NREL Science Drives Innovation

Renewable Power
- Solar
- Wind
- Water
- Geothermal

Sustainable Transportation
- Bioenergy
- Vehicle Technologies
- Hydrogen

Energy Efficiency
- Buildings
- Advanced Manufacturing
- Government Energy Management

Energy Systems Integration
- Grid Integration
- Hybrid Systems
The National Solar Radiation Database (NSRDB)
The Wind Integration National Dataset (WIND Toolkit)

2008-09-03 07:00:00

NREL
Artificial Intelligence (AI) Today

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Where are we?
Google DeepMind’s AlphaGo

Game of Go:
361 possible moves
$3^{361}$ unique board states

https://deepmind.com/research/case-studies/alphago-the-story-so-far
https://www.youtube.com/watch?v=WXuK6gekU1Y
“Autobidder provides independent power producers ... the ability to autonomously monetize battery assets”

https://electrek.co/2020/06/15/tesla-officially-approved-electric-utility-uk-why/
https://electrek.co/2020/05/03/tesla-autobidder-new-product-electric-utility/
Limitations of Mechanistic Cloud Models:
Using Theory to Guide Learning: Physics-Guided Neural Networks (phygnn)

\[ Loss = \lambda_0 \text{Loss}(\hat{Y}, Y) + \lambda_p \text{Loss}_p(\hat{Y}) \]

Open source: [https://github.com/NREL/phygnn](https://github.com/NREL/phygnn)

Example neural network loss surface
phygnn: reduces error, improves data product
What about in the field?
Geothermal Operational Optimization with Machine Learning

Partnership between:

- NREL
- Upflow
- U.S. Department of Energy
- Tuwharetoa mai Kawerau ki te Tai
- ORMAT
Step 1: Build a Digital Twin
Step 2: Hindcast Validation

Steam Delivery

Power Generation
Step 3: Reinforcement Learning

Agent(s) -> Action -> Environment -> Reward + Observation
Reinforcement Learning Experiment #1:

Agent controls:
- Line Pressures
- Wells
Lessons Learned

• Centering the reward at zero is an example of bad reward shaping (at least for this environment)

• The agent *learned how to terminate the episode quickly* to get the least amount of negative reward
Lessons Learned

• Centering the reward at zero is an example of bad reward shaping (at least for this environment)

• The agent *learned how to terminate the episode quickly* to get the least amount of negative reward

• In other words, the negative reward shaping *affected the agent’s will to live!*
Reinforcement Learning Experiment #2

Agent controls:
- Line Pressures
- Wells

Improved:
- Rewards
- Termination conditions
Agent Exploration in Action!
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Graph 1: Normalized Power vs Time

Graph 2: Reward vs Training Steps
Agent Exploration in Action!
Agent Exploration in Action!
Thank you

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GOOML Team:
Andy Blair, Jay Huggins, Ross Ring-Jarvi, Michael Rossol, Paul Siratovich, Nicole Taverna, Jon Weers

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