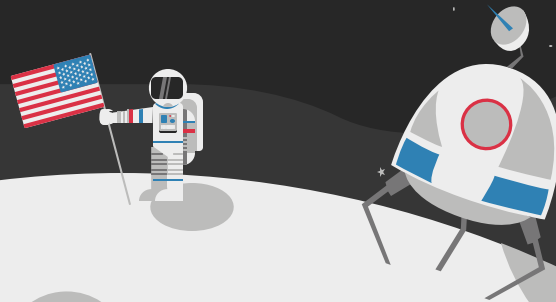


# Moon Rover Automation

Billy McGloin

Georgetown M.S. Data Science & Analytics, 2025



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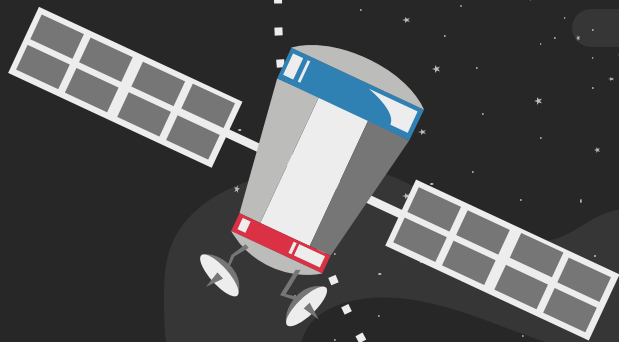
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01

# Reinforcement Learning Overview

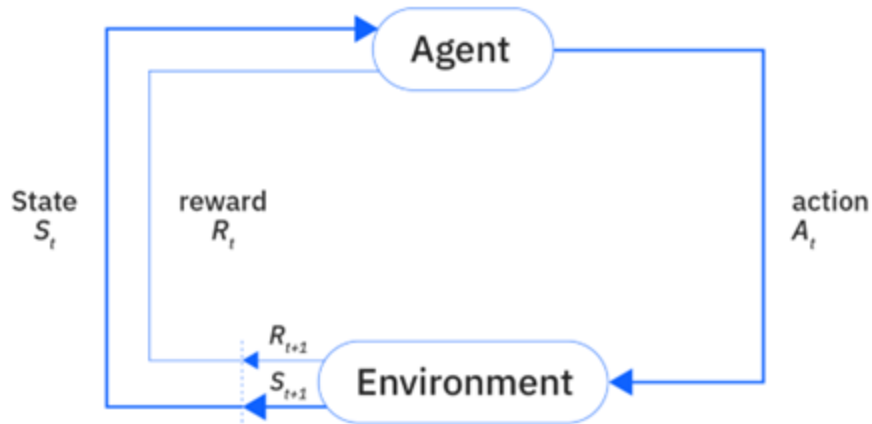
Core Concepts



# Temporal Decision Making in Complex Stochastic Environments



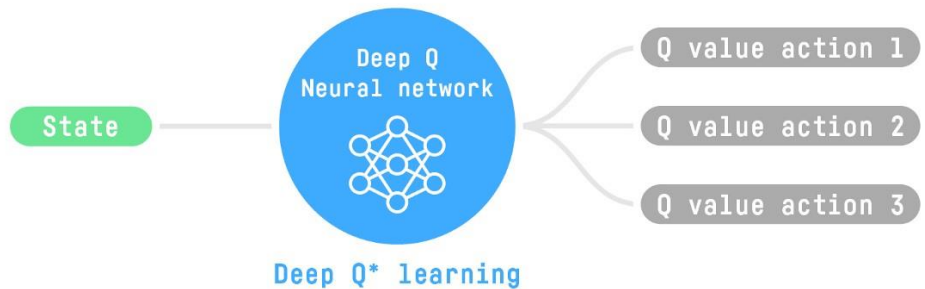
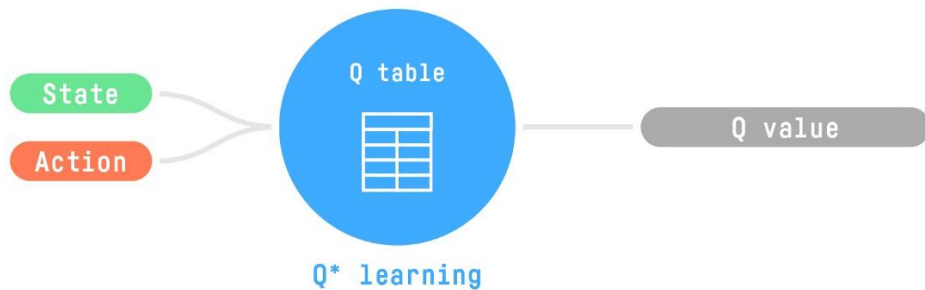
# The RL Framework



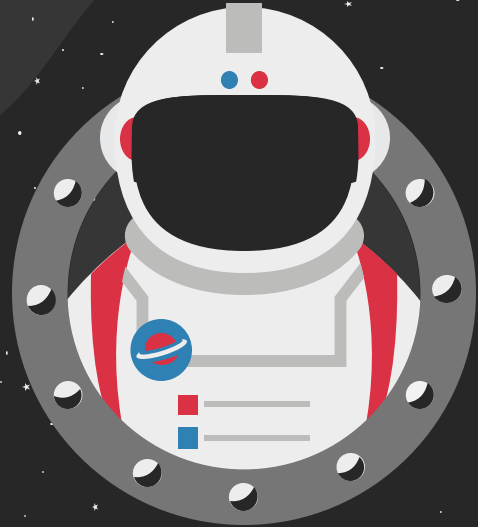
<https://www.ibm.com/think/topics/reinforcement-learning>



# Deep RL



<https://huggingface.co/blog/deep-rl-intro>



02

# The Environment

Simulating the Moon's Terrain

# From Grid-World to the Moon: Navigating the Unknown



## Simulated Moon Terrain



Altitude



Dust



Sunlight

## Avoiding Hazards



Crashes



Getting Stuck



Battery Depletion

## Rover Learns to Explore and Adapt



Resource updates

# 6 Possible Actions



Up



Down



Left









Right



Stay



Gather

3.7		2.3
		
2.8		

# Reward Structure



## Steps

We penalize per step to reward shorter trips



## Resource

Rewards when the rover gathers a resource

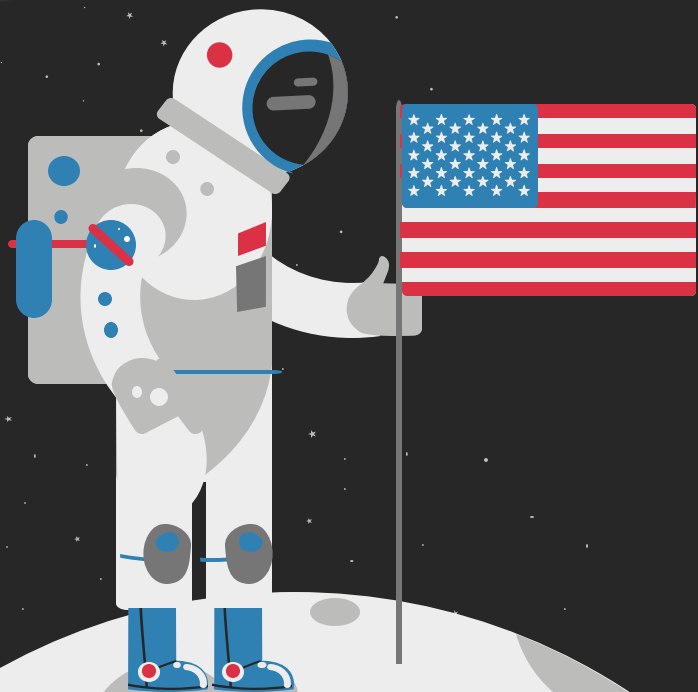


## Energy

We penalize when the battery power is  $< 20\%$  of full capacity



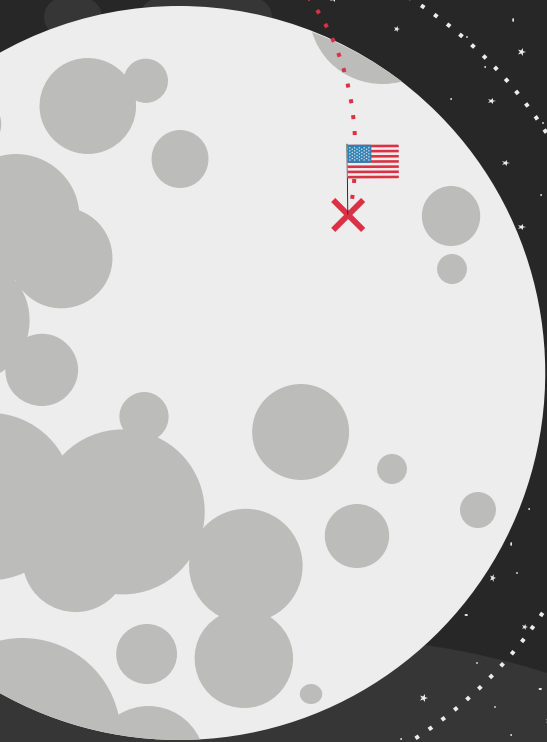
Sunlight, Dust, and Height  
all affect Battery Usage



03

# Training The Rover

Applying RL to Navigate Lunar Terrain



# Soft Actor-Critic (SAC)



Model-Free, Off-Policy




Entropy-based optimization



Reduces Estimation for Stable Learning

# Policy Visualization

<b>Lunar Day: 0</b>	0.5	0.42	0.37	0.32	0.30	0.29	0.33	0.42	0.45	0.47	0.51	0.52	0.52	0.51	0.51	0.53				
<b>Height: 0.7m</b>	0.42	0.40	0.36	0.35	0.34	0.34	0.38	0.43	0.46	0.47	0.50	0.52	0.52	0.52	0.52	0.52				
<b>Dust: 0.19m</b>	0.40	0.40	0.41	0.40	0.38	0.39	0.35	0.37	0.38	0.39	0.41	0.45	0.47	0.49	0.52	0.51	0.53	0.52	0.51	0.51
<b>Battery: 1.00%</b>	0.33	0.35	0.35	0.36	0.36	0.37	0.36	0.39	0.40	0.41	0.43	0.45	0.47	0.49	0.51	0.51	0.52	0.51	0.51	0.53
<b>Stuck: False</b>	0.29	0.31	0.32	0.33	0.34	0.36	0.37	0.39	0.42	0.45	0.46	0.48	0.50	0.51	0.54	0.54	0.53	0.52	0.52	0.51
<b>Action: None</b>	0.29	0.39	0.40	0.43	0.48	0.51	0.54	0.57	0.57	0.56	0.56	0.54	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
<b>Resource: 0</b>	0.20	0.34	0.40	0.47	0.53	0.59	0.62	0.65	0.65	0.60	0.56	0.54	0.52	0.53	0.51	0.52	0.52	0.52	0.52	0.52
	0.18	0.20	0.20	0.20	0.23	0.33	0.41	0.47	0.55	0.61	0.65	0.65	0.60	0.57	0.53	0.52	0.52	0.52	0.52	0.52
	0.00	0.18	0.23	0.25	0.28	0.38	0.42	0.49	0.58	0.64	0.68		0.64	0.60	0.58	0.53	0.52	0.52	0.52	0.52
	0.27	0.27	0.28	0.29	0.34	0.43	0.47	0.52	0.61	0.69	0.69	0.67	0.63	0.59	0.56	0.53	0.53	0.52	0.51	0.50
	0.37	0.35	0.35	0.35	0.39	0.47	0.52	0.58	0.63	0.69	0.67	0.64	0.60	0.56	0.53	0.52	0.52	0.51	0.51	0.51
	0.41	0.41	0.41	0.41	0.45	0.52	0.58	0.64	0.68	0.66	0.65	0.61	0.57	0.53	0.51	0.52	0.53	0.52	0.52	0.52
	0.45	0.45	0.44	0.45	0.48	0.56	0.60	0.66	0.67	0.64	0.61	0.58	0.54	0.53	0.53	0.54	0.55	0.55	0.56	0.55
	0.50	0.51	0.50	0.50	0.53	0.57	0.60	0.63	0.64	0.62	0.59	0.56	0.53	0.54	0.55	0.57	0.58	0.58	0.58	0.57
	0.52	0.52	0.52	0.52	0.55	0.58	0.62	0.66	0.64	0.63	0.62	0.58	0.56	0.58	0.59	0.61	0.62	0.63	0.62	0.58
	0.52	0.52	0.52	0.53	0.57	0.65	0.71	0.75	0.78	0.79	0.79	0.75	0.71	0.70	0.69	0.68	0.67	0.68	0.65	0.60
	0.51	0.52	0.52	0.53	0.57	0.66	0.72	0.78	0.82	0.85	0.86	0.81	0.77	0.75	0.73	0.73	0.71	0.67	0.62	0.59
	0.51	0.52	0.51	0.52	0.57	0.65	0.74	0.82	0.90	0.93	0.91	0.87	0.83	0.79	0.77	0.77	0.71	0.65	0.61	0.57
	0.51	0.51	0.51	0.52	0.56	0.65	0.75	0.88	1.00	0.99	0.98	0.94	0.90	0.86	0.80	0.75	0.68	0.64	0.61	0.56

04

# Beyond the Classroom

Real Data & NASA Collaboration





# NASA Collaboration

Feedback from NASA Scientists

## Lunar South Pole

Incorporating Real-Life Data for Terrain & Lights

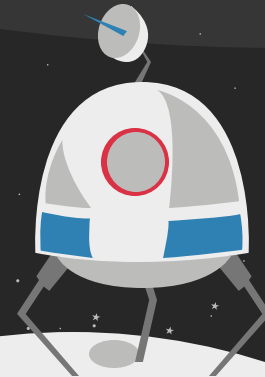
## Diversity of Resources

Importance of Sampling Different Resources

# THANKS!

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# Questions?

*Disclaimer: Only questions sent from Earth will be answered to the best of my capabilities.*

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