Newsletter   Winter 2022

The MERIDIAN Project

As demand for resources continues to grow, nations turn their attention to the ocean, not least Canada with its world's longest coastline. Along with the changing climate, the increased human presence impacts the marine ecosystems, especially in the Arctic. Therefore, to ensure sustainable use of marine resources, we must keep a vigilant eye on our ocean's health.

To monitor what is happening under the water's surface, researchers use their ears rather than their eyes. Across the globe, large numbers of underwater listening stations are being deployed, some from floating buoys, others attached to small autonomous submarines, all recording the underwater soundscape and generating large amounts of complex acoustic data which holds a wealth of information about the ocean's health. This data has unique characteristics and often requires linking of various databases. For example, acoustic data are used to track the movements of endangered marine mammals, or quantify the amount of noise pollution created by marine traffic. Massive amounts of such data are and will begenerated by underwater sensors.

The MERIDIAN project, funded in 2016 under the CFI Cyberinfrastructure program, with provincial support from Nova Scotia, Québec and British Columbia, using Compute Canada's infrastructure, and headquartered at Dalhousie's Institute for Big Data Analytics, was aimed at bringing the advanced AI and Machine Learning methods to derive from this data useful, actionable knowledge. In the span of three years, MERIDIAN has established itself as a unique endeavour in Canada and internationally, advancing the use of Big Data, AI, and Machine Learning in ocean science, to the benefit of our oceans.

Key achievements of MERIDIAN include the development of two open-source software packages, Ketos and Kadlu, now actively used by half a dozen research groups in Canada and internationally for developing novel acoustic detection and classification algorithms based on Artificial Intelligence (AI). Another major contribution of the MERIDIAN project has been the development of a web-based Ocean Soundscape Atlas, an application allowing researchers and ocean managers to visualize ocean noise pollution created by vessel traffic, and to quantify its impact on endangered marine species.

In its short lifetime, MERIDIAN has built a large number of partnerships and collaborations, working with academic researchers, government scientists and NGO groups on solving pressing issues, such as protecting the endangered North Atlantic right whale on Canada's eastcoast. Over 15 data scientists and technicians have been trained byMERIDIAN with unique skill sets that combine elements of ocean scienceand marine biology with advanced Data Science and Machine Learning. Moreover, MERIDIAN has been active in

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knowledge transfer, organizing workshops and – recently – webinars to train Canada's ocean researchers in the use of data science and machine learning. These webinars attracted considerable interest seeing over 50 participants on average.

While the MERIDIAN project is coming to an end this year, the MERIDIAN team will continue its efforts to advance the use of Big Data, AI, and Machine Learning in ocean science in the years to come. Supported by a CFI 2020 Innovation Fund award (Project #40082), Research Nova Scotia, and Dalhousie University, the team will be working on the "Artificial Intelligence Meets Oceans" project, building the Marine Artificial Intelligence Platform (MAIPL). MAIPL will be a virtual laboratory that will make its AI toolkits accessible to a wide range of Canadian and international ocean researchers.

Rising star: Award-winning researcher focused on improving our connectivity

Digital networks enable many of our personal and professional activities, but few of us look very closely into how they work or how they might be improved.

For Israat Haque, however, the topic is both fascinating and essential, shaping her research in network design and optimization and leading to recognition.

In 2021 alone, Dr. Haque has received the Dalhousie President's Excellence Award for Emerging Investigators, the Faculty of Computer Science Dean's Research Excellence Award, and was listed as an N2Women Rising Star in Computer Networking and Communications.

Critical Applications

Through her Programmable and Intelligent Networking (PINet) lab, Dr. Haque and her students focus on designing and implementing systems and networking solutions to support emerging applications such as smart homes, smart cities, surveillance, environmental monitoring, and video analytics.

"The United Nations estimates that more than half of the world's population is connected to the Internet today. Such connectivity is becoming an essential part of our everyday lives, affecting the cars we drive, the pills we take, and how we work and consume information," says Dr. Haque.

"To support such critical applications, the underlying communication network should never go wrong irrespective of any unexpected event (e.g., a storm, a failing link, or a misconfigured router). In practice, though, we often experience failures that disrupt our ongoing services. My team and I have created solutions that prevent, detect, and quickly recover from such failures."

Her team collaborates with researchers across Dalhousie, industry and internationally with partnerships spanning organizations including General Dynamics, Ericsson, Cisco, Defence Research and Development Canada (DRDC), and the University of California, Riverside and Brown University from the United States. Together, they create solutions to tackle some of the challenges posed by the ever-expanding use of the Internet.

Reimagining the cloud

In a recent project, Dr. Haque and her team were the only Canadian group recognized by Facebook Research as finalists through their 2020 Networking request for proposals. Their project explores a shift away from "the cloud" as we know it, opening a new field with new opportunities for providing a better-quality experience for users.

"The proliferation of latency and safety-critical applications such as Augmented Reality/Virtual Reality, surveillance, autonomous vehicles, and health monitoring has forced service providers to move from the distant cloud closer to their users; namely, to edge," explains Dr. Haque.
"The rationale is simple: network devices like

routers are closer to users than any servers. One of our recently developed systems, NetPixel, has shown it is possible to use network switches to classify images with accuracy comparable to traditional servers, all without even reaching out to the latter. In the near future, we envision using NetPixel for complex network functions like encrypted traffic classification."

A bright future

In a letter of support provided to N2Women, Dr Raouf Boutaba from the David R. Cheriton School of Computer Science at the University of Waterloo describes Dr. Haque as, "A talented young faculty member, leading impactful research on network programmability and data-driven IoT applications. Israat is a dedicated mentor striving to build an inclusive and positive environment for her students. I am confident she has an outstanding career ahead."

Dr. Haque plans to use her rising profile to make her research lab, PINet, a hub for high-impact research and innovation across the world. She is currently looking to expand PINet and has open positions for PhD students looking to work on innovative new research projects.

Antimicrobial Resistance Prediction using Machine Learning in the Genomics Era

Rapidly evolving DNA sequencing technologies have revolutionized how we study organisms. Historically, scientists have used lab techniques to understand the structures and behaviours of organisms when exposed to stimuli. Today, affordable and fast DNA sequencing lets us study organisms at the genome level, showing us the genes that underpin their properties.

One rapidly growing area of application involves using machine learning to predict bacterial resistance to antibiotics. Currently, the medical field is struggling with emerging superbugs (i..e, pathogens resistant to multiple antibiotics), which are cutting down the list of effective antibiotic drugs with terrifying speed. Machine learning has a great potential to accurately predict a pathogen's resistance to certain antibiotics, helping clinicians and doctors make better-informed decisions about antibiotic prescription.

PhD student Jee In Kim's research incorporates machine learning with whole-genome data of the Enterococcus species to better predict resistance potential and investigate the possible genetic attributors of antimicrobial resistance. She constructs explainable classification models using algorithms like random forest and logistic regression achieving as high as 91% accuracy in predicting vancomycin resistance.

According to Kim, the potential of machine learning is very exciting for the global antimicrobial resistance crisis. However, as the implementation of the technology is still relatively new, we need to critically assess models and define use cases to continue improving machine learning applications. Success in this endeavour depends on expanding collaborations between computer scientists, genomics researchers, and the practitioners who will ultimately implement these measures in the surveillance and clinical settings.

Kim's research is conducted under the supervision of Rob Beiko in the Faculty of Computer Science and Tim McAllister of Agriculture / Agri-Food Canada. More details are available at her OpenThink blog: https://blogs.dal.ca/openthink/author/jee-in-kim/
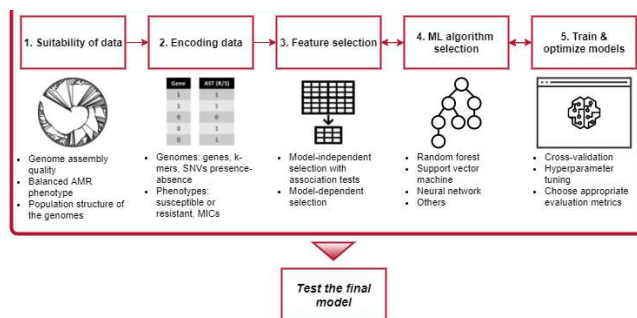
FIG 1   Antimicrobial resistance machine learning prediction workflow overview

The Launch of CANSSI Atlantic

CANSSI Atlantic launched on Wednesday November 10, 2021. This is the Regional Center of the Canadian Statistical Sciences Institute (CANSSI, www.canssi.ca). CANSSI Atlantic has as its mandate to encourage participation in CANSSI programs by researchers from Atlantic Canada, to foster collaborations between researchers in statistical and data science in the region and beyond, and to be an advocate for statistical research in the region.

Joanna Mills Flemming is the first director of CANSSI Atlantic, with a 3-year term. CANSSI Atlantic is in the Chase Building: the conference room will henceforth be the CANSSI Atlantic room and is available for CANSSI related meetings. The launch was a successful event. Don Estep, Director of CANSSI, and Stefan Leslie, CEO of Research NS both gave an address. There was representation from most of the regional universities and from other stakeholders.

Dal Team Wins 2021 RoboCup World Championship

A team of researchers from the Institute for Big Data Analytics at Dalhousie won first place in the RoboCup 2021 world champions this past summer. The victory marked the first time a Canadian team has ever won the competition, which is the largest artificial intelligence (AI) soccer simulation in the world. RoboCup uses soccer simulation to promote robotics and AI research with the research findings used to advance many real-world areas. By 2050, the competition aims to train a team of fully autonomous humanoid robots to win a soccer game against the winner of the most recent World Cup.

Team CYRUS was led to victory against reigning world champions Japan-based HELIOS2021 by Nadar Zare and Mahtab Sarvmaili, a research assistant and PhD student in the Faculty of Computer Science. Their methods use a variety of AI and machine-learning models to train autonomous 'players' in different positions to collaborate and play together in an intelligent way, often mimicking the behaviour of the world's best soccer teams and players.

While these methods are presenting new ways to play and consume sports particularly during a time where much in person activity has been suspended, the team is using their research to help humans improve their soccer techniques through an emerging project with Halifax Wanderers and Dal Varsity. This collaboration will help the teams better understand their players and team dynamics through data analysis using some of the AI methods developed for RoboCup.

The final RoboCuP 2021 round can be viewed on the competition's YouTube channel.

"Information is the oil of the 21st century, and analytics is the combustion engine"

(Peter Sondergaard, Senior Vice President, Gartner)