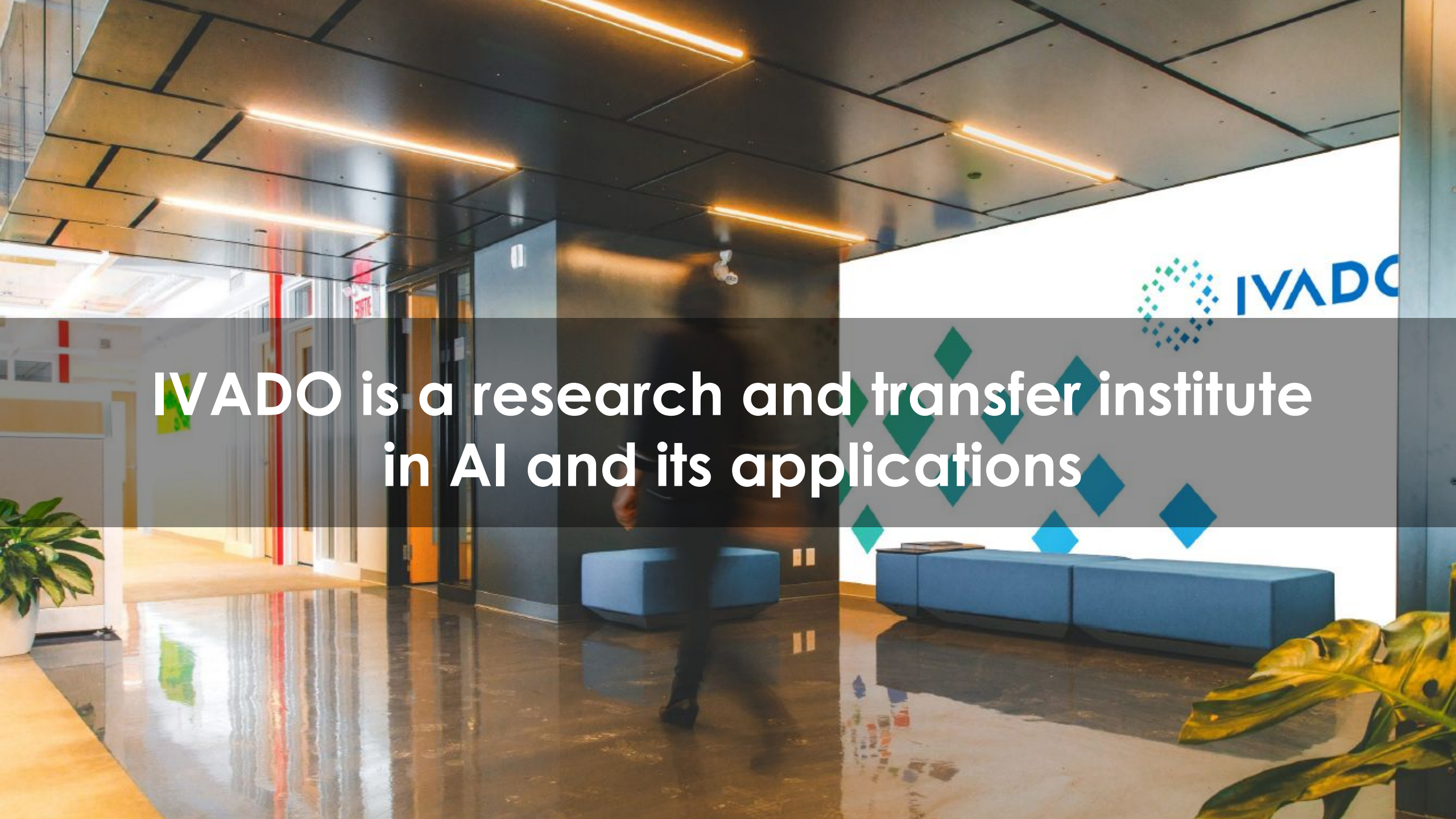
IVADO : Shifting paradigms for a robust, reasoning and responsible AI and its adoption

Luc Vinet
CEO

IVADO

1. **INTRODUCING IVADO**
2. IVADO IN ACTION
3. R^3AI: IVADO'S VISION



IVADO is a research and transfer institute in AI and its applications

IVADO

Université de Montréal

4 institutional partners

HEC MONTRÉAL

POLYTECHNIQUE MONTRÉAL

McGill

UNIVERSITY OF ALBERTA

> 2000 researchers

> 150 partner organizations

Mission : Lead, stimulate and support the collaborative development of AI and of its multifaceted responsible adoption for the benefit of society

IVADO


Transfer
Research
Talent
Entrepreneurship
Training
Equity, Diversity, Inclusion (EDI) & Indigenous engagement

AI is transformative science and technology

- It needs **other sciences** (including humanities and social sciences) to grow
- It requires **societal framing**
- It is poised to **accelerate discoveries**
- It can bring considerable **benefits to society**
- It can **contribute to global challenges**
- It will **transform the workplace** and the **economy**

A transdisciplinary organization

- **brings together** AI **specialists and experts** in: neuroscience, physics, chemistry, biology, health, law, indigenous studies, ethics, social sciences, EDI etc.
- **sustains collaborations** between **academia, industry, government, NGOs**, etc.
- ensures input from user groups, patient partners

IVADO'S STRUCTURE IS DESIGNED ACCORDINGLY

IVADO comprises outstanding research institutes

14 ACADEMIC MEMBERS

CENTRE DE RECHERCHES MATHÉMATIQUES

CIM CENTRE FOR INTELLIGENT MACHINES

CIRRELT

CONSORTIUM SANTÉ NUMÉRIQUE

GERAD

IFTC INDIGENOUS FUTURES RESEARCH CENTRE

Institut Courtois

Institut intelligence et données

IRIC Université de Montréal

Mila

SEMLA ENGINEERING AI APPLICATIONS

tech3lab HEC MONTRÉAL

UNIQUE CENTRE

2 university hospitals

CHUM

CHU Sainte-Justine Le centre hospitalier universitaire mère-enfant Université de Montréal

IVADO community

As of December 21, 2022

Leadership

Luc Vinet, CEO
Mathematical physicist

Yoshua Bengio, Scientific Director
Alan Turing Prize awardee
most influential computer scientist
according to Stanford University

Pierre Dumouchel, Director of Transfer Technology
NLP expert and former executive
director of ETS engineering school

Management

Louise Bossé
Acting Deputy General Manager

Guillaume Chicoisne
Scientific Advisor

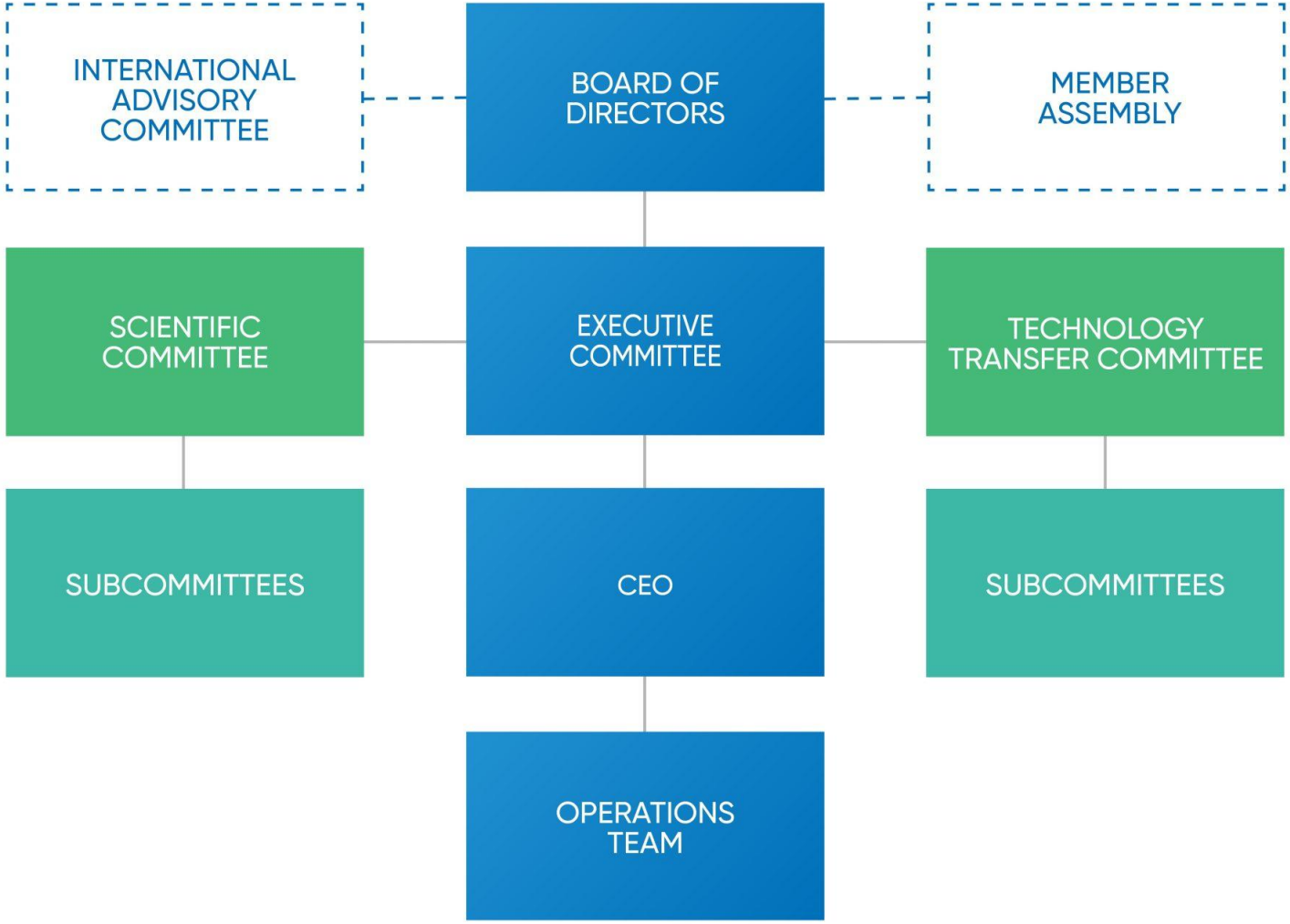
Nancy Laramée
Director of Partnerships

Mélanie Bosc
Director of Training

Catherine Cardinal
Director of Marketing & Communications

David Hartell
Strategic Advisor

Governance


INTERNATIONAL ADVISORY COMMITTEE
BOARD OF DIRECTORS
MEMBER ASSEMBLY
SCIENTIFIC COMMITTEE
EXECUTIVE COMMITTEE
TECHNOLOGY TRANSFER COMMITTEE
SUBCOMMITTEES
CEO
SUBCOMMITTEES
OPERATIONS TEAM

History

- Created in 2016
- Launched with the Canada First Research Excellence Fund (CFREF) program

93,6 M$	CFREF
110 M$	Partners
140 M$	Universities

Purpose: Create value from data (Data Serving Canadians) by integrating Machine Learning with Operations Research in decision making

Catalyst for booming development of AI cluster in Canada

- Pan Canadian AI Strategy and Mila
- Quebec AI Cluster
- Scale AI supercluster (ISED)
- Major players established bases in Montreal
- Numerous industries and start-ups
- Montreal declaration for a responsible development of AI
- Center of Expertise in Montreal on Artificial Intelligence - CEIMIA created to support OECD GPAI (Global Partnership on Artificial Intelligence)

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Research

PURPOSE

Advance knowledge to ensure AI delivers its enormous potential

Achievements

41 M $

in support for research via scholarships and grants since 2016

6 M $

dedicated specifically to 5 major scientific challenges

522

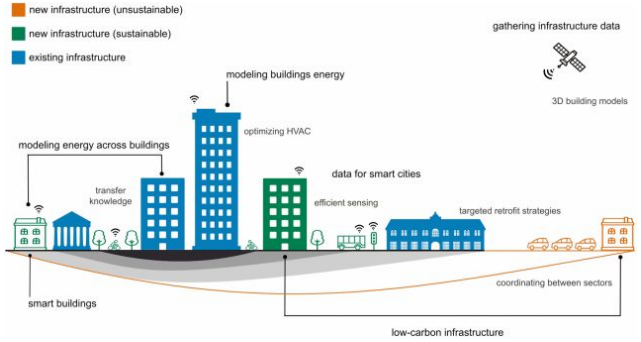
scholarships awarded since 2016

Examples of significant advances

Being able (finally!) to compare MRI scans of the spinal cord
J. Cohen-Adad, E. Alonso-Ortiz et al.

Machine Learning for combinatorial optimization: A methodological tour
Y. Bengio, A. Lodi, A. Prouvost

Collaborative data analysis to improve clinical care in patients with COVID-19
M. Chassé, D. Buckeridge et al.

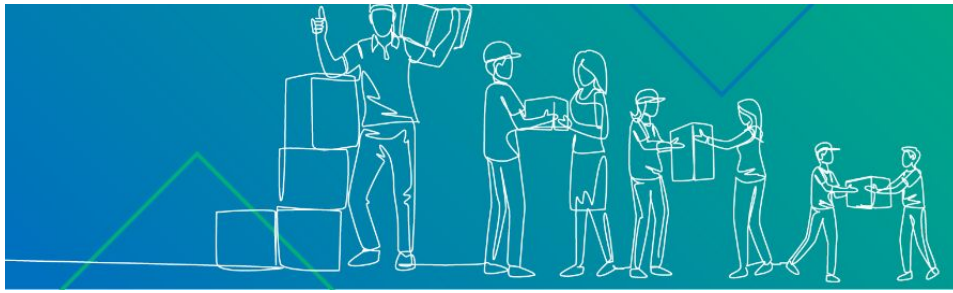


Tackling Climate Change with Machine Learning
D. Rolnick, P. L. Donti, L. H. Kaack, et al.

and many more on our website!

A few publications at a glance…

6M$ | 5 research projects | 17 PI



AI for decision making under uncertainty

AI for biodiversity and climate change

AI for human health

6M$ | 5 research projects | 17 PI

AI for the discovery of materials and molecules

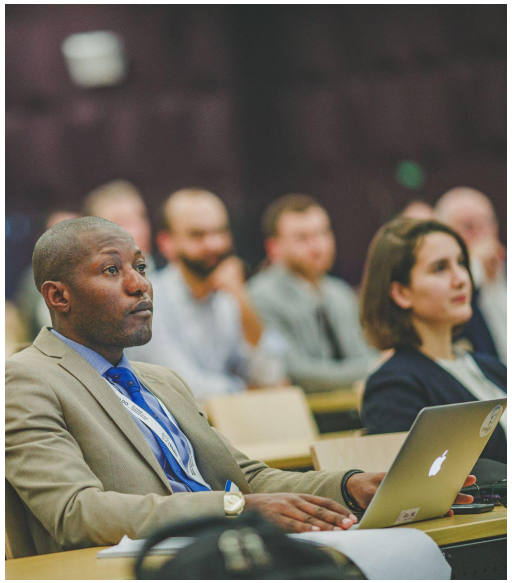
AI adoption

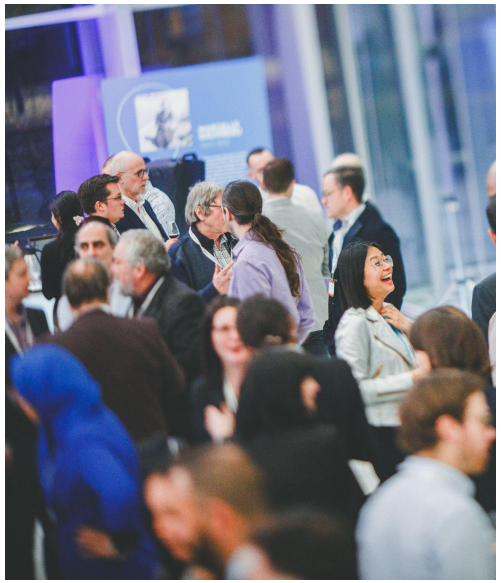
- Process with broad participation and leadership involvement
- Rigorous selection with intersectorial vetting
- Significant managerial support and monitoring

Networking and outreach

Hundreds of workshops and events for research support including :

- SEMLA
- International Symposium - Society, AI and Normativities - Responsible AI
- Montreal AI Symposium
- Synthetic Data for Health Symposium
- 100 days of Data Trek
- AI4Opt x IVADO workshop
- Journées québécoises de valorisation des données
- Data storytelling internship
- …





Training

PURPOSE

Facilitate the adoption of responsible AI in society by developing the talents of today and tomorrow

Training offer

- Training, upskilling and continuing education in AI skills for professionals
- Support the next generation and prepare future AI ambassadors
- Contribute to the knowledge mobilization

Achievements

- Professional training program **“From Data to Decision”**
  - **Over 3 300 participants since 2016**
  - **More than 16 000 attendees to 8 MOOCS** covering topics such as Bias and Discrimination, Essentials of Deep Learning, Recommender Systems,…

- Tools for skill assessment and recognition of key competencies in AI - **to come in March 2023**

Achievements

- **Awareness program for students "DATA TREK"** on how to use AI in their projects -**187 participants over the last 3 years**

- Deep Learning and discovery of molecules for students and professionals
  First school in June 2023

Transfer

PURPOSE

Create fruitful exchanges between academic and non-academic organizations to stimulate both research and innovation for the benefit of society

Achievements

> 130

organizations in Quebec, Canada and internationally are members of IVADO

> 200

researchers from 19 Canadian universities are involved in our collaborative research projects

> 540

collaborative research projects worth over $76M have been undertaken since 2017

Collaborative research at IVADO

01 Project definition

02 Finding the right researchers and students

03 De-risking through research funding

04 Remove barriers

Unique transfer approach

A few success stories

Smarter, greener, more efficient buildings

BrainBox AI

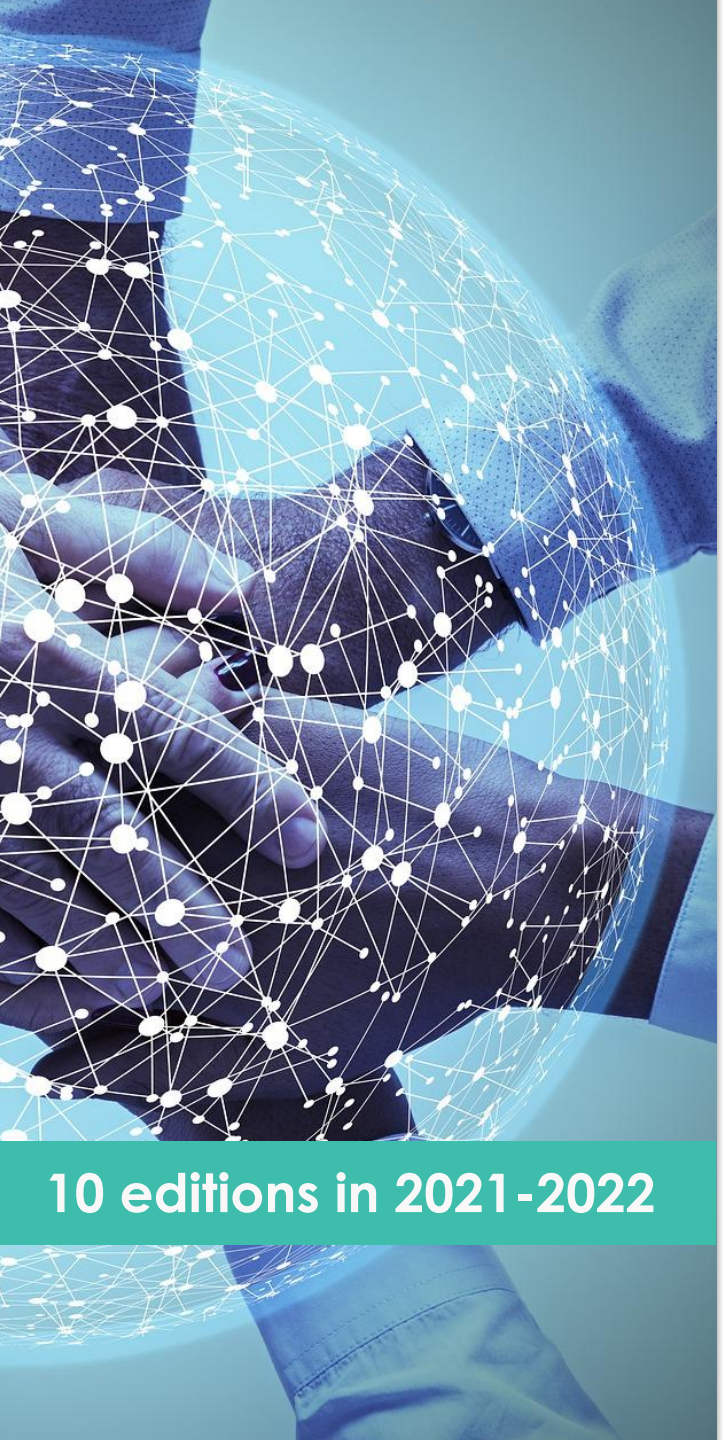
Route optimization for marine shipping

True North Marine

Multidisciplinary AI projects applied to human resources

Airudi

With these 3 companies : 21 applied research projects involving 18 different faculty members from 6 universities · $1.3M invested · $3M in value



Community of Practice in Industrialization of AI

Mission : Share best practices and generate new knowledge to advance professional activity related to the industrialization of AI

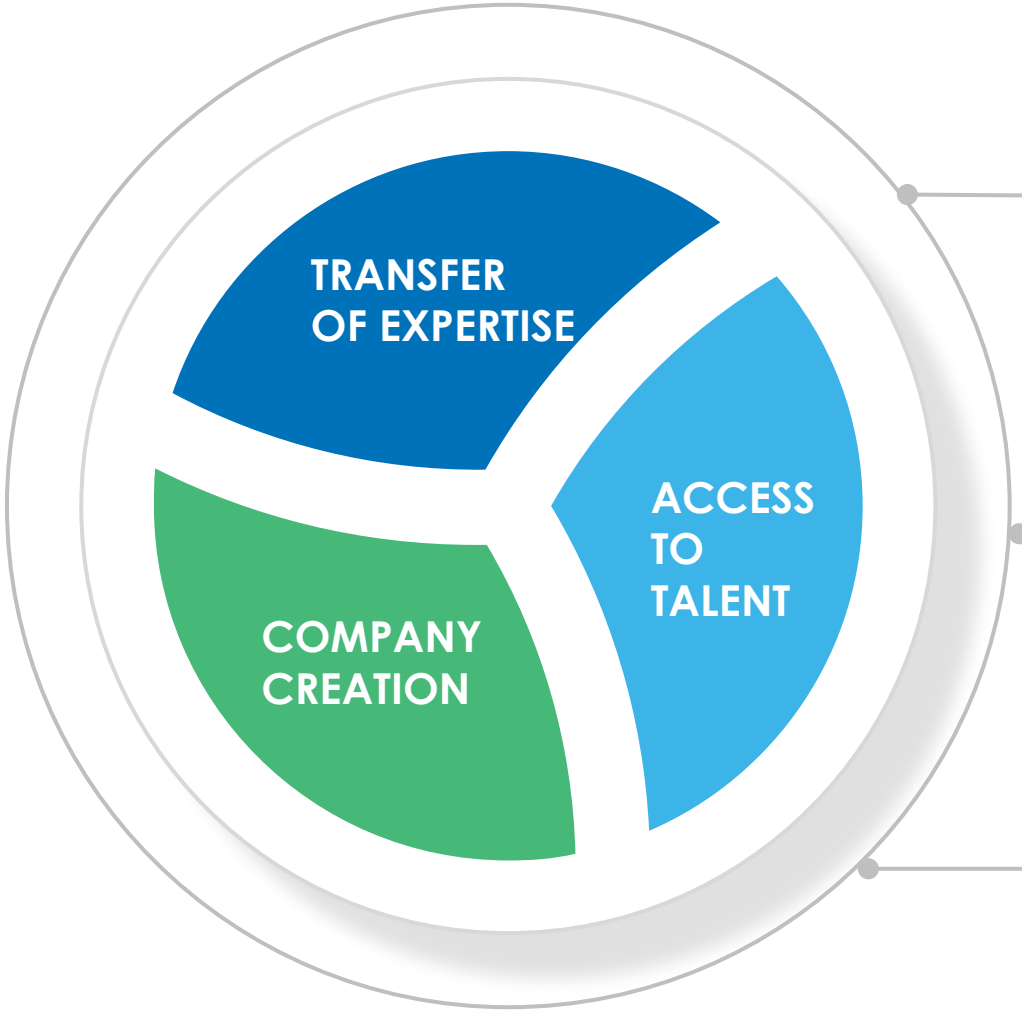
AIR CANADA
AlayaCare
alloprof
axionable the sustainable company
BANQUE NATIONALE
beneva
BRAINBOX AI
CANN FORECAST
coveo™
CROESUS
Desjardins
ExPretio
FERME D'HIVER
GIRO
horoma ai
Hydro Québec
IBM MD
[intact]
LexRock AI
MOOV AI
NEWTRAX
RADIO-CANADA
REVENU QUÉBEC
SYNAPSE C
TD
videns
THALES

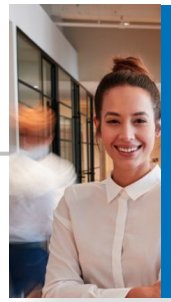
Entrepreneurship

PURPOSE

Support the creation and the flourishing of startups with strong economic growth and innovation potential using AI

Entrepreneurship - 3 main objectives



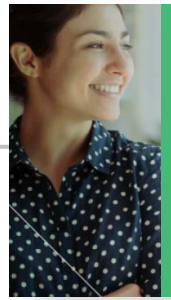


SCIENTIST IN RESIDENCE

PhD students

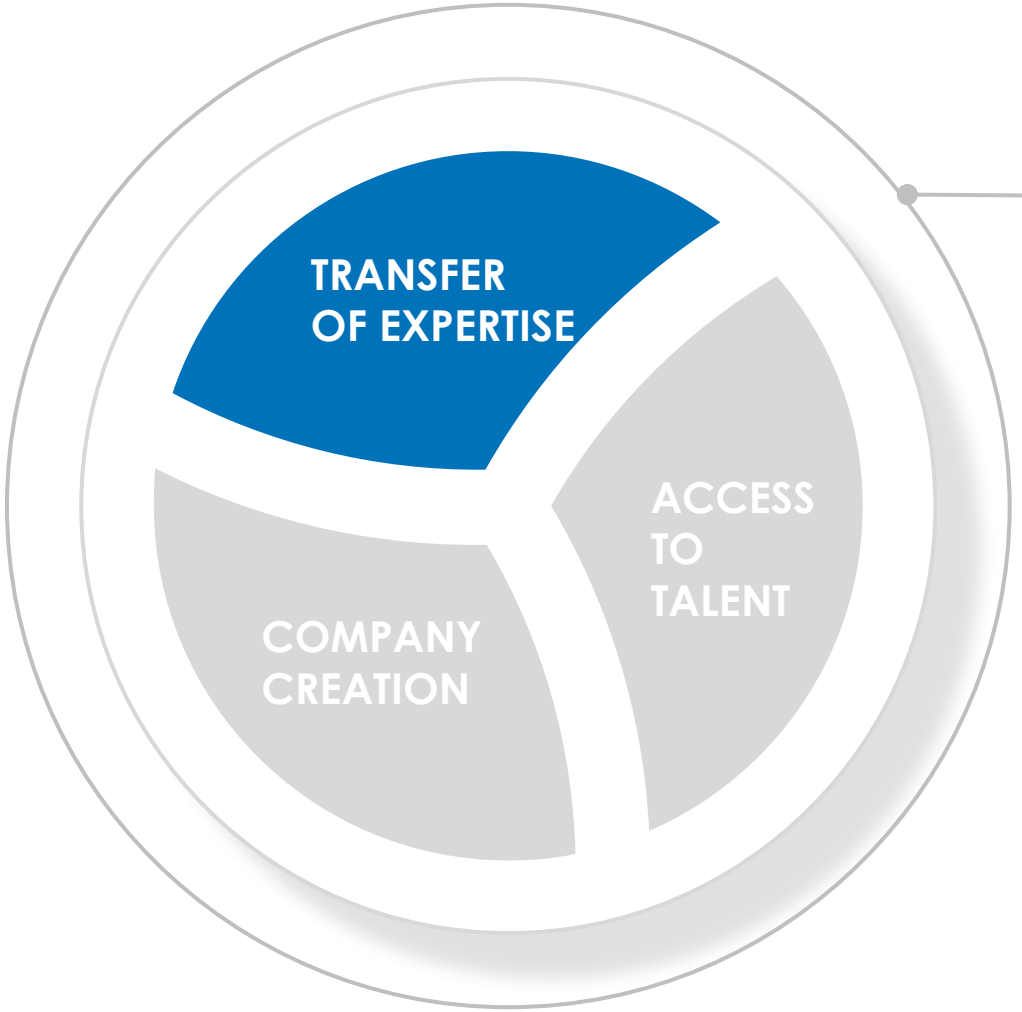
SCIENTIST IN ACTION

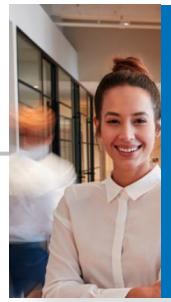
Master's students



ENTREPRENEUR POSTDOC

Entrepreneurship



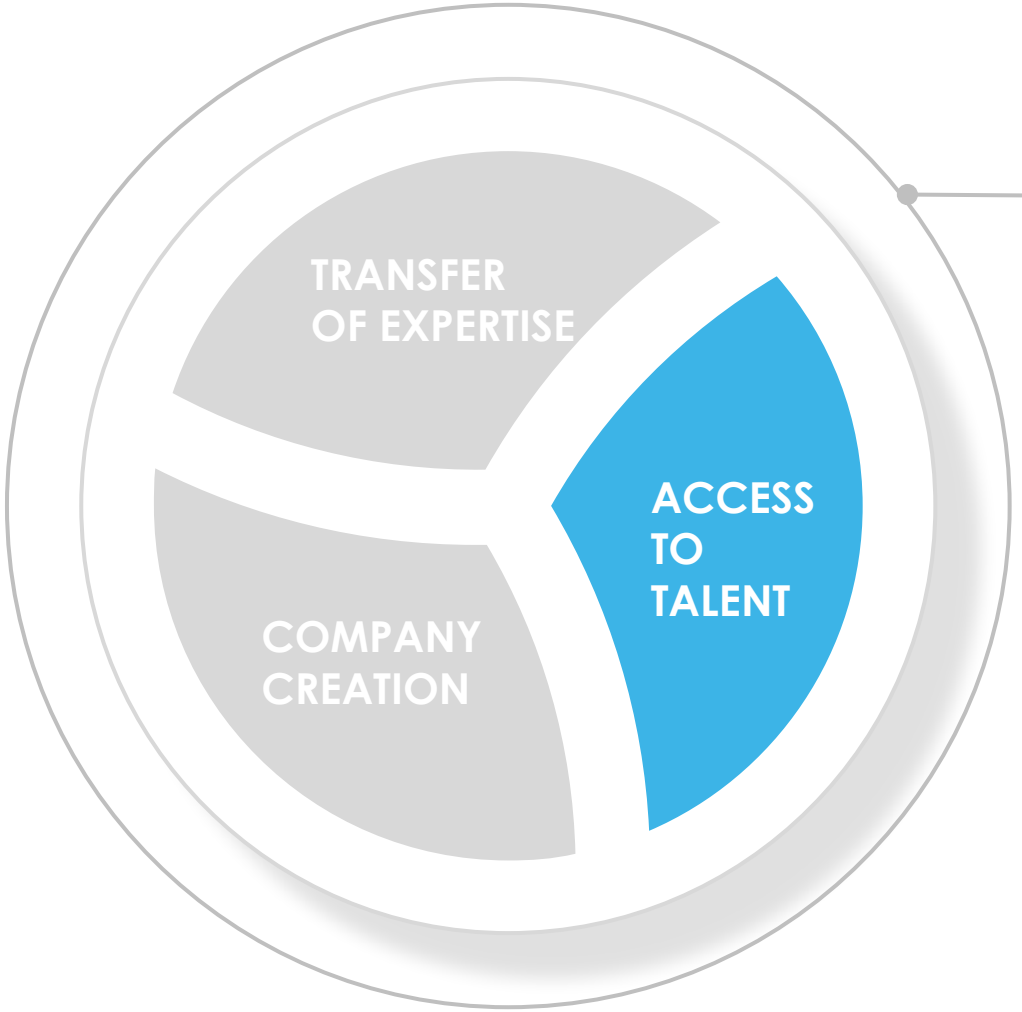


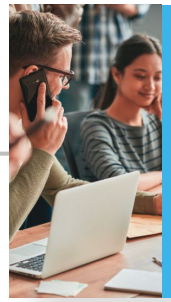
SCIENTIST IN RESIDENCE

Support and validation of startup R&D projects

- **13 startups:** ChrysaLabs, Acrylic Robotics, Geosapiens, Maket, **NeuralDrive**, LS Tech +, Vope Medical, Greenplay, AI Mental Health, Simmunome, Innovention, SCIKOOP, HOP tech.
- 6/13 students are women

Entrepreneurship



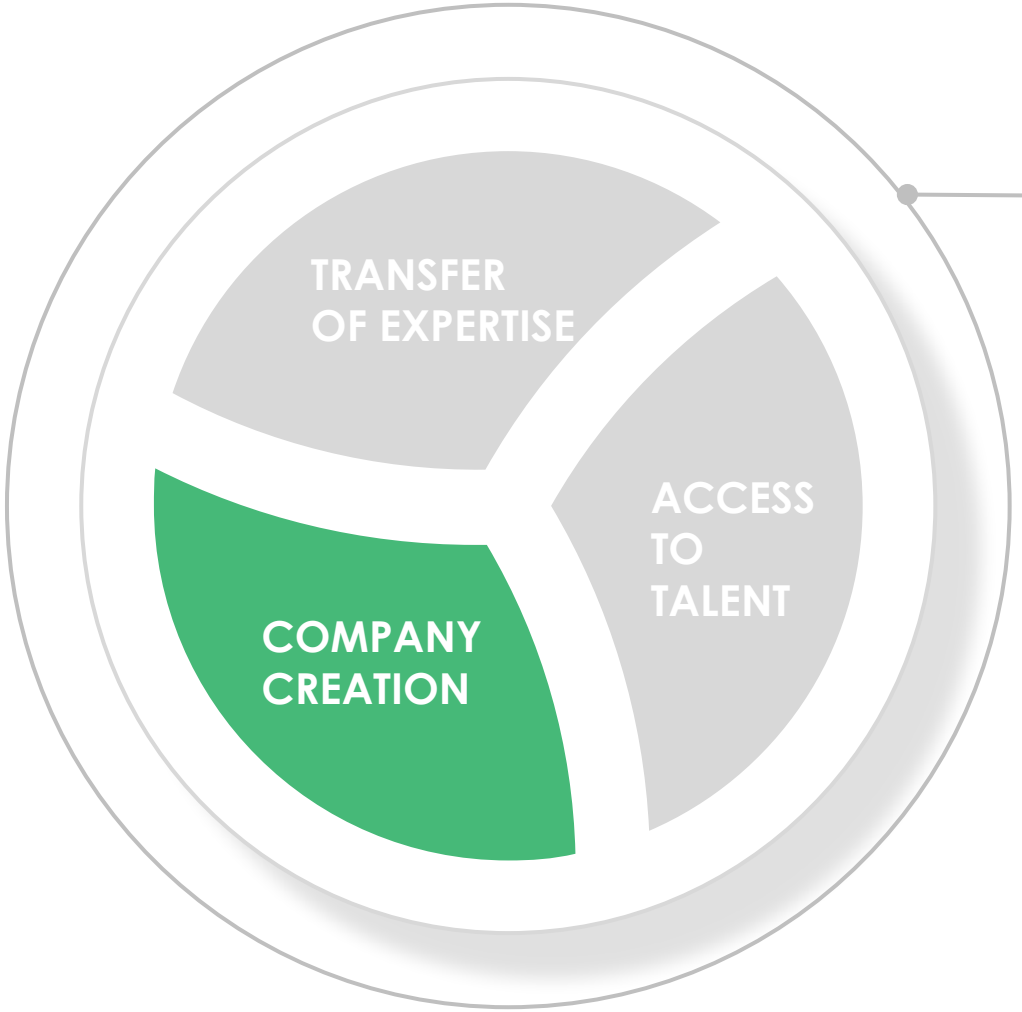


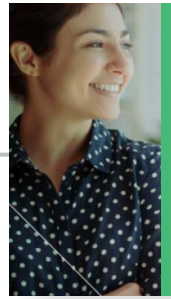
SCIENTIST IN ACTION

Practical internship in digital intelligence in a startup

- **10 startups in varied fields** (Health, responsible finance, food waste, sports, mining industry, marketing, home maintenance…)
- Credited applied research internships from Polytechnique, HEC and UdeM.

Entrepreneurship





ENTREPRENEUR POSTDOC

Creation of companies resulting from doctoral research

- **2022 Winners:** Lucid Axon, Clean Nature, Scient Analytics
- 2/3 candidates are women
- $ 20k in scholarships from the Arbour Foundation

Talent

PURPOSE

Gather, nurture and develop the expertise that will realize the potential of AI

Achievements

- Hiring of 37 IVADO professors
- NSERC Irina Rish Autonomous AI Chair
- Postdoc Fellows program
- Yearly scientific day for students
- IVADO Internship and Job Fair
- Industrial Problem Solving Workshop
- Tech transfer projects involving internships with industry
- Science popularization training and competitions for students
- IVADO student committee

EDI and Engagement of Indigenous Communities

PURPOSE

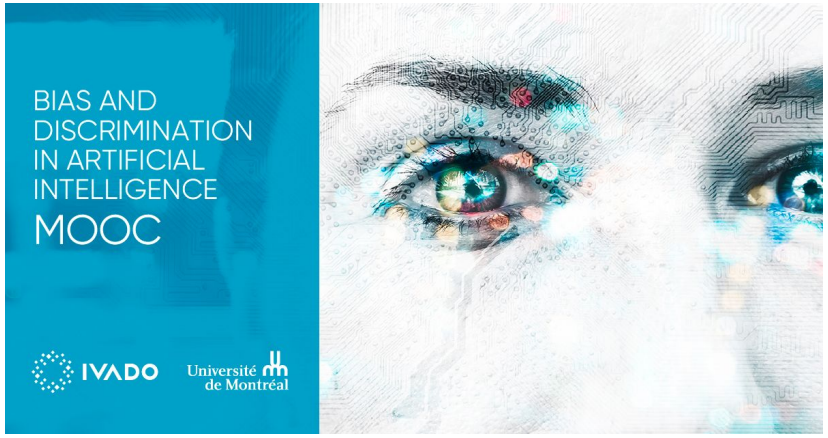
Improve EDI across IVADO's mandate and increase the engagement of Indigenous Communities in all facets

Equity, Diversity, Inclusion

Axis 1 : Fix the numbers
Talent attraction, representation and diversification

Axis 2 : Fix the institutions
Institutional practices, culture and processes

Axis 3 : Fix the knowledge
Knowledge production and innovation



Ensure access to AI for all

- AIMS and IVADO are **advancing STEM in Africa** with 16 new scholarships for a total of $200,000 CA
- Our Action Inclusion Pathway brings together 5 teams of students with industry partners who have identified **inclusion challenges within their organizations**
- Organized discussion panels "**Women and Diversity in AI**" and "**Valuing Black Communities in AI**
- > 2,500 registrations for the **MOOC on Bias and Discrimination in AI**
- Awareness activities around AI opportunities and training aimed at **under represented groups in the workforce**

1. INTRODUCING IVADO
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3. **R^3AI: IVADO'S VISION**

Why R^3AI ?

- Despite all of our collective successes, there are persistent and foundational limitations that prevent broad use of AI for the benefit of societies worldwide

Real-world limitations include:

- lack of robustness in out-of-distribution settings
- paucity of reasoning capacity
- biases and absence of moral values

R^3AI: Shifting paradigms in AI and its adoption

ROBUST

robust models and applications out-of-distribution

REASONING

coherent & explainable

RESPONSIBLE

ethical, inclusive, and in line with values

R^3AI: Shifting paradigms in AI and its adoption

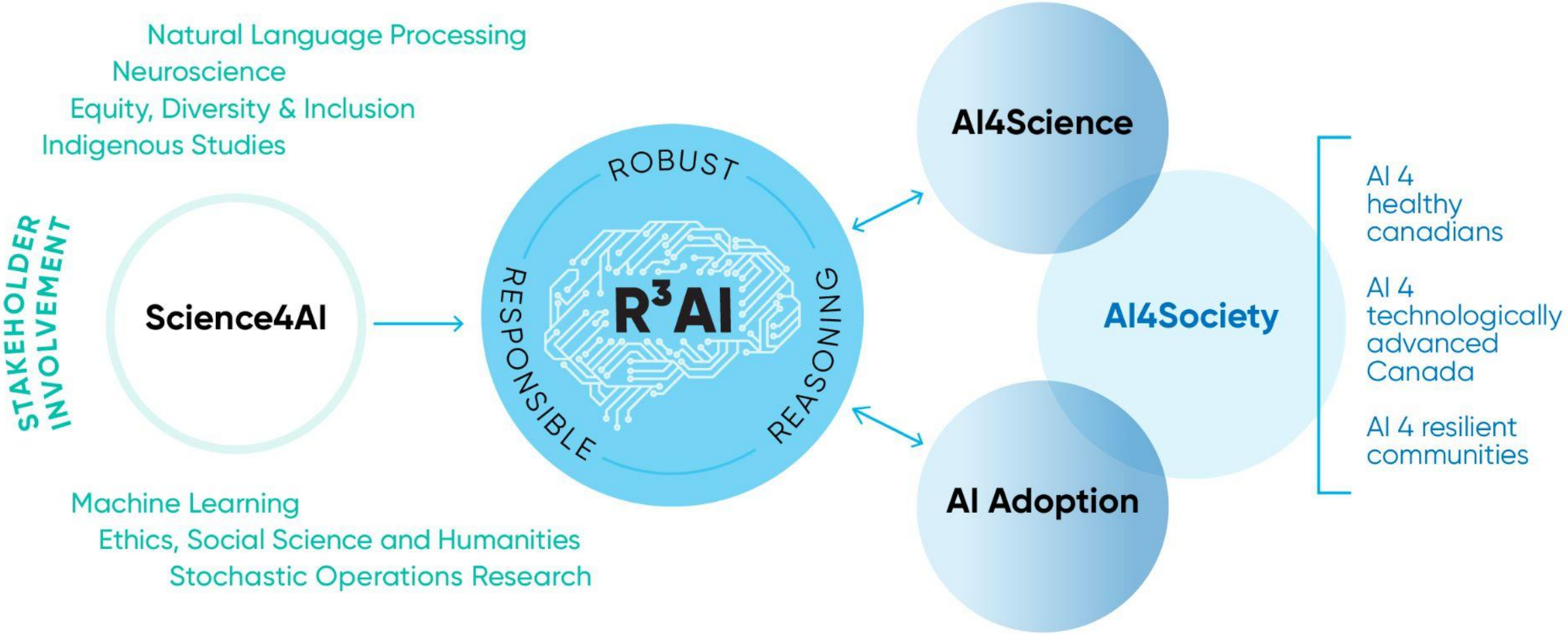
To achieve these bold transformations and further affirm Canada's leadership, IVADO will use its intersectoral academic-partnered approach to:

- **Build R^3AI** = **Science 4 AI**
  Bring AI closer to Human Intelligence via e.g. AI-Neuroscience-Social Science and Humanities collaborations
- **Use R^3AI** = **AI 4 Science**
  Accelerate discoveries (see examples)
- **Adopt R^3AI**
  - advance the **science of adoption**
  - mobilize knowledge with partners, upskill and train

with support from 5 universities and 150+ highly committed organizational partners

4 : 1 leverage of CFREF requested funding **125 M$**

Vision


Natural Language Processing
Neuroscience
Equity, Diversity & Inclusion
Indigenous Studies
STAKEHOLDER INVOLVEMENT
Science4AI
ROBUST
RESPONSIBLE
REASONING
R³AI
AI4Science
AI4Society
AI Adoption
AI 4 healthy canadians
AI 4 technologically advanced Canada
AI 4 resilient communities
Machine Learning
Ethics, Social Science and Humanities
Stochastic Operations Research

R^3AI research and knowledge mobilization objectives

- **AI 4 Science**
  - discovering new molecules
  - increasing resilience to environmental crises
  - ensuring the emergence of learning health systems
  - addressing supply chain issues

- **AI 4 Society**
  - Understand the barriers to AI adoption with our partners
  - Train and educate the workforce to encourage adoption
  - Increasing the responsible adoption of AI
  - Supporting AI entrepreneurship

9 consortiums comprised of our academic members

C1 **AI - neurosciences**	C2 **Machine Learning**	C3 **NLP**
C4 **Implementation Science**	C5 **EDI and Indigenous Peoples**	C6 **Molecule Discovery**
C7 **Environment**	C8 **Health Systems**	C9 **Supply Chains**

R^3AI is the revolution Canada needs

With

- Bengio the most influential computer scientist* worldwide inspiring an outstanding community
- IVADO the multisectoral organization needed to realize it
- Commitment of 5 universities and 150+ partners
- Co-construction with Indigenous Peoples and equity-seeking groups

R^3AI will critically enhance Canada's leadership in AI and deliver for the benefit of all Canadians

* 2023 Stanford University's Top 2% Scientists List

Building strong collaborations worldwide for AI-driven innovation

IVADO

CANADA FIRST
RESEARCH EXCELLENCE FUND

APOGÉE CANADA
FONDS D'EXCELLENCE EN RECHERCHE

Québec

Canada

CODA-19: Collaborative data analysis to improve clinical care in patients with COVID-19

- Helping clinicians on the frontline and ensuring efficient allocation of resources within healthcare institutions.
- Established partnership with 9 Canadian COVID treatment centres, they built a large repository of anonymized, multi-modality data sampled from patients with confirmed or suspected COVID-19.

CHUM

Hôpital général juif
Jewish General Hospital

McGill University Health Centre

Centre intégré universitaire de santé et de services sociaux de l'Estrie – Centre hospitalier universitaire de Sherbrooke
Québec

HSCM
HÔPITAL DU SACRÉ-CŒUR DE MONTRÉAL

CHU de Québec
Université Laval

CHU Sainte-Justine
Le centre hospitalier universitaire mère-enfant
Université de Montréal

Centre intégré de santé et de services sociaux de Chaudière-Appalaches
Québec

The Ottawa Hospital
L'Hôpital d'Ottawa

IVADO

CODA-19: Collaborative data analysis to improve clinical care in patients with COVID-19

- Using this data, a team of leading experts in clinical research and health data science developed models to put big data at the service of clinicians and administrators managing COVID-19 through point-of-care decision tools.
- These tools can help physicians diagnose COVID-19 rapidly, determine if different disease presentations warrant different types of treatment, flag patients at high risk of deteriorating, and ensure healthcare resources are attributed efficiently and equitably.

CODA-19: Areas of research

Rapid diagnosis

Help physicians diagnose COVID-19 rapidly by building point-of-care tools that leverage machine learning models at the bedside.

Clinical phenotypes

Analyze disease phenotypes to assess whether different disease presentations warrant different treatment approaches.

Early warning system

Find warning signs that can alert clinicians to imminent patient deterioration, enabling pre-emptive treatment and monitoring.

Health resource usage

Forecast the need for beds, ventilators, and optimize the provision of healthcare services for patients with and without COVID-19.

CODA-19 objectives

- Build a large database of biological signal data from patients with COVID-19.
- Develop a collaborative data analysis infrastructure to pool data from multiple sites while minimizing the exchange of patient-level information, distributed and federated learning techniques.
- Develop a risk prediction model to identify patients at high risk of COVID prior to the availability of definitive testing.

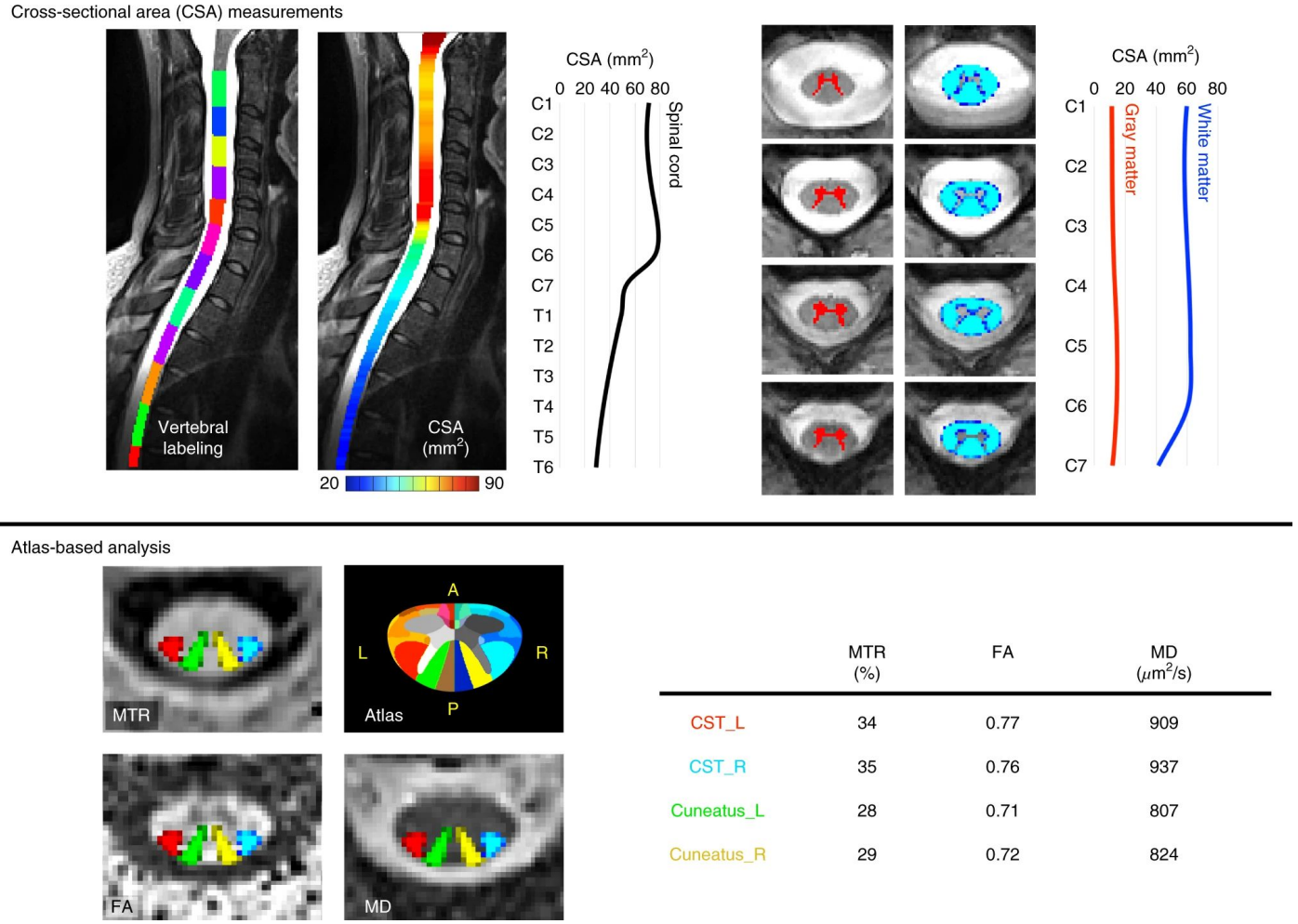
CODA-19 objectives

- Characterize the trajectories of patients presenting different manifestations of the disease.
- Identify patients at high risk of clinical deterioration.
- Make forecasts to plan hospital resources and staffing. The accuracy of predictions will be continuously verified using new cases, which will be identified in real time at participating hospital sites.
- These predictive models were used to build tools that can help physicians better treat patients with COVID-19, and provide actionable recommendations to support Canada's response to COVID-19.

Being able (finally!) to compare MRI scans of the spinal cord

Being able (finally!) to compare MRI scans of the spinal cord

- Until recently, images of the spinal cord obtained by magnetic resonance were not standardized which prevented them from being compared to the evolution of lesions.
- A protocol for standardizing quantitative MRI of the spinal cord that includes ways to position the patient to perform MRI, but most importantly, adjusting several parameters to improve results.



	MTR (%)	FA	MD ($\mu m^2/s$)
CST_L	34	0.77	909
CST_R	35	0.76	937
Cuneatus_L	28	0.71	807
Cuneatus_R	29	0.72	824

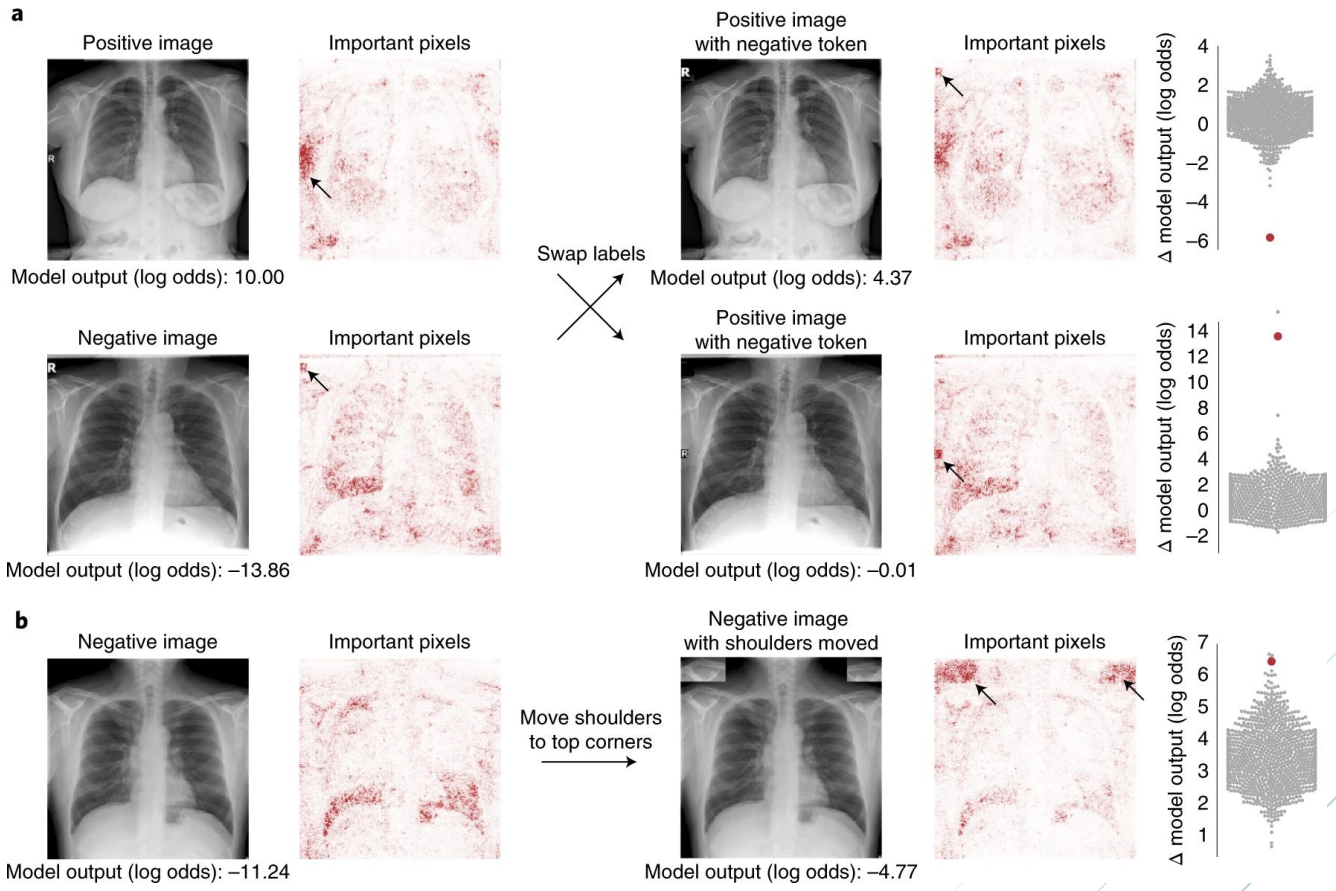
Illustration of the MRI metrics that could be extracted from the spine generic protocol. Source: https://www.nature.com/articles/s41596-021-00588-0

Results

- This discovery is now being used by another CanProCo program, which is investigating the progression of multiple sclerosis.
- They created the first public database of quantitative MRI of the spinal cord based on information gathered from the 260 participants, so that other researchers could use it.
- They continue to use this data to develop an algorithm that will make it possible to automatically analyze MRIs and identify, for example, tumors or multiple sclerosis lesions.

But sometimes… AI for radiographic COVID-19 detection selects shortcuts over signal

Although the model seemed good, it learned things that were irrelevant and that may thus explain the challenges in generalization (different machines, the model learning what the human does rather than the causal pathway, etc).



https://www.nature.com/articles/s42256-021-00338-7