An application of Model-Based Reinforcement Learning to reducing energy consumption in TELUS data centres:

TELUS/Vector collaboration on the development of the Energy Optimization System

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Outline

- Introduction
- Industry Implementation
- AI Implementation
- Result and Innovations
- Next Steps

Introduction

TELUS, Vector Institute & Sustainability

Introduction

- Costs to operate data centres, including Heating, Ventilation and Air Conditioning (HVAC), can be large
  - Data centres accounted for 1.8% of power consumption in the US in 2014*
  - Challenging to optimize the control of cooling while considering various other factors such as weather
- Opportunity to apply model-based reinforcement learning (MBRL) to reduce costs
  - Simulations show potential energy savings between 2.5 - 15%
  - Developed *"Hyperspace Neighbor Penetration"* algorithm innovation to deal with slowly moving variables, e.g., temperature
- Journey to deliver AI solution with real world applications

*Source: https://papers.nips.cc/paper/2018/file/059fdcd96baeb75112f09fa1dcc740cc-Paper.pdf

TELUS

$15B

Annual Revenue

1M+

Volunteer hours annually

#1

Mobile Network in Canada

TELUS is a dynamic, world-leading communications and information technology company. We are committed to using our technology for good and to help make our world a

15.4M

Customer connections

50%

Energy reduction target by 2030

Industry domains

10

Wireless, data, IP, voice, television, entertainment, video, security, health, agriculture

Source: https://www.telus.com/en/social-impact

Source: Opensignal's *Mobile Network Experience Report February 2021*

TELUS & Sustainability

- The application of MBRL to energy reduction aligns with TELUS’ sustainability goals related including the reduction of energy intensity by 50% between 2020 and 2030*

*Source: https://www.telus.com/en/social-impact/caring-for-the-environment

VECTOR INSTITUTE

900+

Industry Program Participants

Drive excellence and leadership in Canada’s knowledge, creation, and use of artificial intelligence (AI) to foster economic growth and improve the lives of Canadians

500+

Researchers

1000

AI Master’s Students enrolled in Ontario

45+

Industry Sponsors

*Source: https://vectorinstitute.ai/wp-content/uploads/2020/11/vector_annual-reportv8.pdf

TELUS x VECTOR INSTITUTE

- AI-for-good initiative operated by Vector's Industry Innovation team
- Industry Collaborative Project
- Explore application of Model-Based Reinforcement Learning (MBRL) methodologies
- Real-world systems for energy efficiency that can translate into sustainability
- Collaboration with TELUS involving various TELUS teams

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A TELUS AI AGENT APPROACHED SUSTAINABILITY LIKE A CHESS GAME

And may have just innovated its way to major new energy savings

February 17, 2021

By Jonathan Woods

Everything in this small, nondescript datacentre comes in singles. There's one server, one cooling unit, and one cardinal rule: stay within thermal guidelines. It's into this setting that TELUS released an AI agent tasked with cooling the room as efficiently as possible, and gave it virtual carte blanche to figure out how.

This was the first real-world test in TELUS' *Energy Optimization System Project (EOS)*, a pilot in which a reinforcement learning agent took control of a real physical system in order to teach itself how to best operate it. Excitement ran high. Two months prior, that same agent had showed it could increase energy efficiency by 2%-15% in a simulator, thanks in large part to a series of its own ingenious innovations.

EOS was born in the Vector Institute's Model-Based Reinforcement Learning (MBRL) Project — the AI-for-good initiative operated by Vector's Industry Innovation team — and was developed by TELUS to align with its sustainability goal of reducing its energy intensity by 50% between 2020 and 2030.

https://vectorinstitute.ai/2021/02/17/a-telus-ai-agent-approached-sustainability-like-a-chess-game-and-may-have-just-innovated-its-way-to-major-new-energy-savings/

Industry Implementation

Processes, challenges & more

Industry Implementation Process

- Key internal partner is Mission Critical Environments (MCE)
  - The MCE team provides long-term strategy, end-to-end leadership and operational support for power and cooling of our critical environments including data centres, central offices and other key facilities throughout Canada

- Other key technical and operational stakeholders
  - Building management
  - Network operations
  - HVAC vendor

- Developed and piloted with TELUS’ commitment to Responsible AI
  - Trust and transparency
  - Creating opportunities to proactively impact social good

- Take away
  - Implementing AI to control disparate physical systems involves many stakehold

AI Implementation

Vincent Zha, PhD

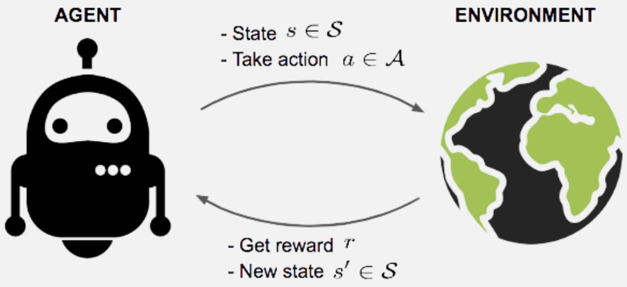
Task for AI - like a chess game

- Goal:
  - Regulate the indoor temperature to be at or below the set-point
  - Minimize energy consumption
  - Satisfy other requirements, e.g. allowing the compressor to rest enough between cycles
- Means
  - Make a choice on a minutely basis
    - Option 1: Run Compressor, expensive but effective in cooling
    - Option 2: Run Free Cooling, very cheap but very less effective in cooling, subject to conditions
    - Option 3: Idle, minimizes cost but no cooling effect
- Like a chess game
  - Sacrifice at the immediate step to gain more in a long term

Picture credit: https://www.hindustantimes.com/science/checkmate-humans-when-machines-start-beating-at-their-own-games/story-xhM6Q58eQpNLCX6eCmRhkK.html

Reinforcement Learning

- Similar to the learning of human being
- Is the future of machine learning
  - Goal-oriented
  - Innovative
  - Achieve long-term results
  - Not require a large dataset



Picture credit: https://lilianweng.github.io/lil-log/2018/02/19/a-long-peek-into-reinforcement-learning.html

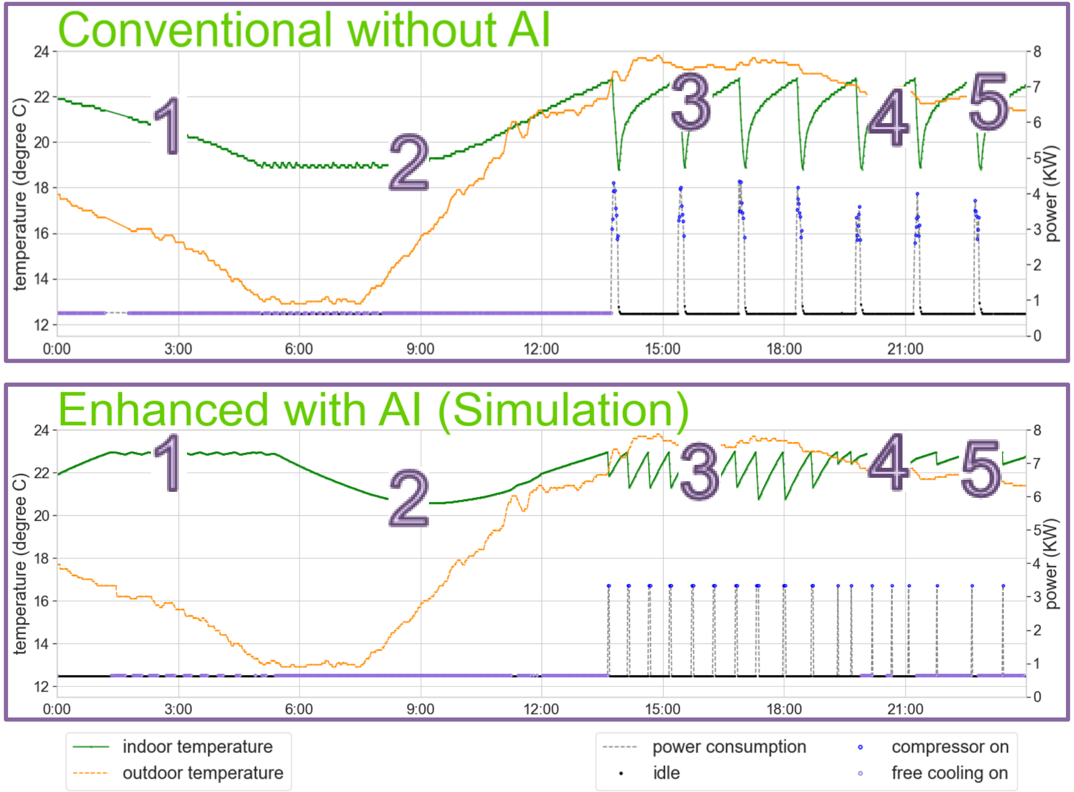
AI Project Implementation

- Built a virtual simulation environment
  - Safe testing
  - Speed up learning, acquired hours of real-world experience in seconds
- Built a robot agent learning in the simulation
  - Model-Based Reinforcement Learning
  - Algorithm innovation: Hyperspace Neighbor Penetration

Picture credit: http://genderedinnovations.stanford.edu/case-studies/extendedVR.html

Result and Innovations

Innovations by AI - leveraging weather forecast, etc.



	Conventional	AI
1	Maintain temperature at a low level	Let temperature rise up to the set-point
2	Only react to the immediate situation	Run free cooling to delay using the costly compressor
3	Reduce temperature by a fixed amount	Reduce temperature by a flexible amount
4	Less use free cooling	Actively use free cooling between compressor cycles
5	Reduce temperature by a big amount	Reduce temperature by a small amount

Save energy by 2-15%, may be even more

Algo innovation: Hyperspace Neighbor Penetration

- Problem with Dynamic Programing
  - Good side: suitable for our case; no randomness in searching; few hyperparameters; fast
  - Problem: slowly changing variable in continuous state space - temperature
  - Require an extremely granular grid system, hugely expensive in computation

- Our algorithm innovation: HNP
  - Idea: capture the state's partial “penetration” into its neighboring hyper-tiles in each transition step
  - Allow for a very coarse grid system, make the computation feasible

- Is orders of magnitude more efficient than traditional way
  - Our solution is based on HNP
  - Science paper in submission

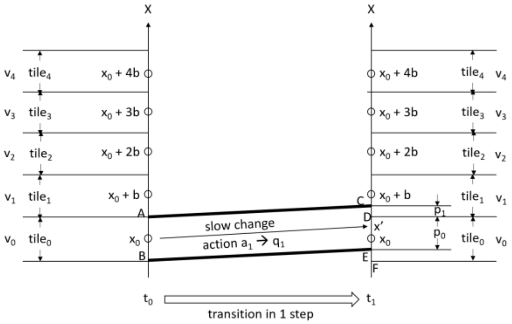


Fig. 3: Hyperspace Neighbor Penetration (HNP) approach. It can handle slowly changing variables by considering the tile's whole range of the state values.

Picture: from our paper in submission: *Hyperspace Neighbor Penetration Approach to Dynamic Programming for Model-Based Reinforcement Learning Problems with Slowly Changing Variables in A Continuous State Space*

Next Steps

Next Steps

- Currently collecting more data to further investigate savings in actual application
- Exploring ways to scale up the Energy Optimization System in TELUS
  - Implement in more small rooms
  - Scale to larger, more complex rooms
  - Open sourcing to the wider AI and HVAC community

TELUS

Thank you!

TELUS

the future is friendly®