogen supply chain and business model which will be necessary for transporting and storing hydrogen. The details of the feasibility study to be conducted are unknown but it is assumed that the study will be based on conducting CCS off the coast of Norway using Norwegian natural gas. There are many suitable sites for CCS in Norway, and the choice of location suggests that large amounts of CO_2-free hydrogen could be supplied using domestic natural gas.

Of course, conversion into a hydrogen-fired power plant will not be necessary if there are technically and economically feasible sites for CCS in the vicinity of gas- and coal-fired power plants. However, suitable sites for CCS are unevenly distributed in Europe and have varying economic efficiency, and one CCS project is struggling: the CCS demonstration project ROAD (Rotterdam Afvang en Opslag Demonstratieproject) in

Rotterdam. The project was to collect 1.1 million tonnes of CO_2 each year from the Uniper coal-fired power plant in the Rotterdam port area and store it in a depleted gas field 20 km offshore. However, the project could be cancelled following the withdrawal of the implementation bodies Engie and Uniper in June, which is widely thought to be due to the soaring cost of the project. For such cases, shifting from coal-fired power to hydrogen-fired power may be an option.

As explained above, shifting from fossil fuel power generation to hydrogen and supplying CO_2-free hydrogen produced in resource-rich countries with a high CCS potential like Norway may also progress in Europe in areas without suitable CCS sites nearby or where CCS is not economically viable. Developments in hydrogen power in Europe, as well as in Japan, must be closely monitored.

UPDATE ON POLICIES RELATED TO CLIMATE CHANGE

氣候變遷相關政策之近期發展

Takahiko Tagami

On August 4, the US submitted a communication to the UN regarding its intent to withdraw from the Paris Agreement as soon as it is eligible to do so. However, a State Department media note stated that the US will continue to participate in international climate change negotiations and meetings to protect US interests and ensure that all future policy options remain open to the administration. The earliest date on which the US can withdraw from the Paris Agreement is November 4, 2020, the day after the next presidential election.

Towards 2020, the international climate change negotiations are scheduled to formulate detailed rules for the implementation of the Paris Agreement, and conduct an ex ante process for the NDCs and an ex post review of the achievements toward the targets for 2020. The formulation of detailed rules is planned to be completed by the end of 2018. Regarding the ex ante process for the NDCs, a "facilitative dialogue" will be held at the end of 2018 to take stock of the collective efforts of Parties in relation to progress toward the long-term mitigation goal of the Paris Agreement, and, based on the results of the dialogue, the Parties will submit their NDCs for 2030 at the beginning of 2020. In 2023, a “global stocktake” will assess the collective progress towards achieving the purpose and long-term goals of the Paris

Agreement, and, based on the outcome, the countries will submit their NDCs for 2035 in 2025. This process will be repeated in a five-year cycle thereafter. Further, for the ex post review of achievements, countries' progress toward achieving their goals as well as information on their mitigation actions will be assessed and analyzed every other year.

The US withdrawal from the Paris Agreement could weaken the forces to repel developing countries' undertakings to set differentiated obligations for developed and developing countries. Developing countries may demand that developed countries raise their ambitions in the facilitative dialogue in 2018. However, a US government official has reportedly said that a major priority for the US in the international climate change negotiations is to force back developing countries' attempts to have separate standards for themselves and developed countries in the implementation guidance for the Paris Agreement. If the US remains at the negotiating table to protect its interests and all future policy options, the impact of its withdrawal on the negotiations may be small in the near term.

Meanwhile, the expert review of the First Order Draft of the IPCC Intergovernmental Panel on Climate Change) Special Report on Global Warming of 1.5°C began on July 31, and is scheduled to end on September 24. The IPCC had been invited by the Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC) on its 21st session (COP21), held in Paris in 2015, to provide a special report on the impacts of global warming of 1.5°C and related global GHG emission pathways in 2018. The Special Report is planned to be approved and accepted at the 48th session of the IPCC in October 2018 following several review processes. Attention must be paid to any impact of this report, which will be submitted before COP24 at the end of 2018, on the international climate change negotiations.

STANFORD RESEARCHERS PLAN FOR DIGITAL COMPANIES AND WORKERS' RIGHTS IN AN ONLINE WORLD

史丹佛研究學者關注當前網路時代數位公司與其員工雙方之權益

By Nicole Feldman

Technology is changing the way we work, providing unique challenges for both employers gauging prospective talent and for employees ensuring their rights and proper working conditions.

Through a series of projects in the Stanford Cyber Initiative, Stanford researchers in the program's Future of Work focus area are investigating how best to develop online work platforms and how policy can mitigate their negative effects.

A team of interdisciplinary scholars is addressing workers' rights on online platforms, among other important issues, as part of the Stanford Cyber Initiative. *(Image credit: nevarpp/Getty Images)*

"Our goals have been to envision what that future might look like, to build technology to empower new forms of organizing and to understand what impact these platforms are going to have on people," said Michael Bernstein, an assistant professor of computer science.

More work in the future will involve crowdsourcing, an already popular method of bringing together virtual workers to accomplish tasks. Bernstein and Melissa Valentine, an assistant professor in management science and engineering, improved on this trend with Foundry, an online platform where people can create their own company. The company's workers are comprised of flash teams, online groups of experts in specific fields. Foundry's ability to adapt to the varied requirements of its owners and its egalitarian model – allowing any of its members to make changes to their business platform – have proven effective in early testing.

"Anyone with a web browser can create and lead an organization of globally-distributed, diverse experts within half an hour," Bernstein said.

But the Cyber Initiative has concerns about workers' rights on these sorts of online platforms, particularly because most online workers are contracted for short-term projects, leaving benefits like health insurance, paid time off and job security in question.

Margaret Levi, a professor of political science and director of the Center for Advanced Study in the Behavioral Sciences, and Bernstein looked to industries — like farming, the creation of railroads and the early development of automobiles — throughout history that followed a similar short-term model to predict the effects on workers' rights and to find policy solutions.

"The new platforms for matching employers and employees do a terrific job at facilitating wide-ranging searches for the right people for the right jobs at the right time," said Levi. "But they have two deficiencies that our project is trying to correct: providing effective power to workers over pay and working conditions, and providing reputational mechanisms that accurately assess the skills and quality of employees. "

Employers are challenged as well, often unable to verify an online employee's quality before hiring. Because they can't count on quality, they don't pay much. And because employees aren't earning much per job, they don't put in much effort. The result is a decrease in both quality and pay.

"We are considering ways to increase workers' control over the labor supply and over the determination of who is qualified as means for improving workers' rights and power," Levi said.

They are exploring the idea of a "digital hiring hall." The platform would draw on information across the internet, compiling and verifying certificates, courses and work experience. It would provide employers confidence in candidates' quality of work, and also allow employees to band together for fair wages and working conditions.

Bernstein described the platform as a "LinkedIn in which every line on your resume represents work you have verifiably completed on online work platforms."

Working alongside Bernstein, Valentine and Levi in the Future of Work area is **Ramesh Johari**, an associate professor in management science and engineering. His work focuses on rating systems and how they can be adapted to function for online employees.