Spotlight

Artificial Intelligence

Using Artificial Intelligence to Advance the State of Multiple Industries

September 2019

U.S. DEPARTMENT OF ENERGY | Office of TECHNOLOGY TRANSITIONS

energy.gov/technologytransitions

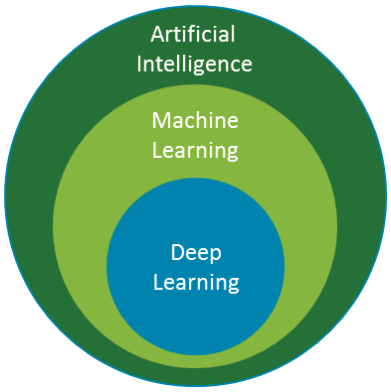
Critical Need for Artificial Intelligence

Artificial intelligence (AI) describes the capability of machines to rapidly learn from large data sets, solve problems, and continuously adapt to new data without human intervention. These machine systems leverage computer science, data science, and mathematics to deliver insight at data rates and scales incomprehensible to humans. AI functions include image and natural language processing, sensor networks, predictive planning, and decision support. AI systems enhance human capabilities and continued development in the field will extend the reach and promise of AI.

AI research, development, and demonstration (RD&D) has grown rapidly over the last 20 years, largely driven by advances in processors and big data. AI is now used in nearly every part of the economy to transform data stores into useful knowledge. Examples include targeted ads, face recognition, digital assistants, and self-driving vehicles. Global spending on AI systems is projected to reach $98 billion in 2023, up from the $37.5 billion forecast for 2019.[1]

The U.S. Department of Energy (DOE) and its National Laboratories maintain an innovation ecosystem to fulfill their missions in science, engineering, and national security. This ecosystem is expanding and improving AI systems, tools, methods, algorithms, and applications. DOE and its laboratories collaborate closely with other federal agencies, industry, and academia to accelerate the development of technologies that maintain U.S. security and competitiveness.

To accelerate AI innovation and partnerships, DOE newly established the Artificial Intelligence and Technology Office (AITO). AITO serves as the DOE's hub for coordinating the agency's efforts as a world-leading enterprise in scientific and technological discovery and accelerates the development, delivery, and adoption of AI.



Artificial Intelligence is widely expected to transform nearly every aspect of society. Machine learning is currently the most widely used subset of AI. Within machine learning, deep learning uses multi-layered neural networks to learn from vast stores of data.

Top AI Industries Based on Projected 5 Year Growth Rates

(2018-2023 Forecasted Compound Annual Growth Rates)

1. **Media** (33.7%)
2. **Federal/Central Government** (33.6%)
3. **Resource Industries** (32.8%)
4. **Education** (32.2%)
5. **Personal and Consumer Services** (32.0%)
6. **Others** (27.9%)

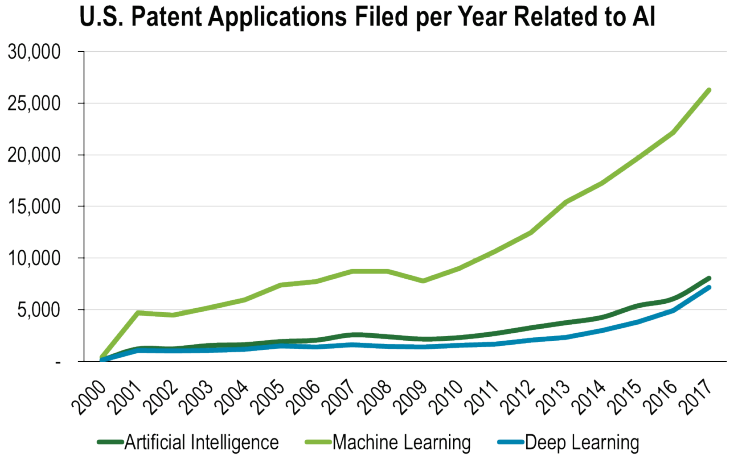
Source: International Data Corporation[1]

Contents

[1] "Worldwide Spending on Cognitive and Artificial Intelligence Systems Will Be Nearly $98 Billion in 2023, According to New IDC Spending Guide." International Data Corporation. Published September 4, 2019. Accessed September 17, 2019. idc.com/getdoc.jsp?containerId=prUS45481219

National Strategies to Advance AI

DOE focuses its efforts on early-stage research to advance technologies and develop the next-generation computing capabilities, infrastructure, and tools that the nation needs but industry is unlikely to develop on its own. AI-related research at DOE fully aligns with the *National AI Research and Development Strategic Plan: 2019 Update* developed by the National Science and Technology Council.[2] The *Plan* establishes a set of priority areas that address ethical and societal implications, safety and security, standards and benchmarks, datasets and environments, and the AI workforce. Federal investment in AI research and development (R&D) is directed toward these eight strategic priorities, which are laid out in the *Plan* and listed below.



Surging interest in Artificial Intelligence

The number of patent applications filed in the U.S. containing the terms AI, Machine Learning, and Deep Learning have increased fivefold over the past two decades.

Data Sourced from The Lens on 9/17/2019. lens.org/. LENS.ORG Solving The Problem Of Problem Solving

Strategy 1: Make long-term investments in AI research

Prioritize investments in the next generation of AI that will drive discovery and insight and enable the United States to remain a world leader in AI.

Strategy 2: Develop effective methods for human-AI collaboration

Increase understanding of how to create AI systems that effectively complement and augment human capabilities.

Strategy 3: Understand and address the ethical, legal, and societal implications of AI

Research AI systems that incorporate ethical, legal, and societal concerns through technical mechanisms.

Strategy 4: Ensure the safety and security of AI systems

Advance knowledge of how to design AI systems that are reliable, dependable, safe, and trustworthy.

Strategy 5: Develop shared public datasets and environments for AI training and testing

Develop and enable access to high-quality datasets and environments, as well as to testing and training resources.

Strategy 6: Measure and evaluate AI technologies through standards and benchmarks

Develop a broad spectrum of evaluative techniques for AI, including technical standards and benchmarks.

Strategy 7: Better understand the national AI R&D workforce needs

Improve opportunities for R&D workforce development to strategically foster an AI-ready workforce.

Strategy 8: Expand public-private partnerships to accelerate advances in AI

Promote opportunities for sustained investment in AI R&D and for transitioning advances into practical capabilities, in collaboration with academia, industry, international partners, and other non-Federal entities.

[2] National Science and Technology Council. "The National Artificial Intelligence Research and Development Strategic Plan: 2019 Update." June 2019. whitehouse.gov/wp-content/uploads/2019/06/National-AI-Research-and-Development-Strategic-Plan-2019-Update-June-2019.pdf

DOE Develops AI Across Multiple Sectors

AI research at DOE is enabling solutions to critical issues in many economic sectors. Leading AI applications include grid optimization for renewable energy sources, transportation network efficiency, quality healthcare access, and advanced manufacturing processes. DOE's AI research provides additional benefits in energy, science, national security, emergency response, and other areas not explicitly highlighted in this document.

DOE's programs and National Laboratories pursue advancements in AI in line with the President's Executive *Order on Maintaining American Leadership in Artificial Intelligence*,[3] which directs Federal Agencies to:

- **Advance Technology.** President Trump is directing the Federal Government to prioritize R&D of America's AI capabilities.
- **Drive Breakthroughs.** America's ability to leverage AI is critical to increasing prosperity, enhancing our national and economic security, and protecting our values.
- **Develop Visionary Leadership.** The President is committed to enacting policies that promote and protect American leadership in technological development and innovation.[4]

"Continued American leadership in Artificial Intelligence is of paramount importance to maintaining the economic and national security of the United States."

– *President Donald J. Trump*

More information on the White House's federal AI framework, strategic plan, and R&D objectives can be found at ai.gov

Examples of DOE Program Office Funding Activities, April 2019

AI Use in Science (Office of Science)

The Office of Science (SC) announced $13 million in funding to develop AI as a tool for scientific investigation and prediction. Approximately $11 million will be devoted to developing algorithms and software for specific scientific programs. The remaining funding will support improving the reliability of predictions from AI and machine learning models.

Learn more at: energy.gov/articles/department-energy-announces-20-million-artificial-intelligence-research

AI as a Tool to Improve Grid Resiliency (Office of Electricity)

The Office of Electricity (OE) announced $7 million in federal funding for several AI-related projects. These projects are expected to support and expedite the future development and application of faster grid analytics and modeling.

Learn more at: energy.gov/articles/department-energy-announces-20-million-artificial-intelligence-research

Advancing the State of the Art through Strategic Investments in AI (ARPA-E)

Advanced Research Projects Agency-Energy (ARPA-E) announced up to $20 million for projects as part of a new program: Design Intelligence for Formidable Energy Reduction Engendering Numerous Totally Impactful Advanced Technology Enhancements (DIFFERENTIATE). Project teams will work on applying AI and machine learning to energy applications—catalyzing innovation in energy technology.

Learn more at: arpa-e.energy.gov/?q=arpa-e-programs/differentiate

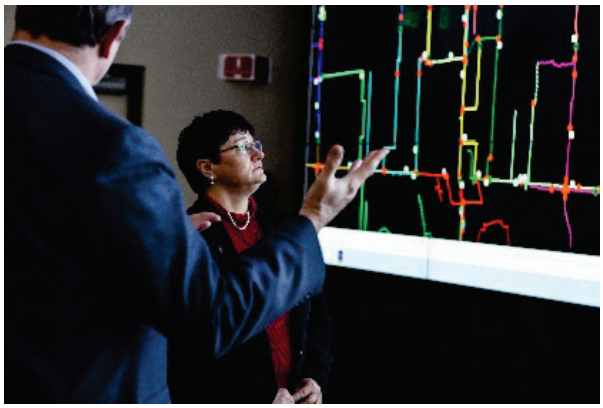
[3] The White House. "Executive Order on Maintaining American Leadership in Artificial Intelligence." February 11, 2019. whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/

[4] U.S. Department of Energy. "White House Fact Sheet: President Donald J. Trump is Accelerating America's Leadership in Artificial Intelligence." energy.gov/articles/white-house-fact-sheet-president-donald-j-trump-accelerating-america-s-leadership.

Using AI for Energy: Grid Modernization and Renewable Energy

DOE and its National Labs are leveraging recent progress in AI to better utilize their massive computational resources and technical workforce in support of further grid modernization, energy efficiency, and renewable energy usage.

Grid Automation and Optimization



Electricity Infrastructure Operations Center at Pacific Northwest National Laboratory (PNNL). Image by Andrea Starr | PNNL.

AI will facilitate grid modernization through autonomous systems optimization. The long-term goal is a fully Autonomous Energy Grid (AEG) that is:

- Secure
- Resilient
- Scalable
- Reliable
- Affordable
- Interoperable across devices in real-time
- Robust
- Flexible

AI research will enable incremental improvements that improve control, management, and security of the grid while moving toward an AEG. Research is needed to develop AI that can:

- Utilize grid data for forecasting and control
- Optimize algorithms for real-time and distributed applications
- Enable scalable and nonlinear control methods that work across asynchronous devices
- Support real-time communications among energy systems across temporal and spatial scales.

Read more at: nrel.gov/docs/fy18osti/70428.pdf

Cybersecurity and National Security

DOE and its National Labs have developed AI systems that help protect critical energy infrastructure from cyberattacks and minimize grid failures. Avoiding disruptions to electric service provides significant economic and social benefits nationwide.

Renewable Energy

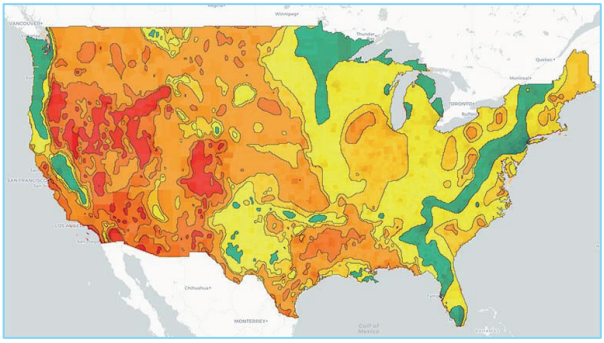
AI can help to increase the generation and use of renewable energy in many ways. For example, it can optimize dispatch of distributed energy resources, improve forecasts of resource availability, and accelerate the discovery of new materials and technology. As shown below, DOE AI is enabling advancements in geothermal and biomass energy.

Geothermal: DOE research is applying AI to the exploration and production of geothermal resources. Successful implementation of machine learning methods could facilitate the discovery of geothermal wells, increase drilling accuracy, and reduce costs.

Learn more at energy.gov/eere/articles/energy-department-awards-55-million-apply-machine-learning-geothermal-exploration

Biomass: Scientists at Idaho National Laboratory are using AI analysis of biorefinery processing data to guide operational adjustments that maximize output while mitigating system damage.

Learn more at inl.gov/article/systems-engineering/



Geothermal Prospector Tool from NREL. Machine learning will help improve data tools like this one. Image from NREL: nrel.gov/news/program/2018/nrel-data-and-tools-accelerate-geothermal.html

Improving the Efficiency of Transportation Systems

DOE and its National Laboratories use AI and machine learning to better understand and optimize transportation systems and urban mobility. These powerful tools are helping to improve safety and mobility in the sector while also reducing congestion and energy use.

DOE, AI, and Autonomous Vehicles

The Vehicle Technologies Office (VTO) within DOE is accelerating the development of safe, connected, and automated vehicles (CAVs). VTO is using AI and machine learning to improve data interpretation and sharing as a means to give CAVs real-time situational awareness.

Self-Driving Cars Provide Benefits to all Drivers

Joint research by Berkeley Lab and UC Berkeley is using deep learning to explore opportunities for autonomous vehicles to:

- Improve traffic flow
- Reduce fuel consumption
- Improve air quality

Learn more at: newscenter.lbl.gov/2018/10/28/machine-learning-to-help-optimize-traffic-and-reduce-pollution/

Benefits of Automation

AI will assist or control vehicle braking, acceleration, steering, and observation of the environment. AI systems are critical to achieving self-driving vehicles and their related benefits:

Reduce the 94% of accidents caused by human error—and associated with 37,133 deaths in 2017.

Save the $242 billion in lost economic activity attributed to car crashes (estimated for 2010).

Restore up to 50 minutes per day to the average driver.

Provide 2 million people with access to jobs or career opportunities

Source: nhtsa.gov/technology-innovation/automated-vehicles-safety#topic-road-self-driving

Transportation Systems and Infrastructure Improved with AI

The National Renewable Energy Laboratory and Oak Ridge National Laboratory are using their powerful scientific computing capabilities to support the **Athena Project**. Data-driven AI tools and statistical models will simulate passenger and freight mobility at the Dallas-Fort Worth International Airport. This "digital twin" of the airport will be built using data from individuals, traffic, freight routes, flight schedules and other sources. The model will then be used to explore the impacts of various expansion scenarios.

The project will help other transportation hubs (ports, airports, etc.) achieve their energy efficiency goals.

Learn more at: athena-mobility.org/

Aerial image of Dallas-Fort Worth International Airport by Tom Walsh. License: CC BY-SA 3.0. upload.wikimedia.org/wikipedia/commons/0/0a/Dallas_-_Fort_Worth_International_Airport.jpg

Delivering AI Innovation for Healthcare Applications

Advances in AI are unlocking new applications and approaches to healthcare. By applying machine learning, DOE's National Labs are improving the interpretation of medical and biological data and enabling advancements in diagnostics, drug discovery, and treatment.

Improving Diagnostics and Treatment

The vast amount of data produced and stored in the form of medical records and images can provide valuable insights into the effectiveness of diagnostic and treatment methods. AI tools make it possible to process and decipher these vast data sources.

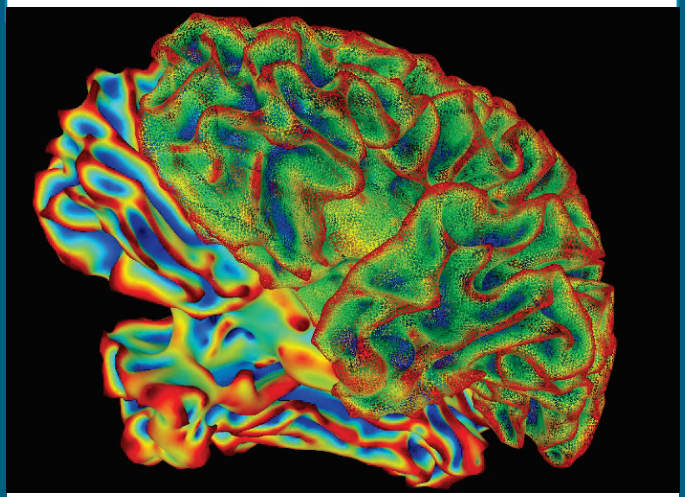
Diagnostics

In April 2018, the Food and Drug Administration approved the first ever AI-based device for detecting certain diabetes-related eye problems. AI will continue to advance the field of diagnostics by identifying trends and connections across patient's electronic health records and by improving the interpretation of medical images.

Treatment

Researchers at Oak Ridge National Laboratory (ORNL) are using AI to match cancer patients with relevant clinical trials. Similar processes can ensure that patients receive the most effective treatment based on their background, genetics, and pathology.

Learn more at: ornl.gov/news/new-ornl-ai-tool-revolutionizes-process-matching-cancer-patients-clinical-trials



This image showing a human brain was produced using MRI data that was put through a computer image processing program. This data can be processed faster than ever using AI running on DOE's supercomputers. AI and the resulting images may one day be used to detect traumatic brain injury in a clinical setting.

Image Credit: National Institute of Mental Health, National Institutes of Health (NIH) from NIH Flickr.

AI Advances Cancer Screening, Detection, and Treatment

A partnership between DOE and the National Cancer Institute is developing an open-source software platform that will enable deep learning methodologies to explore:

- Cancer causes
- Cancer treatment
- Methods to improve patient outcomes.

The Cancer Distributed Learning Environment (CANDLE) can be used to:

- Understand the molecular basis of protein interactions present in some cancers
- Parse health records to determine the best treatment strategies
- Develop predictive models for drug responses.

Learn more at: candle.cels.anl.gov/

AI Increases Understanding of the

AI allows for deeper analysis of DNA coding, drug interactions, cell types, protein folding, and molecular toxicity. Greater understanding of these chemical and biophysical properties of the human body promises to yield advancements in precision medicine and reduce the time it takes to discover and develop new drugs.

"The computing infrastructure at LLNL [sic] will enable machine learning and ultimately get safe drugs to the marketplace quicker. By bringing world-class, leading-edge engineering and high-impact biological fields together, we can develop a comprehensive reference atlas of cell-protein targets to accelerate and hone drug discovery"

Felice Lightstone
Lawrence Livermore National Laboratory (LLNL)

Source: llnl.gov/news/lawrence-livermore-and-american-heart-association-partner-accelerate-drug-discovery

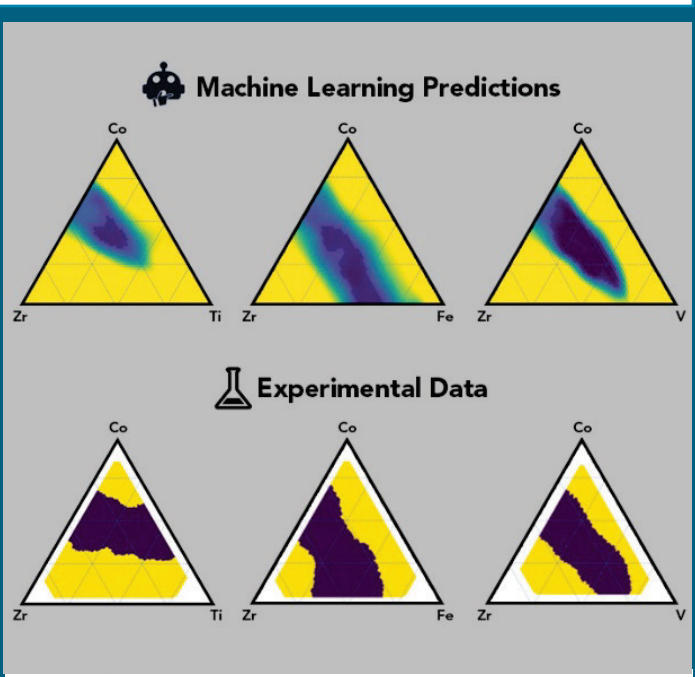
Improvements in Materials Discovery and Manufacturing Processes

DOE National Laboratories are leveraging AI to advance the state of manufacturing and materials research. Researchers are using AI to investigate potential new materials and to improve the design, development, and sustainability of manufacturing processes and manufactured products.

Materials Design and Discovery for Novel Systems and Applications

AI is significantly accelerating the time-intensive materials R&D process. DOE is using AI to advance its research in a variety of areas:

- Designing functional materials with tunable properties
- Improving the efficiency of calculating complex chemistries, as required to develop new materials for manufacturing
- Creating designer defects in diamonds, potentially unlocking insights into quantum computing systems
- Accelerating the discovery of metallic glasses ***SLAC National Accelerator Laboratory (SLAC) project shown on right***
- Speeding the development of new catalysts, with wide-ranging implications for many industries
- Screening new materials that can radically improve the energy efficiency of refrigeration technologies
- Identifying new materials for solar cells.



Summary of SLAC scientist's process for using machine learning to discover metallic glass configurations: There are over a million potential candidates for metallic glass materials and less than 1 in 100 of those alloys are even potentially glass-forming. Without machine learning predictions (shown above), it could take over 1000 years to search all possible combinations of metallic glass compositions. The experimental data shown above verifies and improves the machine learning process, which results in discovery of metallic glass 200 times faster than using traditional methods.

Image from: Yvonne Tang/SLAC; www6.slac.stanford.edu/news/2018-04-13-scientists-use-machine-learning-speed-discovery-metallic-glass.aspx

Enhanced Manufacturing Processes for Better End-Products

Lawrence Livermore National Laboratory's High Performance Computing for Manufacturing Program (co-led by Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory) incorporates machine learning to improve manufacturing processes and products. HPC4MFG aims to:

- Infuse advanced computing expertise and technology into the manufacturing industry
- Stimulate advancements in innovative clean energy technology
- Reduce energy and resource consumption
- Strengthen corporate competitiveness

HPC4 MANUFACTURING

HPC4MFG has issued eight rounds of solicitations and funded 54 projects (some follow-ons) since fall 2015. These projects can be viewed at: hpc4mfg.llnl.gov/projects.html

Partners Advance AI with DOE

DOE recognizes that AI demonstrates exceptional potential to solve long-standing and emerging problems across the U.S. economy. To expedite progress in AI and achieve needed solutions, DOE forms strategic partnerships among its program offices and with other federal agencies, industry, and academia.

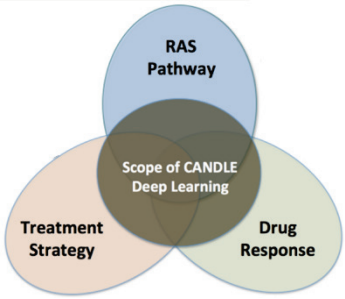
These collaborative partnerships leverage resources to put computing power on a higher trajectory; create secure platforms for sharing large, unique, high-quality data sets; and pursue successful AI applications in areas like national security, medicine, emergency response, and the energy sector—including grid optimization. Some partners may leverage DOE resources to create proprietary outcomes of commercial value, while others will advance basic research to sustain America's leadership in science and discovery. A few examples are shown below.

10^{18}

Exascale computing systems are capable of performing a quintillion (10^{18}) calculations per second.

The **Exascale Computing Project** (ECP) is driving the development of future exascale supercomputers and architectures. This collaborative effort by DOE's Office of Science and National Nuclear Security Administration expedites research in software technology, hardware and integration, and applications development that will allow the United States to fully take advantage of future exascale system capabilities.

Learn more at exascaleproject.org/



The **Cancer Distributed Learning Environment** (CANDLE) is a collaboratively developed, open-source, software platform that provides deep learning methodologies. This partnership between DOE and the National Cancer Institute (NCI in the National Institutes of Health) explores the key protein interactions that are present in 30% of cancers. The aim is to develop predictive drug response models that could improve pre-clinical drug screening and precision medical treatments.

Learn more at candle.cels.anl.gov/

HPC4 ENERGY INNOVATION

The **High Performance Computing for Energy Innovation** (HPC4 Energy) initiative facilitates partnerships between industry and the national labs that use DOE's high-performance computing resources to enable new energy technologies. HPC4 program areas focus on energy challenges in manufacturing, materials, and mobility.

Learn more at hpc4energyinnovation.llnl.gov/

ATOM team members. Photo by Julie Russell/Lawrence Livermore National Laboratory.

Accelerating Therapeutics for Opportunities in Medicine (ATOM) is a consortium to accelerate the pace of drug discovery using high-performance computing, biological data, and new biotechnologies. By incorporating supercomputing simulations and AI, ATOM is developing new tools and models to shorten the drug discovery timeline. Consortium members include GSK, Lawrence Livermore National Laboratory, the NCI's Frederick National Laboratory, and UC San Francisco.

Learn more at atomscience.org/

DOE Leverages Unique Capabilities for AI

DOE's National Laboratories are harnessing their massive scientific data sets, exceptional computing capacity, and specialized expertise to enable and facilitate AI contributions across research domains. The Labs use their advanced mathematical and statistical techniques to improve the reliability of predictions from AI models and drive transformative breakthroughs.

The National Labs use their skills in advanced data analytics, algorithm development, and modeling and simulation to help realize the potential of AI in missions of national importance. These impressive capabilities attract high-value partners from various sectors. The resulting complementary partnerships can provide unparalleled insights and pave the way for game-changing innovations.

Core Capabilities in AI

The National Laboratory System uses its world-class expertise and facilities to conduct basic discovery research, technology development, and demonstration.

The following National Laboratories hold core capabilities in AI R&D:

Argonne National Laboratory (ANL)
Brookhaven National Laboratory (BNL)
Lawrence Berkeley National Laboratory (LBNL)
Lawrence Livermore National Laboratory (LLNL)
Los Alamos National Laboratory (LANL)
National Energy Technology Laboratory (NETL)
Oak Ridge National Laboratory (ORNL)
Pacific Northwest National Laboratory (PNNL)
Sandia National Laboratories (SNL)

Learn more at energy.gov/downloads/annual-report-state-doe-national-laboratories

Partnership Agreements with DOE National Labs

Industry, academia, and other entities can access the specialized expertise and facilities of the DOE National Laboratories by entering into collaborative research agreements. The following mechanisms are available to meet the diverse needs of the U.S. research community:

- Agreements for Commercializing Technology (ACT)
- Cooperative Research & Development Agreements (CRADA)
- Material Transfer Agreements
- Strategic Partnership Projects (SPP)
- Technical Support Agreements
- Technology Licensing Agreements
- User Agreements

In fiscal year 2018, partners using the ACT, CRADA, or SPP mechanisms for high performance computing design and methods research included 36 unique non-federal partner organizations working on 40 active agreements. These partners contributed $5.2 million to this work covered by agreements. In addition, six other federal agencies engaged the labs on 22 active agreements and contributed $43.8 million to this work.*

For more information on how to work with the National Laboratories, please refer to the 2016 *Guide to Partnering with DOE's National Laboratories*, inl.gov/wp-content/uploads/2016/05/Revised-Guide-Partnering-with-National-Labs-Final.pdf

*Partnership Agreement dataset undergoing continuous quality assurance and control and is subject to change.

The Advanced Scientific Computing Research (ASCR) Program

The ASCR program under the DOE Office of Science spearheads U.S. high-performance computing for science research. ASCR develops and deploys the computational and networking capabilities needed to research phenomena of interest to DOE, such as computation chemistry and the simulation of nanomaterials and biological systems. The four program areas of ASCR are as follows:

- Applied Mathematics
- Computer Science
- Next Generation Networking for Science
- Scientific Discovery through Advanced Computing

Learn more at:
science.osti.gov/ascr/

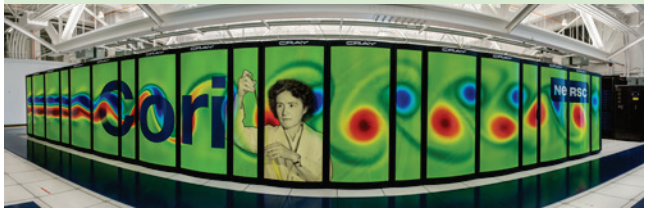


Image credit LBNL

DOE Super Computing Capabilities

In using AI for scientific discovery, DOE has access to the world-leading supercomputing capabilities of the National Laboratories. The Labs now host four of the ten fastest supercomputers in the world—confirming the United States as the current world leader in high-performance computing.

Computing systems such as these enable the Labs and their partners in industry and academia to excel in discovery and innovation. DOE supercomputers run software, models, and simulations that are often too large, expensive, or time consuming to execute elsewhere.

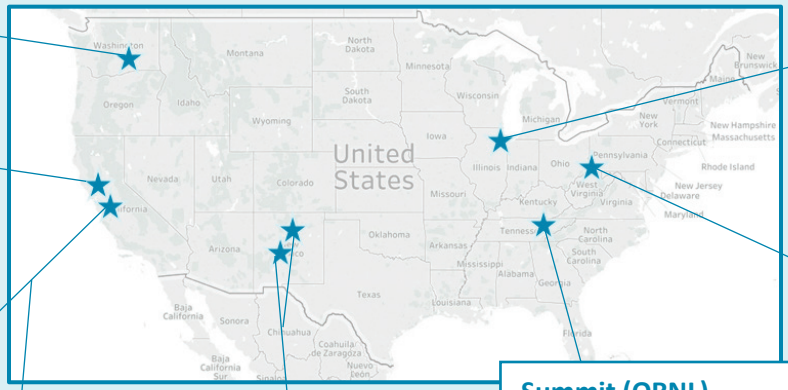
Most Powerful DOE Supercomputers

Cascade (PNNL)
3 Petaflops

Cori (LBNL)
28 Petaflops

Lassen (LLNL)
23 Petaflops

Sequoia (LLNL)
20 Petaflops



Mira (ANL)
10 Petaflops

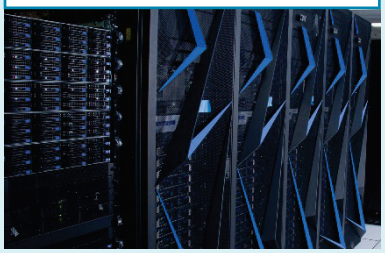
Theta (ANL)
7 Petaflops

BeBop (ANL)
2 Petaflops

Joule 2.0 (NETL)
6 Petaflops

Sierra (LLNL)

At 125 petaflops, Sierra is currently the world's second most powerful computer. This computer allows NNSA to run simulations on nuclear weapons in lieu of underground testing.

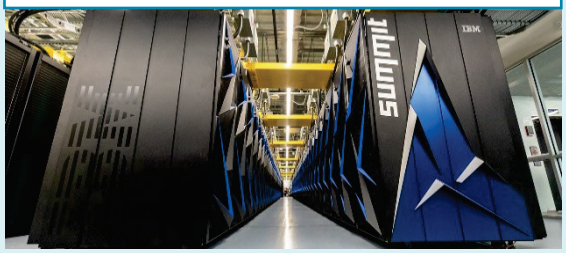


Trinity (SNL, LANL)

Capable of operating at 41 Petaflops, Trinity's computations ensure the National Nuclear Security Administration (NNSA) can maintain a safe, reliable, and secure national nuclear stockpile.

Summit (ORNL)

Summit, currently the fastest computer on the top500 (top500.org/), can perform 200,000 trillion calculations per second (200 petaflops). When using simpler calculations, Summit is performing analyses at exascale levels (over a billion billion calculations per second). Summit has enabled scientists to apply advanced machine learning to multiple topics, such as energy storage, cancer treatment, astrophysics, and fusion energy.



Next-Generation Computing: Exascale

Able to do a quintillion computations per second, exascale computing promises unprecedented breakthroughs in AI and machine learning.

- In 2021, these exascale computers are scheduled to be completed:
  - **Aurora** (Argonne National Laboratory)
  - **Frontier** (Oak Ridge National Laboratory)
- In 2022, an additional exascale computer is expected:
  - **El Capitan** (Lawrence Livermore National Laboratory)

Each project will improve the supercomputing capabilities of their home labs and will contribute to continued development of national AI capabilities.

Reducing Supercomputing Energy Use

As the computational power of supercomputers increases, so does their energy use. DOE strives to design and operate supercomputers that run as efficiently as possible to minimize their energy footprint.

Examples of AI Patents Available for Licensing

DOE funding of the National Laboratories leads to novel technologies that are often patented and later made available for licensing. The following are examples of AI-related technologies available for licensing:

Machine Learning

Dynamic Defense and Network Randomization for Computer Systems
US 9985984, Sandia National Laboratories

In-Situ Trainable Intrusion Detection System
US 9497204, Oak Ridge National Laboratory

Discriminant Forest Classification Method and System
US8306942, Lawrence Livermore National Laboratory

Neural Networks

MSE Based Drilling Optimization Using Neural Network Simulation
US10221671, National Energy Technology Laboratory

Systems and Methods for Estimation and Prediction of Battery Health and Performance
US10209314, Idaho National Laboratory

Classification of Subsurface Objects using Singular Values Derived from Signal Frames
US8717223, Lawrence Livermore National Laboratory

Modeling of Radiation Belt Magnetosphere in Decisional Timeframes
US8428916, Los Alamos National Laboratory

Signal Processing Method and System for Noise Removal and Signal Extraction
US7519488, Lawrence Livermore National Laboratory

Method for Enhanced Accuracy in Predicting Peptides Using Liquid Separations or Chromatography
US7136759, Pacific Northwest National Laboratory

Method and Apparatus for In-Process Sensing of Manufacturing Quality
US6857553, Los Alamos National Laboratory

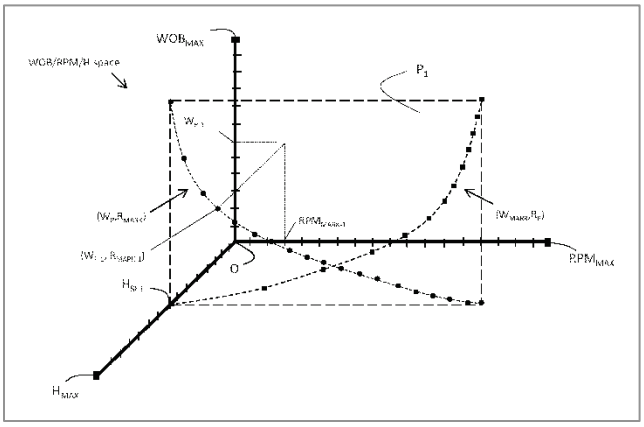
Biologically-Based Signal Processing System Applied to Noise Removal for Signal Extraction
US 6763339, Lawrence Livermore National Laboratory

LAB PARTNERING SERVICE

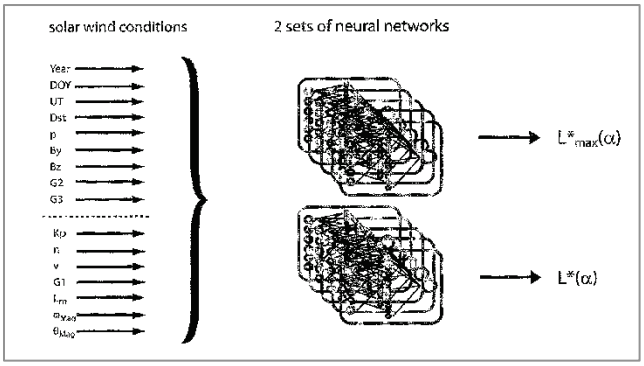
Laboratory Partnering Service (LPS)

LPS is an online platform managed by the Office of Technology Transitions (OTT) that enables public access to world-leading DOE energy experts, project marketing summaries, facilities, and licensing opportunities at the National Laboratories.

For additional and up-to-date information on all available DOE technologies, please visit: labpartnering.org/



Patent Number: US10221671



Patent Number: US8428916

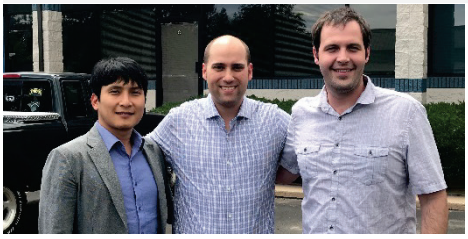
Technology-to-Market Programs Strengthen the Innovation Ecosystem

Energy I-Corps: Relevant Project Teams

AxiVis: Idaho National Laboratory (Cohort 7). AxiVis is developing a data analytics platform that facilitates use of multiple tool kits with the latest machine and deep learning platforms. The platform will allow users to test their intuition and provide a front end that can subsequently be incorporated into larger data platforms.

HYDRA: National Renewable Energy Laboratory (Cohort 1). HYDRA is a statistical framework that can be used to design aggregate forecasting models less susceptible to variability. Through multiple iterations that leverage the strengths of many methods, it creates a single model that is more accurate and reliable than any of the individual methods that went into it.

For additional and up-to-date Energy I-Corps project teams and more information visit: energyicorps.energy.gov/



AxiVis Project Team.

[Image from EIC Website]

Technology Commercialization Fund

The Technology Commercialization Fund (TCF) leverages the Energy Department's annual R&D funding in the areas of Applied Energy Research, Development, Demonstration, and Commercial Application to mature promising energy technologies with the potential for high impact.

The TCF is implemented by OTT to helps businesses move promising technologies from DOE's National Laboratories to the marketplace. TCF projects require non-federal funds to match or exceed the federal investment.

Energy I-Corps

ENERGY I-CORPS U.S. Department Of Energy

Energy I-Corps (EIC) matches teams of Lab researchers with industry mentors for an intensive two-month training period. During this time, the Lab researchers define their technology value propositions, conduct customer discovery interviews, and develop viable market pathways for their technologies.

EIC is managed for the Office of Technology Transitions (OTT) by DOE's National Renewable Energy Laboratory, which leads curriculum development and execution, recruits program instructors and industry mentors, and assembles teams from the following national labs:

Argonne National Laboratory; Berkeley Lab; Fermilab; Idaho National Laboratory; Lawrence Livermore National Laboratory; Los Alamos National Laboratory; NREL National Renewable Energy Laboratory; Oak Ridge National Laboratory; Pacific Northwest National Laboratory; Sandia National Laboratories

Select TCF Projects Relevant to Machine Learning

Machine Learning Workflow Tools for Rapid Optimization of Product Designs and Manufacturing Processes
Argonne National Laboratory

A User-Friendly Commercial Machine Learning Based Software for Large Scale Simulations and Real Time 3-D Analysis and Visualization
Argonne National Laboratory

Low-Cost Battery Health Monitoring and Diagnosis System
Pacific Northwest National Laboratory

Ubiquitous Traffic Volume Estimation through Machine Learning Procedures
National Renewable Energy Laboratory

For additional and up-to-date TCF projects and more information visit: energy.gov/technologytransitions/services/technology-commercialization-fund

Learn More

Organizations may use several mechanisms to partner with the DOE National Laboratories in collaborative research and access the specialized capabilities of their facilities and experts (Page 9).

OTT engages with stakeholders, collects partnership data, and raises awareness on impacts of DOE's partnering efforts. OTT works to expand the commercial impact of the DOE R&D investment portfolio and elevate outcomes of DOE's public-private partnerships.

Contact OTT to learn how to access technical experts, acquire the latest reports, identify promising energy projects, and locate DOE-funded technologies.

Email:
OfficeofTechnologyTransitions@hq.doe.gov

Website:
energy.gov/technologytransitions/

InnovationXLab℠ Summits

The DOE invests more than $10 billion per year in the 17 National Labs. The InnovationXLab℠ meeting series is designed to expand the commercial impact of this substantial investment.

Each summit facilitates the exchange of ideas and information among industry, investors, National Lab researchers, and DOE program managers. The objectives of the summits are as follows:

1) **Catalyze** public-private partnerships and commercial hand-offs utilizing DOE's extensive Lab assets: technology, intellectual property, facilities, and world-leading scientists and researchers;
2) **Engage** the private sector to ensure DOE understands industry's technical needs, risk appetite, and investment criteria, thereby incorporating "market pull" into DOE's portfolio planning; and
3) **Inform** DOE R&D planning to increase commercialization possibilities.

InnovationXLab℠ events are not technical workshops. They enable connections and commercialization opportunities at the decision-maker level.

DOE's Artificial Intelligence and Technology Office

In September 2019, a new DOE office, the Artificial Intelligence and Technology Office (AITO), was announced. AITO aims to transform DOE into the world leader in AI and will accelerate research, development, delivery, and adoption of AI in the United States. AITO will concentrate DOE's existing efforts in AI in order to accelerate the development of AI-enabled capabilities, scale the impact of AI, synchronize AI activities with DOE's core missions, expand partnerships, and maintain American AI leadership.

To learn more about AITO, please visit: energy.gov/artificial-intelligence-and-technology-office

Artificial Intelligence Success Stories

U.S. Department of Energy

Success Stories

U.S. DEPARTMENT OF ENERGY

Office of Technology Transitions

The Office of Technology Transitions develops DOE's policy and vision for expanding the commercial impacts of its research investments and streamlines information and access to DOE's National Labs, sites, and facilities to foster partnerships that will move innovations from the labs into the marketplace.

Artificial Intelligence Can Make the U.S Electric Grid Smarter and More Reliable

Argonne National Laboratory in partnership with the Office of Science, Office of Electricity, and the Midcontinent Independent System Operator

Using artificial intelligence, researchers at Argonne National Laboratory are developing new ways to extract insights about the electric grid from vast quantities of data, with the goal of ensuring reliability and efficiency.

Innovation

How much electricity will you need tomorrow? Answering that question is like looking ahead to your morning commute—somewhat predictable, but by no means ironclad. To manage the uncertainty in predicting power needs, grid operators rely on computer models that help estimate everything from power demand to traffic patterns.

This challenge of factoring in both the certain and the unknown to deliver electricity under different scenarios involves a series of incredibly complex math problems. With the assistance of artificial intelligence (AI), researchers at Argonne National Laboratory are developing new ways to extract insights from vast quantities of data on the electric grid, with the goal of ensuring greater reliability, resilience, and efficiency.

Outcomes

Technology Advancement

Argonne researchers are working on optimization models that use machine learning, a form of AI, to simulate the electric system and the severity of various problems much more quickly than is possible with current widely used models.

Other work at Argonne involves applying AI to speed up the daily calculations that go into regional electric system planning. One such calculation is the security constrained unit commitment (SCUC), which helps grid operators set a schedule for daily and hourly power generation.

Impact

Argonne researchers developed AI that can solve SCUC 12 times faster, on average, then conventional methods[1]. An early version of the method was used successfully in tests at Midcontinent Independent System Operator[2], which oversees electricity delivery across 15 U.S. states and one Canadian province.

Argonne National Laboratory researchers are developing new ways to extract insights from vast quantities of data on the electric grid.

"In power systems, this SCUC problem is solved multiple times a day. Since this problem is solved repeatedly, we can accumulate a lot of data and discover patterns that could be used to solve the next round."

Feng Qiu, Principal Computational Scientist
Argonne National Laboratory

Timeline

2018: Machine learning methods to solve SCUC calculations were tested at the Midcontinent Independent System Operator.

[1]Xavier A., et al. "Learning to Solve Large-Scale Security-Constrained Unit Commitment Problems" arXiv. Feb. 2019

[2]Xavier A., et al. "Transmission Constraint Filtering in Large-Scale Security-Constrained Unit Commitment" IEEE Xplore. May 2019

Artificial Intelligence for Cancer Surveillance and Clinical Trials Matching

Oak Ridge National Lab (ORNL) in conjunction with Los Alamos National Lab, Lawrence Berkeley National Lab, Argonne National Lab, U.S. Department of Energy (DOE) – Advanced Scientific Computing Research, DOE-National Nuclear Security Administration (NNSA), and National Institute of Health/National Cancer Institute (NCI) Surveillance Research Program

Scalable deep learning and knowledge graphs to enable near real-time cancer surveillance and rapid, intelligent matching of cancer patients with promising experimental treatments.

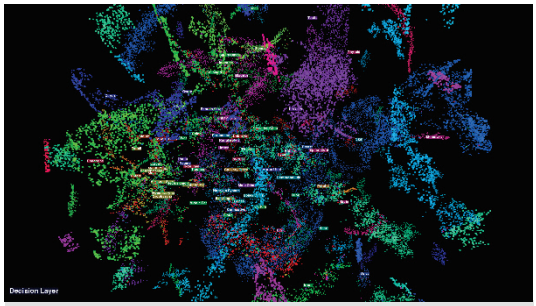
Innovation

This program uses AI to match patients into clinical trials and other research studies at the time of diagnosis. This is an interagency partnership between DOE and NCI's national Surveillance, Epidemiology, and End Results (SEER) Program aimed at leveraging high-performance computing, novel natural language processing algorithms, and population-based cancer surveillance data to develop a more timely, comprehensive, scalable, and cost-effective cancer surveillance program. By leveraging AI to extract critical information from unstructured clinical data, we achieve "near real time" cancer incidence reporting and are approaching real-time eligibility assessments of cancer patients for clinical trials, which show great potential in advancing the standard of care.

However, matching patients with clinical trials remains a challenge, mostly due to the unstructured nature of eligibility criteria as well as the clinical documentation. ORNL scientists leverage large-scale knowledge graphs and deep learning to bring together cancer registry data, medical ontologies, and clinical trials data to answer complex questions and provide real-time feedback for patients and clinicians on the novel experimental treatments available to them.

Outcomes

Deployed AI algorithms processed over 12 SEER cancer registries and millions of pathologies with increased efficiency and accuracy. The precision and efficiency of AI is expected to reduce the workload burden for cancer registrars while allowing them to realign their focus on abstracting additional complex variables (e.g., new cancer biomarkers, cancer recurrence) currently not possible using AI.



Multi-Task Deep Learning Network for Automated Information Extraction from Free-Text Pathology Reports

"Through this collaboration, we're beginning construction of the 21st century digital launchpad needed to conduct next-generation cancer research and providing a framework for the many future missions that will produce critical innovations in cancer treatment."

Warren Kibbe, Ph.D., Director,
NCI Center for Biomedical Informatics and Information Technology

Timeline

June 2016: DOE-NCI interagency partnership agreement signed.[1]

August 2018: AI technology tested across 11 SEER registries a for fast and accurate incidence reporting.[2]

February 2019: SmartClinicalTrials technology presented at the White House event on The Opportunity Project (TOP) Health Sprint, sponsored by the Census Bureau, coordinated by the Department of Health and Human Services, and led by two Presidential Innovation Fellows.[3]

[1] ncifrederick.cancer.gov/about/theposter/content/ extreme-scale-computing-project-aims-advance-precision-oncology

[2] "DeepAbstractor: A Scalable Deep Learning Framework for Automated Information Extraction from Free-Text Pathology Reports", AACR Special Conference on Convergence: Artificial Intelligence, Big Data, and Prediction in Cancer, Newport, RI, October 14-17, 2018.

[3] technology.org/2019/03/05/new-ornl-ai-tool-revolutionizes-process-for-matching-cancer-patients-with-clinical-trials/

Artificial Intelligence Systems for Precision Brain Injury Diagnostics and Outcome Predictions

Lawrence Livermore National Laboratory (LLNL), Lawrence Berkeley National Laboratory (LBNL), Argonne National Laboratory (ANL) in conjunction with the TRACK-TBI consortium (led by University of California, San Francisco)

Enabling a new era in precision traumatic brain injury diagnosis and personalized treatment

Innovation

Traumatic brain injuries (TBI) affect millions of people each year and is a complex and heterogeneous disease, which remains an enduring challenge for precision medicine.

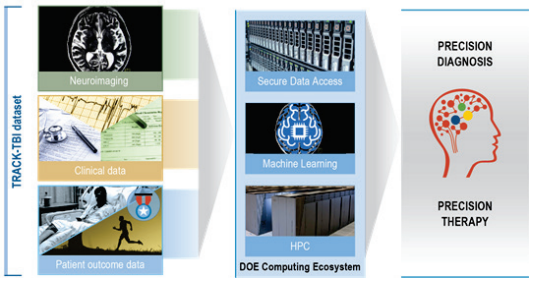
DOE national laboratories are partnering with TRACK-TBI (Transforming Research and Clinical Knowledge in Traumatic Brain Injury), the largest national study of TBI in the civilian population. DOE's data and computational infrastructure enables trusted analysis of complex, aggregated datasets.

LLNL is analyzing some of the largest and most complex multi-modal TBI patient data collected, including advanced computed tomography (CT) and magnetic resonance imaging (MRI), proteomic and genomic biomarkers and clinical outcomes using state-of-the-art artificial intelligence (AI)-based technologies and the nation's top supercomputing resources. These systems will be integrated into DOE's research in science and energy and national security programs.

Outcomes

The team is combining clinical data from 3,000 patients with high performance computing, simulation, and artificial intelligence to develop a predictive model to better understand how the brain works and responds to trauma. The work of this collaboration is accelerating brain connectome mapping to reveal novel insights.

In August 2019, a memorandum of understanding was signed at LLNL by DOE and the Weill Family Foundation to foster collaboration to demonstrate AI-based research breakthroughs that span from basic science focused on a better understanding of how the brain functions, to clinical and translational research focused on developing novel methods for preventing, treating and repairing damage caused by diseases and disorders of the brain.



LLNL applies high-performance computing to accelerate learning from complex datasets for TBI.

"This type of project is possible only when we bring together the new levels of computing capability available in DOE with the revolutionary new analytics being developed through machine learning. It takes both elements to make progress. This is one of the most difficult computing challenges we've ever seen."

Jim Brase, LLNL Deputy Associate Director for Computing

Demand Response Optimization and Management System

Lawrence Berkeley National Laboratory (LBNL) in conjunction with AutoGrid and Columbia University

Developing an automated control software to manage real-time energy demand

Innovation

The Demand Response Optimization and Management System – Real-Time (DROMS-RT) is designed to monitor real time demand across the electric grid and use that information to provide energy prices to millions of customers.[1] Customers will have the ability to react to these prices, incentivizing them to alter their usage with respect to grid conditions.

Outcomes

Technology Advancement

AutoGrid developed a scalable software-as-a-service (SaaS) demand response software that generates forecasts based on real-time signals. The system collected usage data from customer locations and utilized a machine learning engine that processes over a million forecasts every 10 minutes. AutoGrid's platform has expanded to provide big-data analytics and predictive control services.[2]

Impact

New demand response systems can enable homeowners and businesses to control energy usage and utility bills by providing them real-time price updates and grid-wide energy demand and supply conditions. Customers adjusting their energy usage based on generated forecasts can enable grid operators to improve their management of short-term grid demand and supply fluctuations. DROMS-RT is also expected to reduce the cost of demand response system operations and dynamic pricing programs in the United States. Continued development of this platform can improve reliability, reduce costs, and improve flexibility by enabling end uses to knowingly see how their demand is affecting the electric grid. Information and flexibility such as this will support future renewable resource penetration.

DROMS system features. Utilizing these functions enables the system to effectively manage customers demand response systems based on preferences and grid events.

"Having fast, automated demand response is just another arrow in the quiver of grid operators trying to balance the grid and keep the lights on.[3]"

Dave Watson, Lead Investigator
Lawrence Berkeley National Laboratory

Timeline

Jan. 2012 – March 2014: AutoGrid project with ARPA-E support through the GENI Program.

2015: AutoGrid is named a World Economic Forum Technology Pioneer, a member of the Red Herring Top 10 North America, a member of the Cleantech 100, and a Smart Grid Company to Watch.

[1] arpa-e.energy.gov/?q=slick-sheet-project/integration-renewables-demand-management

[2] arpa-e.energy.gov/?q=impact-sheet/autogrid-geni

[3] newscenter.lbl.gov/2012/05/02/bringing-the-electric-grid-into-the-21st-century/

Exascale Deep Learning to Accelerate Cancer Research

Oak Ridge National Laboratory (ORNL) in conjunction with Stony Brook University, Department of Energy (DOE) Advanced Scientific Computing Research, and Oak Ridge Leadership Computing Facility

Multi-node evolutionary neural networks for deep learning (MENNDL) identify cancer-fighting cells 16 times faster than current techniques.

Innovation

ORNL, in collaboration with Stony Brook University, developed an evolutionary multi-objective convolutional neural network (CNN) to optimize both the CNN's classification accuracy and run-time performance. This design process achieved a speed of 1.3 Exaflops on ORNL's Summit, the world's most powerful computer, with extensive use of NVIDIAs GPU Tensor Cores. The data used during development were images of cancer containing tumor-infiltrating lymphocytes (TILs), which are computationally expensive to identify but critical for treatment as the latest research has shown that high densities of TILs correlate with favorable clinical outcomes.

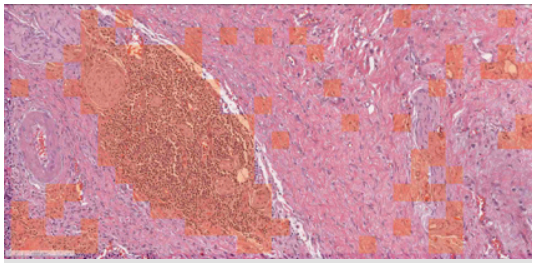
Outcomes

Technology Advancement

When applied to cancer pathology images, the resulting MENNDL-designed network, whose design goes beyond what a human expert would have imagined, performs 16 times faster than the current state of the art in identifying cancer-fighting white blood cells within whole image pathology slides.

Impact

In practical terms, this means that pathology imagery that would have taken years for cancer researchers to analyze can now be completed within hours, accelerating the evaluation of new cancer treatments. This approach clearly demonstrates that the combination of high-performance computing (HPC) with Artificial Intelligence (AI) can rapidly accelerate scientific breakthrough discoveries for social good.



MENNDL helps to automatically identify cancer fighting cells in pathology images

"The MENNDL approach […] further advances this work by targeting the development of methods to dramatically reduce computation time required to carry out Pathology based TIL prediction."

Robert J. Gillies, Ph.D., Martin Silbiger Chair, Dept. of Cancer Physiology, H. Lee Moffitt Cancer Center & Research Institute

[1] This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Advanced Scientific Computing Research, Robinson Pino, program manager, under contract number DE-AC05-00OR22725.

[2] This research used resources of the Oak Ridge Leadership Computing Facility, which is a DOE Office of Science User Facility supported under Contract DE-AC05-00OR22725.

Experimental Strategy Games

Sandia National Laboratories (SNL), Lawrence Livermore National Laboratory (LLNL), and University of California Berkeley

New technologies are making wargames more accessible and repeatable, allowing for data analysis to provide increased insight and understanding of strategic risks and opportunities.

Innovation

International relations are increasingly interconnected and complex, and researchers are seeking insights into conflicts, disputes, and escalation dynamics. Sandia is working with UC Berkeley and LLNL under a Berkeley-led project titled the Project on Nuclear Gaming (PoNG). The resulting game, SIGNAL (Strategic Interaction Game between Nuclear Armed Lands), offers players a chance to make strategic game play decisions using political, economic, and military tools. With this new approach, the project has created a way to observe thousands of playthroughs by different players in a game involving cyber, conventional, and nuclear capabilities thus allowing for machine learning and data analytics to study conflict escalation.

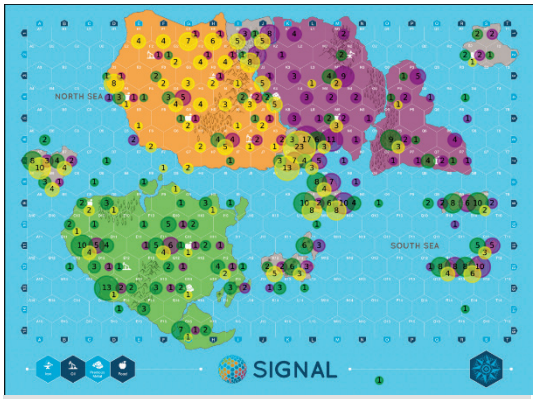
Outcomes

Technology Advancement

SIGNAL, available online, serves as the first example of a large-scale, experimental gaming approach for examining nuclear deterrence and conflict escalation dynamics and will allow researchers to analyze players' strategies. The project seeks to better understand how new experimental gaming techniques can deepen insight into conflict escalation and the potential implications of new weapon types and technologies.

Impact

The game allows the collection of data that can be used to explore new questions, such as how the broader population would react in certain types of conflict situations. The PoNG team recruits early-career security specialists and graduate students in related fields to play the game, giving them a chance to practice real-time strategic decision making. In addition, several academic and international organizations are interested in partnering with us on the pedagogical value of this new gaming approach.



SIGNAL is a next-generation experimental wargame designed for gathering data on strategic decision making in hypothetical scenarios to better understand deterrence and conflict escalation dynamics.

"What we're working towards is new tools for understanding key concepts like deterrence and escalation, and exploring how people behave in a crisis. The more we can understand that, the better we can inform decision makers on possible options for reducing risk in these situations."

Bethany Goldblum, UC Berkeley

Timeline

2017: Grant received to explore and analyze implications of nuclear weapons through a series of games in which players confront escalation dilemmas

December 2018: SIGNAL board game platform launched

May 2019: SIGNAL online game launched

[1] pong.berkeley.edu/about/

[2] homelandsecuritynewswire.com/dr20190122-benefits-of-nextgeneration-wargames

[3] sandia.gov/news/publications/labnews/ articles/2019/03-15/signal.html

[4] mmr.sandia.gov/article/science-of-nuclear-security-lets-you-win-this-strategy-game/

[5] carnegie.org/news/articles/eight-grants-address-emerging-threats-nuclear-security/

EyeSea

Pacific Northwest National Laboratory (PNNL) and the Department of Energy (DOE) Water Power Technologies Office

Using machine learning to assess environmental impact on marine environments.

Innovation

PNNL scientists and engineers developed EyeSea, a software tool to automate underwater video footage. EyeSea uses a machine learning visual algorithm to flag when any aquatic species enters the camera frame, which is positioned to monitor a marine hydrokinetic (MHK) turbine.

Outcomes

Technology Advancement

EyeSea uses machine learning to automate the analysis of MHK turbines for scientists. EyeSea runs while a camera maintains view of an MHK, continuously flagging moments when marine animals appear in frame. This is done autonomously, so that scientists can review the flagged footage later and not sift through hours waiting for animals to appear. EyeSea's initial test over two months required scientists to analyze 43 hours of footage and observe 20 fish interactions with no injuries. Scientists assessed that EyeSea has an accuracy of 85 percent, which they are improving through algorithm refinement.

Impact

EyeSea provides a way to accelerate the understanding the environmental of MHK turbines by minimizing the work scientists have to do. Scientists only have to analyze and observe the video segments flagged by EyeSea, ignoring the rest of the video which has no activity. MHK turbines have the capability to provide over 10% of the electricity demand of Pacific states' but require a thorough environmental analysis prior deployment.

EyeSea watches underwater video waiting for objects or marine life to appear within its view near a marine hydrokinetic turbine.
[Image: PNNL][1]

"If successful, EyeSea will be made available to MHK operators and developers to streamline siting and permitting processes, and meet post-installation monitoring requirements at future MHK sites."[1]
-PNNL Press Release

Timeline

2017: EyeSea is tested at a pilot MHK turbine in Alaska.

[1] waterpower.pnnl.gov/mhk/highlights/highlight.asp?id=2886

[2] github.com/pnnl/EyeSea

[3] energy.gov/eere/success-stories/articles/eere-success-story-pnnl-develops-eyesea-machine-learning-tool-automate

Improving Mammogram Interpretation

Oak Ridge National Laboratory (ORNL) in conjunction with the Department of Energy (DOE) Office of Science

Using deep learning to improve the detection and diagnosis of breast cancer

Innovation

In many instances, the early detection and accurate diagnosis of a disease like breast cancer can determine the success of the treatment. These diagnoses rely on the expertise and good judgment of the health care professionals that review patient mammograms. However, studies have shown that radiologists are significantly influenced by their previous diagnostic experiences, which is also known as context bias.[1]

In an effort to reduce error and limit misinterpretations, a team of scientists at ORNL are working to better understand the cognitive processes used by radiologists while analyzing medical images. With the help of a head-mounted eye-tracking device, the team was able to record the eye movements of radiologists as they reviewed mammograms to determine whether context bias influenced their individual results.

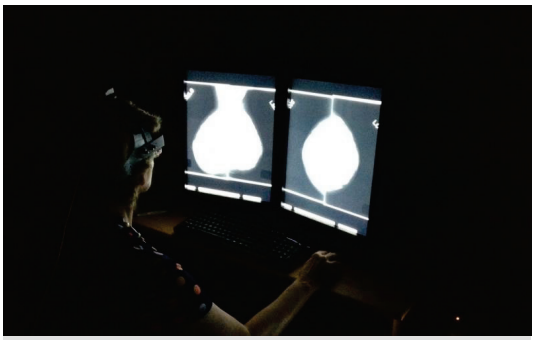
Outcomes

Technology Advancement

The ORNL team employed artificial intelligence (AI) in the form of deep learning models to analyze the massive dataset collected on eye movements. Using this method, they were able to discern how the eye paths of individuals differed from image to image and also determine the effect that previous experiences had on diagnostic decisions.

Impact

This research has the potential to assist health care professionals in reducing errors due to context bias and, in turn, help the hundreds of thousands of women that are affected by breast cancer each year in the United States.[1] ORNL's work also has the potential to be used in the training of new medical professionals as well as to advance the use of personalized medical decision support for the whole health care sector.



Radiologists using the eye-tracking device to examine mammograms to understand errors and misinterpretations of images.
[Image Credit: Hong-Jun Yoon/ORNL, U.S. Department of Energy][1]

"These findings will be critical in the future training of medical professionals to reduce errors in the interpretations of diagnostic imaging and will inform the future of human and computer interactions going forward."
Gina Tourassi
Director of Health Data Science Institute,
Oak Ridge National Laboratory

Timeline

2018: The team published two papers showcasing their results in the Journal of Medical Imaging and the Journal of Human Performance in Extreme Environments.

[1] ornl.gov/news/ornl-researchers-use-ai-improve-mammogram-interpretation

[2] ornl.gov/content/modeling-sequential-context-effects-diagnostic-interpretation-screening-mammograms

[3] docs.lib.purdue.edu/jhpee/vol14/iss1/3/

Increasing Crop Yields with Artificial Intelligence

Lawrence Berkeley National Laboratory (LBNL) in conjunction with the University of Arkansas and Glennoe Farms.

Scientists are bringing together molecular biology, biogeochemistry, environmental sensing technologies, and machine learning to help revolutionize agriculture and create sustainable farming practices that benefit both the environment and farms.

Innovation

Through its 2017 pilot project establishing a large-scale field research site, the AR1K team are collecting data to produce actionable insights for sustainable and environmentally friendly land management strategies. The role of microbes in the health of the soil is the centerpiece of this research. By understanding how microbes work in the soil and modifying the soil environment, farmers can engineer microbial communities to enhance soil productivity. AR1K aims to decrease economic Risks, increase crop yields, Reduce Chemical Fertilizer Use, Improve Crop Value, and Create Additional Value Streams for Farmers.

Outcomes

Technology Advancement

To grow soybeans, corn, and rice at AR1K Smart Farm in Arkansas, soil samples are run through powerful machines to have their microbes genetically sequenced, drones are flying overhead taking hyperspectral images of the crops, and soon supercomputers will be crunching the massive volumes of data collected. A key challenge for advancing these goals is the recognition of the significant spatial variability of soil properties within a single field and between fields.

Impact

Repeated use of bulk fertilizers and chemicals depletes the soils and causes other environmental damage. This creates a vicious cycle forcing farmers to use more chemical and salt-based fertilizers to get the same yields, thus making the current model of industrial agriculture potentially unsustainable and increasingly expensive for the farmers. Machine learning is helping scientists develop and evaluate microbial amendments, or "probiotics for soil," to replace carbon, phosphorous, and other lost nutrients.

This farm in Arkansas may soon be the most scientifically advanced farm in the world.
[Credit: Jay McEntire]

"Microbes are a critical component of soil health and productivity. By understanding how microbes work and modifying the environments where they function, we can eventually engineer microbial communities to enhance soil productivity. What's more, Berkeley Lab's research is showing that healthy soils are more resilient to system shocks such as climate change, drought, and insects."

Dr. Ben Brown
Staff Scientist
Lawrence Berkeley National Laboratory

Timeline

2017 - Present: Pilot study began in 2017 and data has been collected in each of the two growing seasons since this time.

[1] AR1K Project: eesa.lbl.gov/projects/ar1k-sustainable-profitable-agriculture-research/

[2] AR1K Website: ar1k.org

Machine Learning and Exascale Computing Opening New Doors to More Effective Cancer Treatment

Argonne National Lab in conjunction with the Exascale Computing Program, Department of Energy (DOE) Office of Science, National Cancer Institute (NCI), Los Alamos National Lab (LANL), Lawrence Livermore National Lab (LLNL), and Oak Ridge National Lab (ORNL)

Argonne National Lab (ANL) is leading a multi-institutional effort that melds medical research and high-performance computing to enable a more personalized and effective approach to cancer treatment.

Innovation

In a typical cancer study, more than eight million measurements are taken from the biopsy of a single tumor. But even as technology allows us to characterize the biological components of cancer with greater accuracy, the massive amount of data that is produced has out-paced our ability to quickly and accurately analyze it. To tackle these challenges, researchers globally are looking toward the promise of exascale computing. Exascale systems could realize compute times 50 times faster than today's most powerful supercomputers.

ANL is leading a multi-institutional effort to advance an exascale computing framework focused on the development of the deep neural network application CANDLE (CANcer Distributed Learning Environment). CANDLE, which is funded by the DOE's Exascale Computing Program, supports the Joint Design of Advanced Computing Solutions for Cancer (JDACS4C), a DOE and NCI collaboration. LLNL and ORNL are also contributing to the CANDLE project.

Outcomes

Technology Advancement

CANDLE is addressing key cancer challenges to enhance and accelerate research at the molecular, cellular and population level by employing an advanced machine learning approach—known as deep learning—with a combination of novel data acquisition and analysis techniques, model formulation, and simulation.

Impact

CANDLE aims to enable the most challenging deep learning problems in cancer research to run on the most capable supercomputers in the DOE.

The Aurora supercomputer, expected to be one of the nation's first exascale computers, is slated to go live in 2021.

"Deep learning is the use of multi-layered neural networks to do machine learning, a program that gets smarter or more accurate as it gets more data to make predictions. It's very successful at learning to solve problems."

Rick Stevens,
Principal Investigator on CANDLE and Associate Laboratory Director for Argonne National Laboratory's Computing, Environment and Life Sciences Directorate

Timeline

March 2017: Release of a robust set of benchmarks (core deep learning problems).

July 2017: First release of the CANDLE environment.

November 2017: Awarded HPCwire Reader's and Editors' Choice Awards.

April 2018: Second release of the CANDLE environment.

April 2019: Third release of the CANDLE environment.

Machine Learning Helping Optimize Engineering Design and Process

Argonne National Laboratory (ANL) in conjunction with the Department of Energy (DOE) Vehicle Technology Office, Parallel Works, Inc., and Convergent Science, Inc.

Researchers at the U.S. Department of Energy's Argonne National Laboratory are using machine learning to help companies slash engineering design times and costs

Innovation

In a manufacturing setting, the traditional approach to design optimization of a new product involves a lot of experimental testing, evaluating prototypes, and going through multiple design iterations.

As the volume and complexity of data increases, it is extremely challenging for engineers to make sense of all the multi-dimensional information and make sound decisions in a timely manner. This uncertainty increases the number of costly experimental test campaigns, lengthens development timescales, and raises the cost of development.

In an effort to combat these limitations, industry increasingly relies on high-fidelity computer models as virtual representations of real-world devices. High-fidelity modeling represents an improvement over costly physical development and testing, but, importantly, it remains time-consuming.

Argonne National Laboratory is augmenting high-fidelity modeling with machine learning to dramatically accelerate the design optimization process while maintaining the reliability of the data.

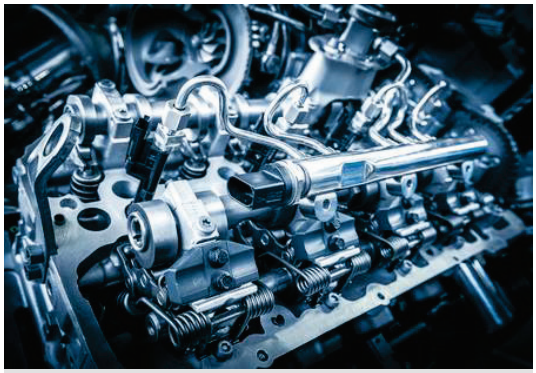
Outcomes

Technology Advancement

A job that might take hours using high-fidelity modeling alone takes milliseconds when the modeling is augmented by machine learning.

Impact

Argonne recently worked with a global petroleum and natural gas company to optimize a diesel engine to run on a gasoline-like fuel. Using high-fidelity modeling, the company's development time took months. By tapping into Argonne's supercomputing resources and machine learning expertise, the company was able to reduce the development time to days, with the same quality of result.



Machine learning techniques can help companies reduce design time from months to days and slash product development costs.

"We, on a regular basis, help industry seek improved technology and product design solutions at much shorter turnaround times, leveraging our expertise in HPC, high-fidelity modeling, and machine learning."

Pinaki Pal, Research Engineer
Argonne National Laboratory

Timeline

2019: Two software copyrights and a provisional patent are secured for the novel machine learning design optimization techniques developed at Argonne.

2019: A two-year DOE Technology Commercialization Fund project is awarded to Argonne and partners Parallel Works, Inc. (Chicago) and Convergent Science, Inc. (Madison, Wis.). The project is aimed at implementing Argonne's software technology into an end-to-end machine learning workflow for design optimization in Parallel Works' commercial software platform.

Making Manufacturing Processes More Efficient and Effective via Machine Learning

Argonne National Laboratory (ANL) in conjunction with the Department of Energy (DOE) Office of Science.

Argonne National Laboratory researchers are using machine learning to help humans optimize advanced manufacturing processes, enabling a better human-machine partnership that will be critical to U.S. manufacturing going forward.

Innovation

Advanced manufacturing processes involve multi-component materials and complex thermo-chemical reactions that result in a large volume of data, often generated at a high rate. Ideally, operators would get near real-time feedback/data on material properties and process parameters, thus enabling them to discover new mechanisms and phenomena more quickly and make adjustments that would improve efficiency and effectiveness. However, current approaches deliver feedback/data "post mortem," long after the manufacturing process is complete.

Argonne National Laboratory researchers are using machine learning to analyze data and optimize manufacturing processes in near real-time (in minutes). As a proof of concept, the team is applying this methodology to the flame spray pyrolysis (FSP) process. FSP is a gas phase combustion synthesis method enabling the production of a range of materials. Applications include catalysts and battery cathode materials.

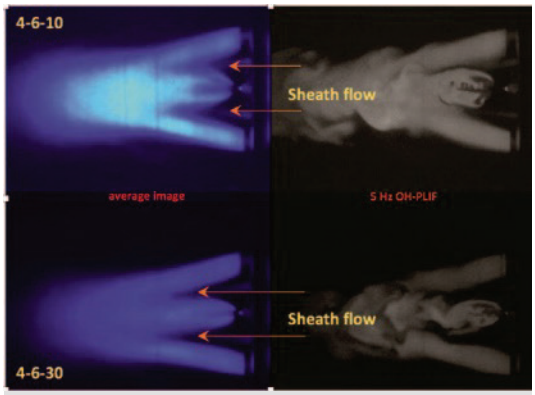
Outcomes

Technology Advancement

When applied to FSP, Argonne's approach considers processing parameters such as composition and gas-flow rates. Insights gained from experimentation, computational fluid dynamics, and thermodynamics serve as input for machine learning algorithms, which probe the design/process parameter space for optimum baseline parameters. Based on the machine learning findings, processing parameters are updated to yield better results.

Impact

This work is providing us a clearer picture of manufacturing processes, thus making them more efficient and effective.



Flame spray pyrolysis (FSP) is a gas phase combustion synthesis method enabling the production of a range of materials. Argonne researchers are using FSP as a proof of concept for their methodology of using machine learning to optimize manufacturing processes.

"The human-machine partnership is changing science and technology. The computer is now a team member that provides guidance for scientific discovery and process optimization."

Marius Stan, Program Lead, Intelligent Materials Design, Argonne National Laboratory

Timeline

2016: Development of a Flame Spray Pyrolysis reactor at Argonne begins.

2018: Argonne announces availability of Flame Spray Pyrolysis technology as a new way to manufacture nanomaterials.

[1] energy.gov/sites/prod/files/2018/03/f49/FY2016_APR_Advanced_Batteries_R%26D_Part-3of5-opt.pdf

Neuromorphic Computing for Improved Processing

Sandia National Laboratories (SNL), Department of Energy's (DOE) Advanced Simulation and Computing Program.

Whetstone has enabled neural computing networks to process information up to 100x more efficiently than current traditional computing networks.

Innovation

Computing can no longer rely upon scaling to enable advances, and Moore's Law can no longer enable exponential improvements in computing power. With traditional processor performance at a plateau, researchers have looked to brain-inspired, neuromorphic architectures to enable future capabilities, such as event detection, tracking, intelligent decision-making, and improved computation for autonomous vehicles. SNL has developed Whetstone, a software for training conventional artificial neural networks (ANNs) to behave as spiking neural networks, at its Neural Exploration & Research Lab (NERL). NERL has partnered with many leading industry manufacturers and university researchers to provide access to a wide variety of neuromorphic hardware and software algorithms. Whetstone, which offers open source code, is a spiking tool that functions as a supplemental computer code tacked on to more conventional software training programs.

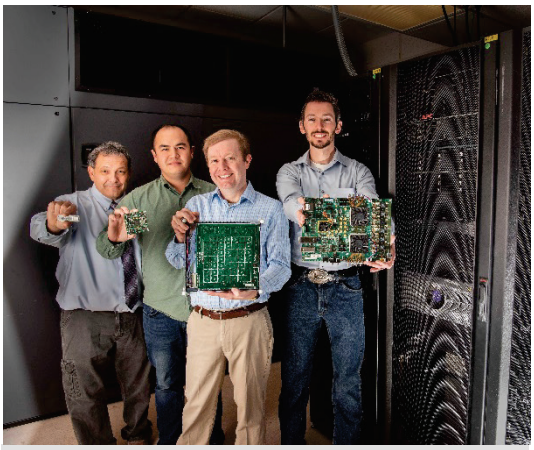
Outcomes

Technology Advancement

Neuromorphic computing has the potential to bring advanced computational power to resource constrained environments which otherwise might require a supercomputer to compute. Whetstone trains and sharpens artificial neurons by leveraging those that spike only when enough energy—that is, information—has been collected. The training has proved effective in improving standard neural networks and is being benchmarked for neuromorphic systems. The software enables a simplified system that saves energy.

Impact

Whetstone enables widespread and easy-to-implement adoption of new powerful neuromorphic hardware platforms for use in low power embedded applications. The technology could be the key to solving many sensing and computing issues that exist in remote and constrained environments such as self-driving vehicles or cellphones.



Steve Verzi, William Severa, Brad Aimone, and Craig Vineyard (left to right) display different varieties of neuromorphic hardware featured in Sandia's Neural Exploration & Research Lab.
[Photo by Randy Montoya]

"The largest AI companies have developed spiking tools for their own products, but none are as fast or efficient as Whetstone. And their tools usually only work with their own hardware and software. Whetstone, in contrast, works on many neural platforms."
Stephen Mraz, Machine Design

Timeline

2018: Neural Research & Exploration Lab founded

2018: Sandia filed patent for Whetstone

2018: Whetstone made open source

[1] github.com/SNL-NERL/Whetstone

[2] sandia.gov/news/publications/labnews/articles/2019/02-28/Whetstone.html

Neuromorphic Computing Improves Efficiency

Sandia National Laboratories (SNL), Stanford University, University of Massachusetts Amherst

Allowing computers to learn and process information at the point it is sensed, rather than being transferred to the cloud for computing.

Innovation

Machine learning algorithms are demanding larger amounts of data storage and power to complete increasingly difficult tasks for activities such as those in voice recognition, robotics, and autonomous driving. These advancements increase the need for more energy and computing efficiency at a rate that outpaces current computer hardware capabilities. Researchers at SNL led by A. A. Talin along with collaborators at Stanford University and the University of Massachusetts, Amherst have designed a prototype for a new array of artificial synapses that mimics the way the brain processes and stores information.

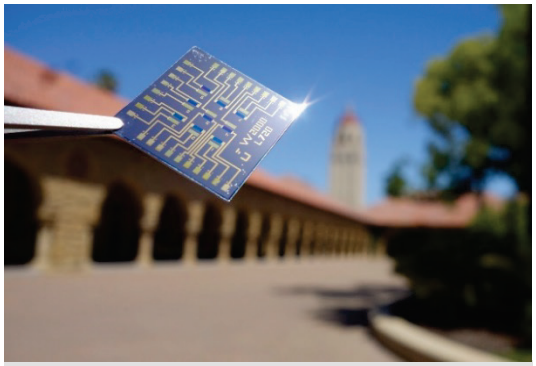
Outcomes

Technology Advancement

In testing, the artificial synapses prototype, a three-terminal design called a Redox Transistor (RT) memory, performed better than anticipated in processing speed, energy efficiency, and durability. The RT, based in organic electronics, acts as a battery that researchers use to control the flow of electricity, similar to the way the brain is wired. Researchers published their findings in early 2019, reporting that the energy efficiency performance of the developed RT could surpass that of its digital counterparts by nearly three orders of magnitude.

Impact

These developments will allow computers to process and store information in one action, rather than processing information then transferring that information to storage, thereby reducing energy consumption and increasing efficiency, opening up new methods for neuromorphic computing. It is projected to improve machine learning while using a fraction of the power of a standard processor and 10 times higher speed than the best digital computers. Widespread applications of these developments include those in mobile and wearable devices and will enable continuous learning by computers and similar devices over their lifecycle.



An array of artificial synapses mimics how the brain processes and stores information.
[Image courtesy of Armantas Melianas and Scott Keene, Stanford University]

"With the ability to update all of the data in a task simultaneously in a single operation, our work offers unmistakable performance and power advantages."
Elliot Fuller, Sandia National Laboratories

Timeline

January 2017: Inorganic redox transistor artificial synapse created by Sandia

February 2017: Organic artificial synapse created by Sandia and Stanford

2017: Continuing work addresses energy efficiency levels

April 2019: Work published in *Science Magazine*

[1] share-ng.sandia.gov/news/resources/news_releases/neuromorphic_computing/

[2] news.stanford.edu/2017/02/20/artificial-synapse-neural-networks/

[3] systemx.stanford.edu/news/2019-04-25-000000/stanford-researchers%E2%80%99-artificial-synapse-fast-efficient-and-durable

[4] prod-ng.sandia.gov/techlib/auth-required.cgi/2019/197167j.pdf

[5] science.sciencemag.org/content/sci/364 /6440/570.full.pdf

Reducing Suicide Risk for Veterans

Lawrence Berkeley National Lab (LBNL), Argonne National Lab (ANL), Brookhaven National Lab (BNL), Los Alamos National Lab (LANL), Oak Ridge National Lab (ORNL), Pacific Northwest National Lab (PNNL), and Sandia National Labs (SNL) in conjunction with U.S. Department of Veterans Affairs (VA).

Seven U.S. Department of Energy Labs are partnering with Veterans affairs to reduce suicide risk in veterans by incorporating deep learning to analyze medical records and find potential suicide risk indicators.

Innovation

Researchers at DOE, led by Berkeley Lab and LANL, developed algorithms to conduct a statistical analysis of electronic health records (EHRs) to look for key indicators of suicide risk. Suicide is the 10th leading cause of death in the United States[1], with higher suicide rates among veterans. LBNL is partnering with the VA through the MVP-CHAMPION Partnership to incorporate high performance computing and artificial intelligence to support suicide prevention. Researchers used deep learning methods to analyze data sets composed of thousands of EHRs to attempt to identify patients who have a high suicide risk.

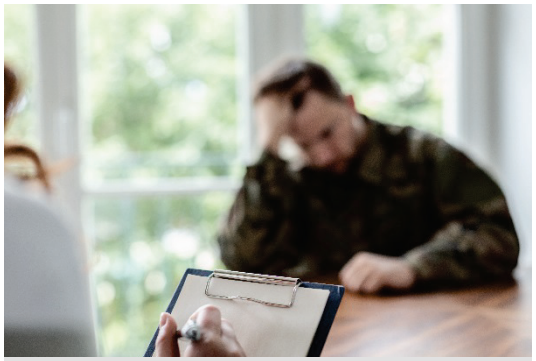
Outcomes

Technology Advancement

The data the group looked at consisted of both structured data, such as patient demographics and previous procedures, and unstructured data comprised of handwritten doctors' notes. The team initially ran the model only with structured data to conclude which patients were at high risk for suicide. In the future, the unstructured data could be incorporated to provide insights on how a doctors' wording can further indicate suicide risk.

Impact

By incorporating both structured and unstructured data, the algorithm can get a more complete picture of the person's suicide risk. Through the MVP-CHAMPION partnership, researchers will begin to use the algorithm to analyze the VA's database of 750,000 veterans. This analysis can support doctors in their assessments of which patients are at high suicide risk and would benefit from additional support. The team seeks to build on this work to create tailored suicide risk scores for VA doctors and patients.



To improve veterans care, the Million Veteran Program-Computational Health Analytics for Medical Precision to Improve Outcomes Now (MVP-CHAMPION) partnership is facilitating cooperation between the DOE and VA to put supercomputing to use identifying veterans who have elevated risk of suicide.

"The VA has been collecting medical records and genomic data from some 700,000 veterans, and they need help from DOE to interpret all of this information to improve healthcare for these individuals."

Silvia Crivelli
Computational Biologist
Computational Research Division, LBNL

Timeline

2017: DOE and VA announce the MVP-CHAMPION Partnership.

2017: ORNL deploys advanced data and compute enclave for VA protected health information.

2018: LANL, BNL, and ANL named team leads for Suicide Prevention, Cancer, and Cardiovascular Disease

2018: Berkeley Lab becomes involved in MVP-CHAMPION through the VA's Million Veteran Program Suicide Prevention Exemplar project.

[1] nimh.nih.gov/health/statistics/suicide.shtml

[2] newscenter.lbl.gov/2019/04/03/deep-learning-to-help-veterans/

Scientists Develop New Approach for Identifying Materials

Argonne National Laboratory (ANL) in collaboration with the University of Cambridge in England

A new design-to-device approach for identifying application-specific materials by leveraging machine learning techniques, data mining, and simulation

Innovation

By combining the power of supercomputing with data science and experimental methods, DOE researchers collaborated with the University of Cambridge in England to develop a novel design-to-device approach to identify promising materials for environmentally friendly dye-sensitized solar cells (DSSCs). The project developed an automated workflow, which employed a combination of simulation, data mining, and machine learning to enable the analysis of thousands of chemical compounds concurrently. Using the Theta supercomputer at the Argonne Leadership Computing Facility (ALCF)—a DOE Office of Science User Facility—the team pinpointed five high-performing, low-cost dye materials from a pool of nearly 10,000 candidates for fabrication and device testing.[1]

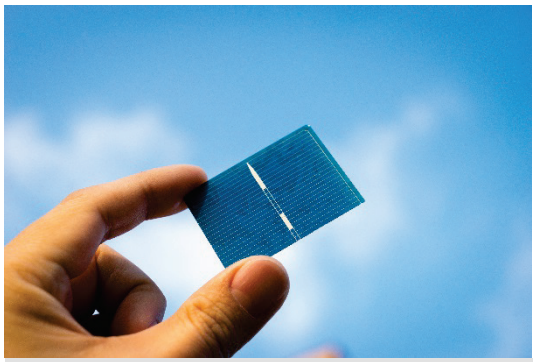
Outcomes

Technology Advancement

The novel data-driven materials discovery approach helped identify structure-property relationships between a DSSC working electrode substrate (TiO_2) and organic, spectrally responsive dyes, and validated these results experimentally. The multi-step data mining and screening process narrowed an initial batch of 10,000 dye candidates to 3,000 and then applied electronic structure and energy level calculations to further refine the list of ideal dyes for experimental verification to 30. Furthermore, the five most promising dyes were initially synthesized in laboratories around the world, requiring a worldwide collaboration to coordinate this research.[1,2]

Impact

This novel process reduced the manual curation of databases—what normally requires many years' worth of work—down to a matter of months and, ultimately, a few days. The resulting solar cells perform to world-recognized photovoltaic standards, even meeting those of organometallic materials that act as industry standards.[2]



Machine learning and data mining in conjunction with large-scale simulations enabled the identification of list-absorbing dye molecules for solar-powered windows.

"… we were able to demonstrate the full cycle of data-driven materials discovery—from using advanced computing methods to identify materials with optimal properties to synthesizing those materials in a laboratory and testing them in actual photovoltaic devices."

Jacqueline Cole
Head of the Molecular Engineering Group,
Cavendish Laboratory, University of Cambridge

Timeline

2016: ALCF Data Science Program awards project for discovering new dye materials suitable for DSSCs[3]

2018: Research from this project was published in Advanced Energy Materials.

[1] anl.gov/article/scientists-use-machine-learning-to-identify-highperforming-solar-materials

[2] anl.gov/cnm/article/datadriven-workflow-discovers-optimal-pairing-for-dyesensitized-solar-cells

[3] osti.gov/servlets/purl/1426666

Speeding Discovery of Metallic Glass

SLAC National Accelerator Laboratory (SLAC) in partnership with the National Institute of Standards and Technology and Northwestern University

Research team unlocks shortcut for discovering and improving metallic glass and other elusive materials.

Innovation

In an effort to expedite the discovery of new materials, the research group at SLAC combined machine learning (ML) techniques with experiments that develop and screen hundreds of sample materials at a time. This approach led to the discovery of three new blends of ingredients that form metallic glass—a steel alternative that is stronger, lighter, and more corrosion- and wear-resistant—about 200 times faster than possible without computing.[1,2]

First developing advanced ML algorithms, DOE researchers then used a proprietary materials science data platform which stores data primed for analysis by artificial intelligence. After investigating thousands of alloys containing three cheap, nontoxic metals, scientists crafted two sets of sample alloys that were scanned by an X-ray beam with the resulting data feeding into the materials database. The identified samples represented three different combinations of ingredients, two of which had never been used to make metallic glass before.[1]

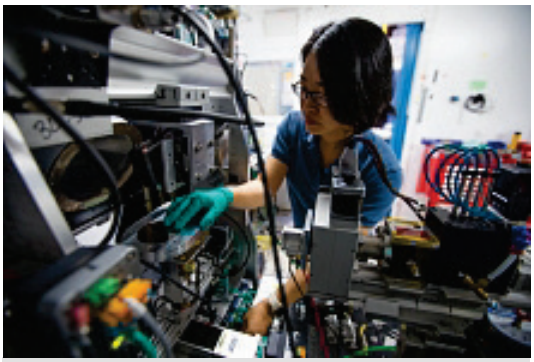
Outcomes

Technology Advancement

By facilitating the rapid verification of predictions with experimental measurements and repeatedly cycling results into the successive rounds of learning and experiments, researchers significantly accelerated the investigative process. Over the past 50 years, scientists investigated roughly 6,000 combinations of ingredients that form metallic glass—with this advancement, the team developed and screened 20,000 combinations in one year.[2]

Impact

This project helped drastically improve the group's success rate for finding metallic glass—from one out of 300 or 400 samples tested to one out of two or three samples tested. AI has also advanced the speed of discovery to unveil hidden trends and identify high-performance materials more effectively than traditional, purely human-driven materials development.



The Stanford Synchrotron Radiation Lightsource combines artificial intelligence with experiments to rapidly analyze materials.
[Image by Dawn Harmer/SLAC National Accelerator Laboratory]

"It typically takes a decade or two to get a material from discovery to commercial use. This is a big step in trying to squeeze that time down."

Chris Wolverton
Professor, Northwestern University

Timeline

2018: Results of research models and simulations published in Science Advances.

[1] slac.stanford.edu/news/2018-04-13-scientists-use-machine-learning-speed-discovery-metallic-glass.aspx

[2] forbes.com/2018/04/22/scientists-use-artificial-intelligence-to-discover-new-materials

Understanding Protein Folding

Oak Ridge National Laboratory (ORNL)

Utilizing computing algorithms in order to understand the process of protein folding.

Innovation

Researchers at Oak Ridge used deep learning to simulate the process of protein folding from one form to another. Using a newly developed software called HyperSpace, the researchers were able to interpret the intermediate steps of protein folding— where misfolds can often occur—and improve upon their analyses.

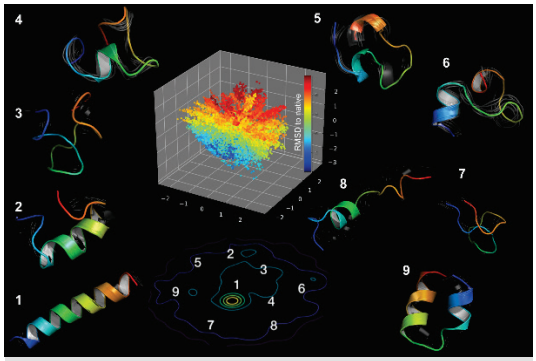
Outcomes

Technology Advancement

The team adapted an existing deep learning algorithm known as a convolutional variational autoencoder (CVAE) to study protein folding in molecular dynamics simulations. They then entered the protein folding trajectories from the simulations into a deep learning network and uncovered intermediary steps in the protein folding process. In order to improve the algorithms, the team used the computing capabilities of Oak Ridge's Compute and Data Environment for Science (CADES) to develop HyperSpace to simplify hyperparameter optimization.

Impact

A further understanding of protein folding can lead to more information about its purpose and how it interacts in the human body. Protein misfolds are attributed to the development of multiple diseases including Alzheimer's and diabetes. On top of improved analysis into why proteins misfold, this computational analysis and the HyperSpace software also have the potential to be used to study other biological phenomena such as the interaction between two separate proteins.



There are at least 8 intermediate steps during the protein folding process. Further studying of these steps can lead to further understanding of proteins and factors that affect human health.
[Image: ORNL]

"The overall shape of a protein determines its function, so some small perturbation in that shape can produce a misfolded protein and lead to serious medical conditions."

Arvind Ramanathan
Staff Scientist, Oak Ridge National Laboratory

Timeline

2018: Findings first published in BMC Bioinformatics

[1] ornl.gov/news/modified-deep-learning-algorithms-unveil-features-shape-shifting-proteins

Using Biomimicry to Quickly Detect Outbreaks

Sandia National Laboratories (SNL) in conjunction with the Centers for Disease Control and Prevention (CDC) and the University of New Mexico

Using deep learning to improve the detection of and response to disease outbreaks in the U.S.

Innovation

With data from emergency departments across the country, the CDC has traditionally identified and tracked potential outbreaks using a statistical method that analyzes a single health variable at a time (e.g., number of hospital visits, reason for visit). The team at SNL is working to improve this biosurveillance system with inspiration from the human immune response.

The body's immune system is extremely complex and a key component to its success is the T-cell, a specific type of white blood cell that targets foreign pathogens. The SNL researchers were able to mimic the T-cell response and develop a synthetic T-cell algorithm. The new method simultaneously tracks multiple variables to provide a more nuanced result.[1]

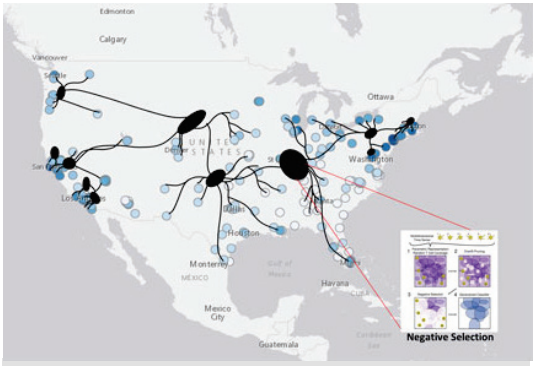
Outcomes

Technology Advancement

To further improve upon outbreak detection, the SNL team is using deep learning to decipher health data. The machine learning technique helps to find and make sense of patterns in the incoming data, which is often unstructured and may contain spelling errors. While still in development, preliminary testing indicates that the team's deep learning algorithm exceeded more conventional methods.[1]

Impact

The research conducted at SNL could contribute to current CDC practices and improve upon the U.S. biosurveillance system. With a faster and more accurate system, the CDC would be able to provide a more effective response that reduces the spread of disease and even saves lives. The researchers are now looking into how a new distributed system inspired by lymph nodes could further improve outbreak detection and public health investigations.



A biosurveillance network similar to how lymph nodes behave in the human body can potentially lead to improvements in detection of regional disease outbreaks.

[Image: SNL]

"Ultimately, this project will lead to a more complete understanding of the immune system, as well as a practical way to quickly identify and respond to disease outbreaks and other biological threats."

Melanie Moses
Professor, University of New Mexico

Timeline

2016: Project to work on applying novel biosurveillance systems incorporating artificial intelligence begins.

[1] sandia.gov/news/publications/labnews/articles/2018/13-04/biomimicry.html

[2] share-ng.sandia.gov/news/resources/news_releases/detecting_outbreaks/

ViDeoMAgic

Los Alamos National Laboratory (LANL)

Developing new methods of analyzing structures to assess their health and discover potential defects.

Innovation

Scientists at LANL have developed an innovative technology that analyzes video of a vibrating structure, such as a car, plane, or bridge, and assesses the structure's response to dynamic loads. Video-Based Dynamic Measurement & Analysis or ViDeoMAgic can extract high-spatial resolution information on the dynamic properties of a structure—including displacement time, natural frequencies, and damping ratios.

By providing this important information, researchers can monitor structural health and determine how structures handle vibration and dynamic loads. This information is critical to the design and performance of structures.

Outcomes

Technology Advancement

ViDeoMAgic utilizes unsupervised machine learning algorithms to analyze the dynamic responses to the vibration and extract the structure's properties. The technology functions automatically and is both cost-effective and an order of magnitude faster than any other technique.

Impact

The data that ViDeoMAgic provides can be used to evaluate the health of a system and detect potential damage in real-time before it reaches a critical level. This would allow professionals to remedy damage to structures that would otherwise lead to expensive repairs or disasters such as bridge collapse. As of 2018, the LANL team was seeking a commercialization partner to bring the new technology to market.

ViDeoMAgic uses video imaging processing to rapidly analyze vibrations of structures and materials.

[Image: LANL]

"ViDeoMAgic is used to achieve pixel level motion measurement an order of magnitude faster than any other technology available."

Chuck Farrar
Engineering Institute Director
Los Alamos National Laboratory

Timeline

2014: The first patent application affiliated with ViDeoMAgic is submitted.

2018: ViDeoMAgic wins an award at the 2018 R&D 100 Awards.

[1] lanl.gov/discover/news-stories-archive/2018/October/1029-videomagic.php

[2] youtube.com/watch?v=Khg_k9iRV6U&feature=youtu.be

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