Field:
Social Sciences

Session Topic:
New Challenges in Crisis Management

Introductory Speaker:
Daisuke Fujii, University of Tokyo

Title: Balancing Infection Prevention and Economic Activity

The COVID-19 pandemic has posed the world a question that has not been asked for many decades: how should a society balance infection control and economic activity during a pandemic? There is a trade-off between the two at least in the short run, and the optimal degree of anti-contagion policies such as lockdowns depends on the social values of the community. There are several difficult tasks to achieve the right balance between infection prevention and economic/social activity. First, we need quantitative assessments of various policies on health and economic outcomes. How many lives can a month-long strict lockdown save from COVID-19? What is the associated economic loss and other negative impacts on social activities? We need to answer these questions in an ever-changing environment due to the emergence of more infectious variants, unforeseeable arrival of vaccines, etc. Elucidation of the unintended outcomes of anti-infection measures is another difficult challenge. Studies have revealed that lockdown policies had a negative impact on children's cognitive skills and exacerbated the frailty of the elderly. It is also reported that the number of suicides increased, and the number of births decreased in Japan during the pandemic. The causal relationship between anti-contagion policies and these negative impacts on society is still not clear. Yet, we need to shed light on many different aspects of social activities. Organizing interdisciplinary teams of talented researchers swiftly and producing policy-oriented analyses in a timely manner is another big challenge. We explore the challenges and lessons learned during the pandemic in order to better prepare ourselves for future crisis.

Glossary:
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Background Review Article:

Session Speaker: Amélie QUESNEL-VALLÉE, McGill University

New Challenges in Public Health Crises Management: Equity, Diversity, and Inclusion

Amélie Quesnel-Vallée

My research focuses on the impact that government policies can have on social inequalities in health. Social inequalities in health are those differences in health that occur not out of ‘natural’ biological processes (e.g., aging), but rather out of exposure to modifiable social factors (e.g., education). Following decades of research documenting the association between deleterious social conditions and poor health, the World Health Organization declared in 2008 that ‘social injustice is killing people on a grand scale’.

But political action is slow to come, and 12 years later, the COVID-19 pandemic demonstrated unambiguously how disease can quickly spread along social fault lines. For instance, in many jurisdictions, racialized populations were disproportionately affected by this disease beyond the known biological risks, pointing to excess (social) risks arising, for instance, from occupational and housing conditions.

These trends are not only troubling from the point of view of health equity, but also because there is evidence that these inequalities are impeding the very work of public health crisis management in a self-reinforcing loop that is increasingly harder to break. I will provide examples of research projects that are conducted in partnership with various non-academic organizations with the common goal of increasing equity, diversity, and inclusion, as examples of a promising way forward in breaking this vicious cycle.

Field:
Social Sciences

Session Topic:
New Challenges in Crisis Management

Speaker:
Mari Tanaka, Hitotsubashi University

Title: Small business under COVID-19: Estimating the impacts of the government's anti-contagion and economic policies

To contain the spread of coronavirus infection, governments throughout the world introduced large-scale social anti-contagion policies, such as the lockdown of cities and temporary closure of businesses. These anti-contagion policies inevitably reduce people's income, thus there is a trade-off between health and wealth in a short-run. However, once the infection is contained, they could benefit both health and the economy in a long-run. At the same time, governments have introduced several economic policies to mitigate the economic damages, for example, by the provision of direct subsidies to firms and households. To make the correct decisions under crisis, governments need to understand the extent of short-run economic and epidemiological trade-off as well as the sizes of potential long-run benefits of anti-contagion and economic policies.

In the paper I have written with Kohei Kawaguchi and Naomi Kodama, we estimate the short-run effects of anti-contagion policies on the economy, the impacts of subsidies to firms to ease the economic damage, as well as the potential medium-run economic benefits of the anti-contagion policies. This study focuses on small businesses, which are most vulnerable to the economic crisis. We study this issue in the context of Japan, where the number of new infections surged from March to April 2020, followed by the declaration of emergency state, which led to the local governments' request for firms to suspend business temporarily and for individuals to stay at home. At the same time, the Japanese government introduced a series of new subsidy schemes to rescue small businesses.

Glossary:

Background Review Article:

Kohei Kawaguchi, Naomi Kodama, Mari Tanaka, "Small business under the COVID-19 crisis: Expected short- and medium-run effects of anti-contagion and economic policies," Journal of the Japanese and International Economies, Volume 61, 2021, 101138. https://doi.org/10.1016/j.jjie.2021.101138.

Introductory Speaker: Gwen O'SULLIVAN, Mount Royal University

2nd Japanese-Canadian Frontiers of Science (JCFoS) Symposium

March 6-9 2023, Banff, Alberta

The role of Environmental Geoscience in Society's Changing Natural Resource Demands

Environmental liability in resource extraction – lessons learned from legacy sites

The world has been extracting resources, including oil, gas and minerals, for centuries with the commodities being key economic driver in the Canadian and global economy[1]. Currently, coal is the largest revenue generator for mining companies, however with the push to a clean energy transition the demand for minerals may overtake coal by 2040. While the growth of mineral supply will play a vital role in enabling clean energy transitions, if poorly managed mineral development can lead to significant environmental impacts, including biodiversity loss, land use change, water depletion and pollution, waste-related contamination, and air pollution. It is estimated the liability associated with the management of mine wastes in Canada and the US is in excess of $50 billion[2].

Early mines had little to no environmental studies completed prior to the commencement of mining activities and no attention was paid to potential adverse environmental consequences of the mining activity and waste deposition. Unfortunately, many of these early mines have been abandoned after the minerals were no longer economically retrievable leaving us with a legacy of long-lasting environmental pollution. In Canada alone, there are estimated to be 10,000 orphaned and abandoned mines for which the owner cannot be found, or they are financially unable to carry out cleanup.

In the 20th and 21st century mining regulations evolved and saw the development of federal environmental statutes that hold polluters accountable for damage. In this talk we will explore the evolution of major environmental acts, implications for retroactive liability, and the role of effective environmental management to handle environmental liability for future mining activities. Using case studies, we will explore lessons learned from legacy sites, and how these have informed developments in environmental monitoring practices – dispersion, bioaccumulation, and toxicological effects (terrestrial and marine environments).

[1] https://www.canada.ca/en/news/archive/2014/11/extractive-industries-canadian-advantage-home-abroad.html

[2] https://natural-resources.canada.ca/our-natural-resources/minerals-mining/mining-resources/mining-wastes-resources/18288

Session Speaker: Matt LINDSAY, University of Saskatchewan

2nd Japanese-Canadian Frontiers of Science (JCFoS) Symposium
March 6–9, 2023, Banff, Alberta, Canada

Critical mineral production and mine waste generation: Challenges and opportunities for avoiding another environmental crisis

Matthew B. J. Lindsay, Ph.D., P.Geo.
Department of Geological Sciences, University of Saskatchewan, Saskatoon, SK, Canada

Global transitions toward clean energy systems, advanced technologies, and novel materials are dramatically increasing demand for critical minerals, including copper, cobalt, nickel, lithium, and rare earth elements. Accelerated development of new mine production capacity is being prioritized globally to address looming supply-demand gaps and stabilize commodity prices, thereby helping to realize the many purported environmental, economic, and social benefits offered by critical minerals. Expanded mine production will, however, increase generation of mine wastes that pose significant environmental risks and financial liabilities that could diminish these benefits. Recent estimates suggest over 300 new mines are needed globally over the next decade to meet rapidly growing demand for critical minerals. Corresponding generation of waste materials at copper mines alone is projected to double by 2030 and to increase fivefold by 2050. Despite considerable advances in mine waste management and reclamation capabilities over recent decades, financial liabilities far exceed assurances reserved for mine remediation and significant technical challenges remain. Ongoing innovation in mineral processing, waste management, and site reclamation are urgently needed to simultaneously increase critical mineral production and mitigate future environmental risk. In this talk, I will discuss current challenges and future opportunities related to mine wastes in a critical mineral context. Specifically, I will explore biogeochemical controls on element mobility under varied environmental conditions within diverse mine waste materials. I will also consider how underlying biogeochemical processes may be exploited to mitigate environmental impacts and, potentially, enable critical mineral recovery. Finally, I will briefly examine opportunities for reprocessing of existing waste materials and for critical mineral recovery at reclaimed mine sites, both of which could supplement critical mineral production and decrease associated environmental risks.

Field:

Earth Science / Geosciences / Environment

Session Topic:

The Role of Environmental Geoscience in Society's Changing Natural Resource Demands

Speaker:

Tatsuo Nozaki, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Title: Metallogenic study on seafloor mineral resources and its fundamental contribution to environmental geoscience

Tremendous amounts of seafloor mineral resources, such as hydrothermal sulfide deposits, ferromanganese (Fe-Mn) nodules, Fe-Mn crusts, and rare-earth and yttrium (REY)-rich mud, are widely distributed on a deep-sea floor. Geoscientists are interested in the formation mechanism of such mineral deposits and have conducted metallogenic studies from various aspects of geology, petrography, geochemistry, geophysics and so on. If we can wholly understand the formation mechanism of the mineral deposits, it would contribute to developing more efficient exploration policies and tools.

Seafloor hydrothermal deposits have been so far considered to be formed by abiotic/inorganic and thermo-chemical processes. Recently, *in-situ* sulfur isotope ($\delta^{34}S$) measurement by using a secondary ion mass spectrometry (SIMS) was applied (Nozaki et al., 2021_*Geology*). They conducted *in-situ* sulfur isotope measurement on pyrite grains along with the maturation process of mineral deposit and concluded that a microbial activity (bacterial sulfate reduction) has an important role in the initial sulfide mineralization because the framboidal pyrite that was formed at the initial mineralization stage has highly negative $\delta^{34}S$ values. Another example of the metallogenic study on seafloor hydrothermal deposits is a unique project of "Kuroko (hydrothermal sulfide) cultivation" using an artificial hydrothermal vent. During the drilling cruises at the active hydrothermal sites, several drill holes with hydrothermal fluid discharge was formed and unnaturally rapid growth of sulfide chimney was observed (Nozaki et al., 2016_*Sci. Rep.*), which inspired us the cultivation project of sulfide minerals on a deep-sea floor.

The above examples of the metallogenic study can satisfy our curiosity, but such research field is classified as basic and fundamental research. Together with the introductions of REY-resource problems, I would like to discuss the role of geoscientist to the environmental and resource issues.

Glossary:

- Seafloor hydrothermal deposit; Cu-Pb-Zn±Au±Ag mineral deposit formed at deep-sea hydrothermal sites. This type of deposit is mainly composed of sulfide and sulfate minerals formed by mixing and cooling of hot hydrothermal fluid (>300 ^{o}C) with ambient cold seawater (2 - 4 ^{o}C).

- Kuroko (black ore): Kuro and ko means black and ore, respectively in Japanese. Kuroko is the kind of ore in the volcanogenic massive sulfide deposit (past seafloor hydrothermal deposit) on land and shows black color because it is dominated by sulfide minerals of sphalerite (ZnS) and galena (PbS).
- Ferromanganese (Fe-Mn) nodule; Fe-Mn nodule is mainly distributed on a deep-sea abyssal plain. The size of Fe-Mn nodules is up to ~15 cm and typically has a rounded spherical shape. Fe-nodule is especially enriched in Co, Ni, Mn, REY, and Pt.
- Ferromanganese (Fe-Mn) crust; Fe-crust, so called Co-rich crust, is mainly distributed on slopes of seamounts. The thickness of Fe-Mn crusts is up to ~15 cm and thinly covers surface of seamounts. Fe-Mn crust is especially enriched in Co, Ni, Cu, Mn, REY, and Pt.
- Rare earth and yttrium (REY)-rich mud; Deep-sea mud (pelagic clayey sediment) having more than 400 ppm of ΣREY discovered by Kato et al. (2011_*Nat. Geosci.*). Most of REY is concentrated on biogenic Ca-phosphate (BCP) derived from fish teeth and bones.
- Sulfur isotope; Sulfur has four isotopes of ^{32}S, ^{33}S, ^{34}S and ^{36}S. These ratios with respect to standard material ($\Delta^{33}S$, $\delta^{34}S$ and $\Delta^{36}S$) are used for unraveling the origin and process of sulfur contained in the samples.

Background Review Article:

1. Kato, Y., Fujinaga, K., Nakamura, K., Takaya, Y., Kitamura, K., Ohta, J., Toda, R., Nakashima, T. and Iwamori, H. (2011) Deep-sea mud in the Pacific Ocean as a potential resource for rare-earth elements. *Nature Geoscience*, **4**, 535-539.
2. Nozaki, T., Ishibashi, J.-I., Shimada, K., Nagase, T., Takaya, Y., Kato, Y., Kawagucci, S., Watsuji, T., Shibuya, T., Yamada, R., Saruhashi, T., Kyo, M. and Takai, K. (2016) Rapid growth of mineral deposits at artificial seafloor hydrothermal vents. *Scientific Reports*, **6**, 22163.
3. Nozaki, T., Nagase, T., Ushikubo, T., Shimizu, K., Ishibashi, J.-i. and the D/V Chikyu Expedition 909 Scientists (2021) Microbial sulfate reduction plays an important role at the initial stage of subseafloor sulfide mineralization. *Geology*, **49**, 222-227.
4. Ohmoto, H. (1996) Formation of volcanogenic massive sulfide deposits: The Kuroko perspective. *Ore Geology Reviews*, **10**, 135-177.

Field:
Mathematics / Informatics / Engineering

Session Topic:
AI for Fairness and Social Good

Introductory Speaker:
Masaki OGURA, Osaka University

Title:　Perspectives on Artificial Intelligence

In this presentation, we will first outline the core ideas and recent evolution of artificial intelligence technologies. In particular, we explore the original idea of artificial intelligence by its founder, John McCarthy, and its current state to clearly distinguish what AI was supposed to be and what current AI technologies are. We will then attempt to discuss the potentially negative social impacts of AI technologies, using examples from recidivism algorithms and education. We will also extend this discussion to the issue of using AI technologies for scientific discovery, to examine whether simply collecting data and feeding it into AI technologies can lead to meaningful advances in science. We then discuss how incorporating our prior knowledge into AI models, referred to as geometric learning and model-based machine learning, can effectively address these issues. To illustrate the idea of model-based machine learning, we will review the speaker's recent work on applying the learning technique to control problems, where the speaker has applied a deep learning-oriented technique called deep unfolding to a type of control problem called model predictive control. The talk will conclude with some key questions about AI for fairness and social good.

<u>Field:</u>
Mathematics / Informatics / Engineering

<u>Session Topic:</u>
AI for Fairness and Social Good

<u>Speaker:</u>
Takashi MATSUBARA, Osaka University

Title: Geometric and Bayesian Deep Learning for Incorporating Our Needs

Recent advancements in artificial intelligence technology are closely tied to the progress of deep learning, an inductive approach that approximates a system of interest using data.
While it excels at creative areas, such as drawing, it struggles in areas that require rigor, such as natural and social sciences. This is mainly due to the scarcity and bias of available data, resulting in unrealistic, unreliable, and unfair decision making.

In contrast, scientific computing takes a more deductive approach. Its purpose is to make accurate predictions of real-world phenomena on a large scale and over a long period of time. To achieve this, it is necessary to gain insights into the mathematical structures underlying the phenomena and design computational methods that preserve those structures. This perspective defines convolutional neural networks as a computational method designed to preserve translational symmetry.

Related researchers including me propose to incorporate the idea of structure preservation into deep learning, which is called "geometric deep learning." This involves constraining the function space approximated by deep learning to a subspace. By doing so,when learning from data of physical phenomena and conducting simulations, it is possible to guarantee that energy conservation and momentum conservation laws are preserve. Moreover, this approach can help determine whether the phenomenon is energy-conservative or dissipative. In a more general sense, when applying medical data, disease-specific features can be selectively separated, which enables fair decisions that are not affected by individual differences such as gender and age.

References:
- Michael M. Bronstein, Joan Bruna, Taco Cohen, Petar Veličković, “Geometric Deep Learning: Grids, Groups, Graphs, Geodesics, and Gauges,” arXiv, 2021.
- Takashi Matsubara, Takaharu Yaguchi, “FINDE: Neural Differential Equations for Finding and Preserving Invariant Quantities,” ICLR, 2023.

- Takashi Matsubara, Koki Kusano, Tetsuo Tashiro, Ken'ya Ukai, Kuniaki Uehara, "Deep Generative Model of Individual Variability in fMRI Images of Psychiatric Patients," IEEE TBME, 2021.

Glossary:

- Deep learning: a machine learning method that can approximate any function from data. It began with a mathematical model of neurons in the brain, artificial neural networks. While it used to aim to mimic the human cognitive system, many current studies are only loosely related to neuroscience. Additionally, deep learning is not limited to approximating functions and can apply to various general mappings such as functionals.
- Convolutional neural networks: artificial neural networks that use the technique of convolution used in signal processing. It began with mimicking the structure of the visual cortex in biological organisms. It guarantees a structure that "the meaning of an object in an image is independent of where it appears."
- Geometric deep learning: deep learning that guarantees a geometric structure including convolutional neural networks.
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Background Review Article:

Session Speaker: Kristen BOS, University of Toronto

Environmental Data Politics and Justice

What if the purpose of pollution data was to create and preserve a healthy environment for seven generations ahead? What could environmental and pollution data be like if we began with our responsibilities and accountabilities to land? This presentation shares some collaborative work from the Environmental Data Justice Lab at the Technoscience Research Unit at the University of Toronto. The Indigenous-led project, The Land and the Refinery, stories the relationship between colonialism, data, and pollution in Canada's Chemical Valley, where 40% of Canada's petrochemicals are processed. Topics for discussion will include how methodologically we begin with Land—capital "L" to refer "to the unique entity that is the combined living spirit of plants, animals, air, water, humans, histories, and events recognized by many Indigenous communities" (Liboiron 2021) and how we have confronted the inadequacies of environmental data through our app, Pollution Reporter, data visualizations, and visual critiques that imagine how pollution data could work better for Indigenous communities.

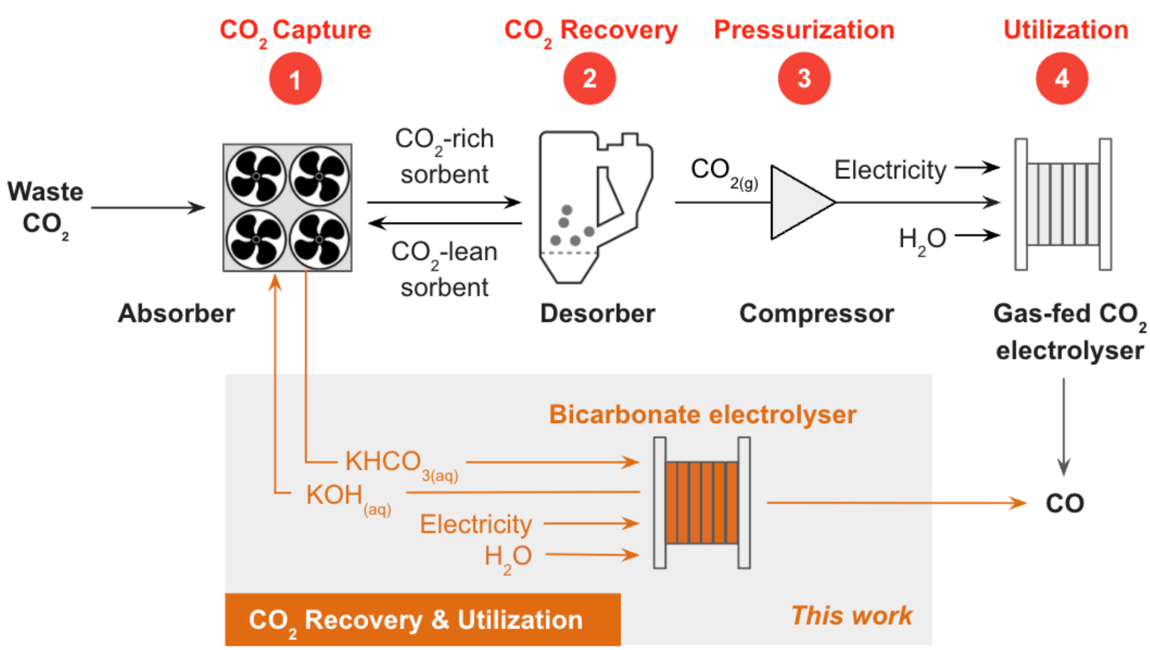
Introductory Speaker: Curtis BERLINGUETTE, University of British Columbia

Reactive carbon capture

Prof. Curtis P. Berlinguette

Department of Chemistry and Department of Chemical & Biological Engineering
The University of British Columbia

Carbon capture and utilization schemes require that CO_2 captured from the atmosphere (or a point source) be released from the sorbent, and that the sorbent be recycled to capture additional CO_2. Alkaline solutions such as KOH are effective at capturing CO_2 through reactions that form (bi)carbonates, but the recovery of CO_2 gas and hydroxide before CO_2 electrolysis requires energy-intensive steps. We have solved this problem by designing an electrochemical reactor that converts bicarbonate "reactive carbon capture solutions" into carbon-containing products. In this presentation, I will show how this reactor couples CO_2 utilization with upstream carbon capture, and also how it can perform better than the reactors fed with gaseous CO_2 that are widely studied today.



Session Speaker:

Claudiane OUELLET-PLAMONDON, École de technologie supérieure, Université du Québec

Accelerating New Materials Discovery with Automated High-Throughput Methods: Example of 3D Printing Concrete and Silicon-Based Materials

Claudiane Ouellet-Plamondon

Automated algorithmic approach allows providing a new look at many current challenges connected to materials. This presentation shows two approaches to accelerating material discovery. The vision of 3D printed concrete is to design infrastructure better adapted to their environment. The algorithmic design is bio-inspired from swarm behaviour. In evolutionary algorithms, the system is considered a black box. The optimization aims to find an optimal solution to a set of constraints connected to the material behaviour and application. For creating new concrete mixes for 3D printing, the design of experiments allows defining the experimental plan. The basic methods are the complete factorial plan and the fractional factorial plan. The advanced methods are the Taguchi method and the D-optimal design. The optimization can occur from genetic algorithms, neural networks and evolutionary neural networks. The method requires defining criteria to achieve from a set of starting materials. It allows building quicker concrete prototypes with sophisticated shapes. The optimization algorithms allow defining materials composition and to do iterations of tests until the optimum mixture is found. Another example of algorithmic method is based on a machine learning approach to obtain an optimized interatomic-potential function from a database generated from density functional theory. The database contains exotic forms of materials and elements, starting from silicon, oxygen, and silica database. From these examples, we can build confidence on the applicability of the automated methods to discover new materials and the emergence of life.

Field:

Chemistry / Materials Science

Session Topic:

Accelerating New Materials Discovery with Automated High-Throughput Methods

Speaker:

Daisuke Tanaka, Kwansei Gakuin University

Title: Machine-Learning-Assisted Exploration of Metal-Organic Frameworks

Machine learning has recently attracted attention as an efficient exploration tool, especially in the area of materials science. In particular, several attempts to optimize synthesis conditions of materials using machine learning have been reported. However, the application of machine learning techniques to predict synthesis conditions for novel materials remains limited, while its application in novel material discovery seems promising. One reason for this is that machine learning is generally good at interpolation, but the search for synthesis conditions for new materials essentially involves extrapolation because it is necessary to try completely new synthesis conditions that are different from those used in the past. Another reason is that it is difficult to quantify the synthesis of new materials, making it difficult to treat the problem of synthesis condition search as a regression problem.

In this presentation, I will talk about synthetic exploration of novel metal-organic frameworks (MOFs) assisted by machine learning. MOFs are porous organic-inorganic hybrid materials, which have been widely studied as promising environmental energy materials. To the best of our knowledge, this is the first example of applying machine learning to synthesis for the exploration of unknown MOFs. The synthetic results generated from high-throughput screening experiments were evaluated using interpretable machine-learning technique, which enabled us to determine the optimal conditions for the synthesis of novel MOFs.

Glossary: Metal-organic frameworks (MOFs): MOFs are crystalline porous materials constructed from metal ions and organic bridging ligands. Their framework topology can be designed through a combination of metal ions and organic ligand. MOFs are promising materials for a wide range of applications, such as separation, storage and catalysis.

Background Review Article:

"Big-Data Science in Porous Materials: Materials Genomics and Machine Learning"
K. M. Jablonka, D. Ongari, S. M. Moosavi, B. Smit, *Chem. Rev.*, 2020, **120** , 8066 -8129
https://pubs.acs.org/doi/10.1021/acs.chemrev.0c00004

Introductory Speaker: Laurence PERREAULT LEVASSEUR, Université de Montréal

Will artificial intelligence transform our understanding of the universe?

Although the Concordance Model of Cosmology, called the Standard Model of Cosmology or the Lambda CDM Inflationary Model, has been extremely successful over the past few decades in terms of predictions on a wide range of time and space scales, the nature of its three main components, namely the nature of inflation, dark matter, and dark energy, still remains elusive. In the next decade, a large number of new observatories and large sky surveys will come into operation to try to unravel the nature and properties of these mysterious components. Although they hold great promise for discovery, the volume of data produced by these new observatories will be unprecedented and will exceed our current analysis capabilities. To help lift the veil on some of the greatest remaining mysteries in cosmology, artificial intelligence is emerging as an essential discovery engine. In this talk, I will review how machine learning is about to transform the way we do cosmology, and how it will enable a new generation of discoveries about our universe.

Field:
Physics / Astrophysics

Session Topic:
How Can Artificial Intelligence Solve Fundamental Problems in Physics?

Speaker:
Yu Nakahama, High Energy Accelerator Research Organization (KEK)

Title: Application of Artificial Intelligence in High Energy Physics

In High Energy Physics, one of the major goals is to understand the fundamental constituents of matter, “Particles at a scale of 10^{-19} m”. We aim for addressing mysteries of the universe; for instance, what are the basic building blocks of matter? What are the forces that govern their interactions unitedly? What was the early universe like and how will it evolve? What is “dark matter”?

How do we study them experimentally? We recreate the conditions of the early universe just after the Big Bang, by colliding particles almost at the speed-of-light using high-energy particle accelerators, measure how the particles decay through large detectors, and analyse big data, in large international projects. High Energy Physics experiments, such as the Large Hadron Collider project at CERN in Switzerland and the SuperKEKB project at KEK in Japan, are considered "Big Science", discovering innovations such as world-wide-web.

As we quest for higher energies (at an order of 10^{14} eV), more precise measurements at fast response (every 10^{10} second), the experimental conditions become much more challenging, requiring much larger sizes and complexities in facilities, experiments, and collision data (of 10^{18} byte per year) in future. It turns out that these will not be scalable by simple extension of the existing techniques.

One of the promising solutions to extend High Energy Physics to be scalable & smarter is the application of artificial intelligence to all steps in experiments, from design, construction, operation, and physics analysis. Also, since we have not found new physics phenomena beyond the current standard model framework of particle physics, artificial intelligence may suggest discoveries in a data-driven manner beyond what physicists can think of. In this talk, we will outline the recent progress and introduce our challenges.

Glossary:
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Background Review Article:

Session Speaker: Christopher SMEENK, Western University

Opacity and Understanding

Are physicists using machine learning (ML) techniques like a hero consulting an oracle? Although the oracle speaks the truth, that is not sufficient to guide action.The oracle's cryptic statements cannot be interpreted properly until, tragically, the hero's fate has already been decided. There seems to be a similar tension between the capacities of some ML techniques and the goals of fundamental physics. As with the oracle, in many cases ML techniques have achieved extremely high ac-curacy. Yet the workings of these models are often a "black box" − accuracy is accompanied, again, by inscrutability or opacity. An uninterpretable answer to a fundamental problem threatens to be as useless as the oracle's pronouncements.

I will pursue two related lines of argument in response to this pessimistic view. First, in many applications the opacity of an ML technique is not an obstacle to guiding further research. For example, a "black box" technique can discover new physical quantities that are relevant to explaining patterns in the data, perhaps spurring different types of physical models. There are several ways opaque ML results can enrich our picture of a physical system. Second, philosophers have recently proposed that we should think of scientific understanding as a form of mastery − an ability to grasp how a system will respond in a variety of situations. Understanding in this sense requires an ability to extend models to new domains, but it does not require full transparency. ML methods may provide understanding of novel domains, in this sense, without also providing a "solution" (in the form of a simple, easily interpreted model).

Field:

Biology / Life Science

Session Topic:

Can We Create Life in the Near Future?

Introductory Speaker:

Norikazu Ichihashi, The University of Tokyo

Title: What can we learn from creating life-like things?

Recent progress in biochemical and computational techniques allows us to create biological phenomena *in vitro* or *in silico*. In my opinion, these attempts have at least three aims. First, we can learn the underlying principles to achieve target biological phenomena through the process of creation. For example, the recent development of artificial intelligence provides insight into the underlying principle of human intelligence. Second, we can understand the origin of life through creation. The common ancestor of all living organisms is widely believed to have emerged from a self-reproducing molecule (or molecules) in ancient Earth. The creation of biological functions with simple molecules in a test tube provides knowledge regarding how biological functions can emerge from prebiotic molecules. Third, we can obtain new technology through creation. Living things have many unique and useful characteristics, such as synthesizing complex organic molecules on a microscale and having self-reproducing ability. If these biologically unique functions are implemented in an artificial system, it would be a more controllable new technology that may replace all the current process that uses natural organisms. The two speakers of this session will talk about their recent studies related to one or two of these aims. Dr. Katherine Elvira is synthesizing droplet-based artificial cells in microfluidics for drug discovery and healthcare applications. Her study embodies the advantage of using life-mimicking systems for industrial applications. Dr. Mizuki Oka is studying conditions that allow open-ended evolution, in which new and complex features continuously emerge, by a computational method. Her group recently found that coevolution with the environment gives rise to complex features. The study provides important insight into how complex biological features emerge via evolution. I hope that this session will be an opportunity for many people to know our field of study.

Session Speaker: Katherine ELVIRA, University of Victoria

Building artificial cells and tissues from the bottom up

It costs 2.6 billion USD over 10-15 years to develop just one new drug. And one of the major downsides of developing new drugs is that they must be tested in animals, which is problematic because many drugs that work for animals, do not actually work in humans. During the drug discovery process, drug candidates are tested on cells to try and understand how these potential new drugs might behave in humans. But cells are complex, and it is not always possible to know what effect each component of the cell has on drug transport.

The term “artificial cell” is controversial because it applies to such dissimilar entities as simple models of the cell membrane, to more complex structures that include life-like functions. The goal of my research is to use microfluidic technologies to build bespoke artificial cells and tissues from the bottom up, starting with the cell membrane and then adding other cellular components such as transporter proteins and the cell microenvironment. This allows us to quantify how each component of a cell affects the uptake of drugs. We use these artificial cells to mimic how an orally administered drug moves from the intestine into an intestinal cell, and then from the cell into the blood stream, to mimic how the cell membrane changes during cancer and to build artificial tissues such as the blood brain barrier on a chip. We want our new artificial cell models to help us predict drug behaviour in humans.

Field:

Biology / Life Science

Session Topic:

Can We Create Life in the Near Future?

Speaker:

Mizuki OKA, University of Tsukuba

Title: Towards open-ended evolution in artificial systems

Open-ended evolution is a subfield of artificial life that focuses on realizing continuous evolution in artificial systems [1]. Researchers in this field employ computational methods to simulate and understand life-like systems with the aim of potentially creating life itself and gaining new insights into our understanding of life through a constructive approach.

Experimental subjects in open-ended evolution studies are often virtual organisms, and various computational algorithms, including novelty search and quality diversity algorithms, have been developed to facilitate this research [2,3,4,5]. In this presentation, I will outline the key concepts and findings in the field of open-ended evolution.

The applications of the technology generated through open-ended evolution research are diverse, ranging from artificial computer systems, such as the creation of game characters and environments [6], to biological systems, including the synthesis of biological robots like Xenobot [7]. Other potential applications include the continuous discovery of new drugs or materials.

References

[1] N. Packard et al. (2019). Open-Ended Evolution and Open-Endedness: Editorial Introduction to the Open-Ended Evolution I Special Issue. Artificial Life, 25(1), 1–3.

[2], J. Bhatia et al. (2021), Evolution Gym: A Large-Scale Benchmark for Evolving Soft Robots, In proc. of NeurIPS, pp. 2201-2214.

[3] J. Lehman and K. O. Stanley (2011), Abandoning objectives: Evolution through the search for novelty alone, Evol. Comput. 19, 2, 189–223.

[4 J.B. Mouret, J. Clune (2015), Illuminating search spaces by mapping elites, arXiv:1504.04909.

[5] R. Wang et al. (2019), Paired Open-Ended Trailblazer (POET): Endlessly Generating Increasingly Complex and Diverse Learning Environments and Their Solutions, In proc. of GECCO 19, pp.142-151.

[6] Endo et al., (2022), Toward automatic generation of diverse congestion control algorithms through co-evolution with simulation environment, In proc. of ALIFE 2022, Paper No: isal_a_00515, 33.

[7] B. Douglas et al., (2021), A cellular platform for the development of synthetic living machines" (English). Science Robotics 6 (52): 1853–1859.