Lecture 21:Real-World RL

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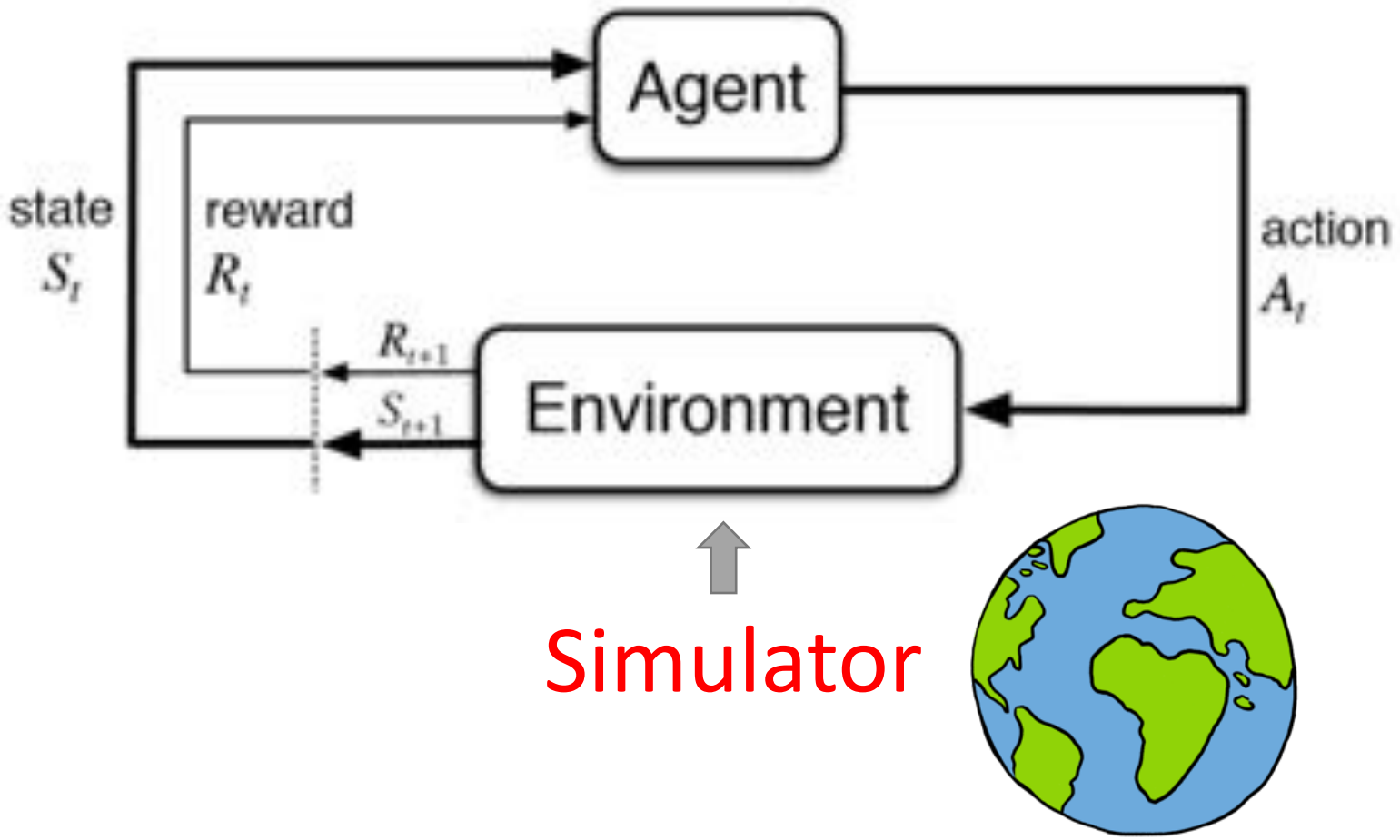
Simulator RL versus Real-World RL



Priorities in Real-World RL

- Policy Gradient ↓
- Complex representations ↓
- Computational efficiency ↓
- Control environment ↓
- Learning ↓
- Last policy ↓

Guided Policy Learning ↑

Generalization ↑

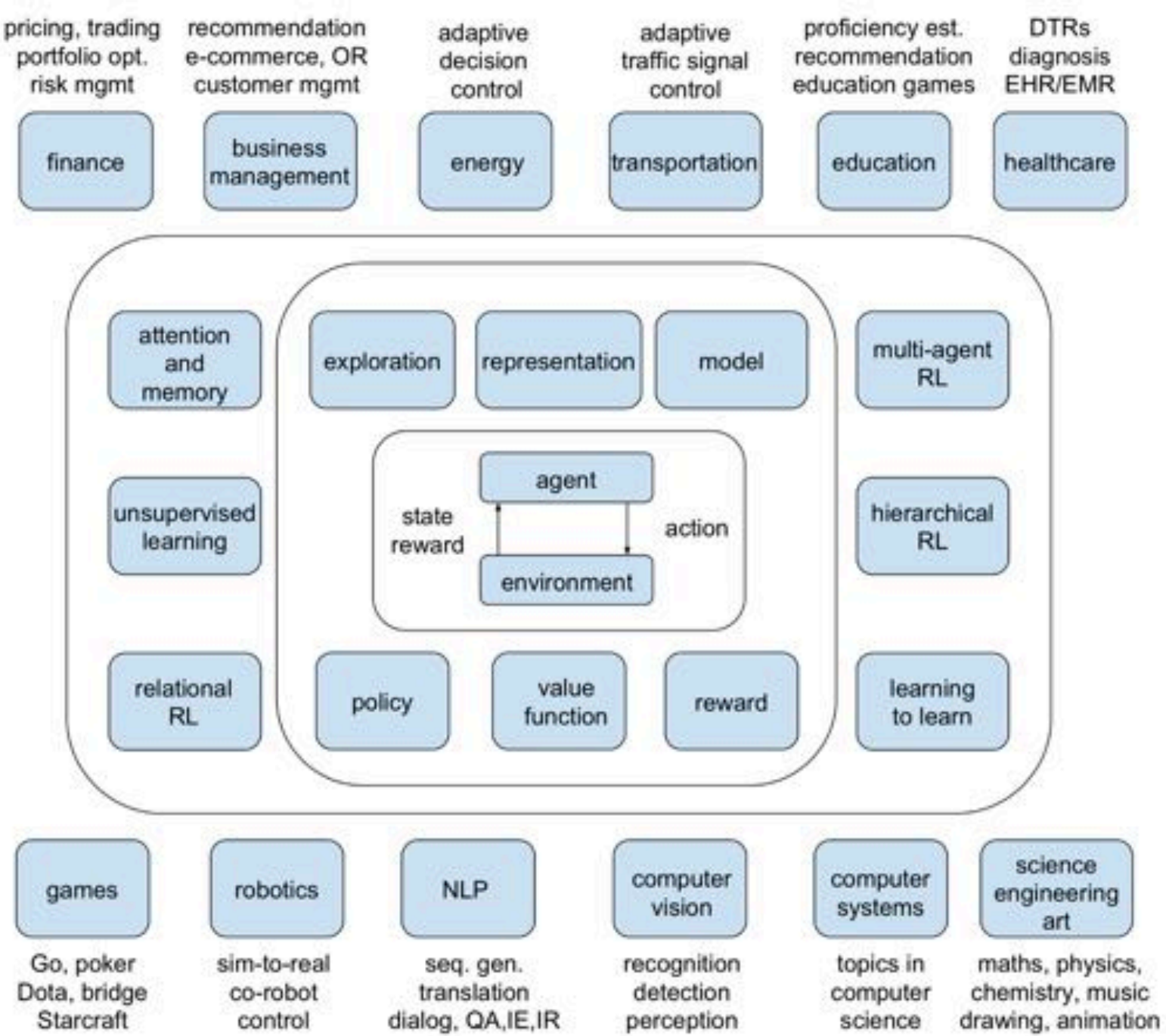
Sample efficiency ↑

Environment controls ↑

Evaluation ↑

Every policy ↑

RL Applications

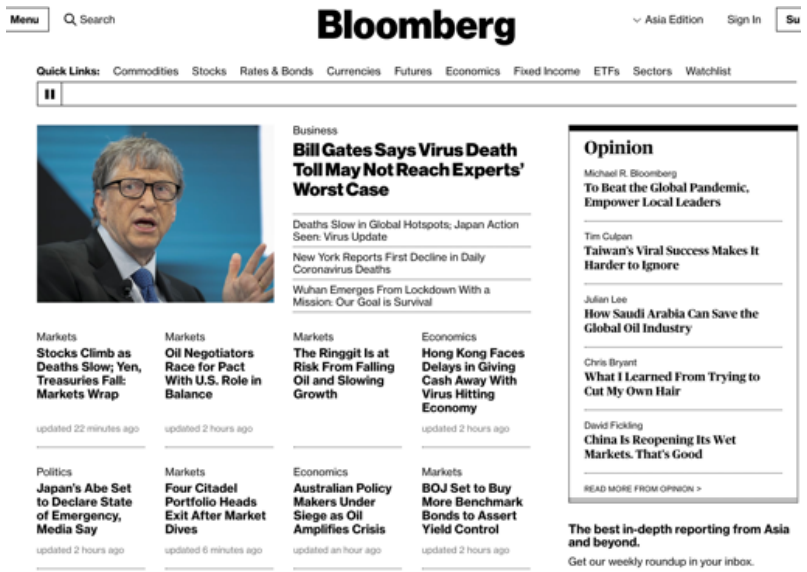


Yuxi Li, Deep Reinforcement Learning, https://arxiv.org/abs/1810.06339, 2018

Application to e-commence

Contextual Bandits

- In real-world, there is usually some context that help you make a decision
- For example:
  - Patient data for clinical trials
  - Consumer data for news/movie recommendation



Contextual Bandits

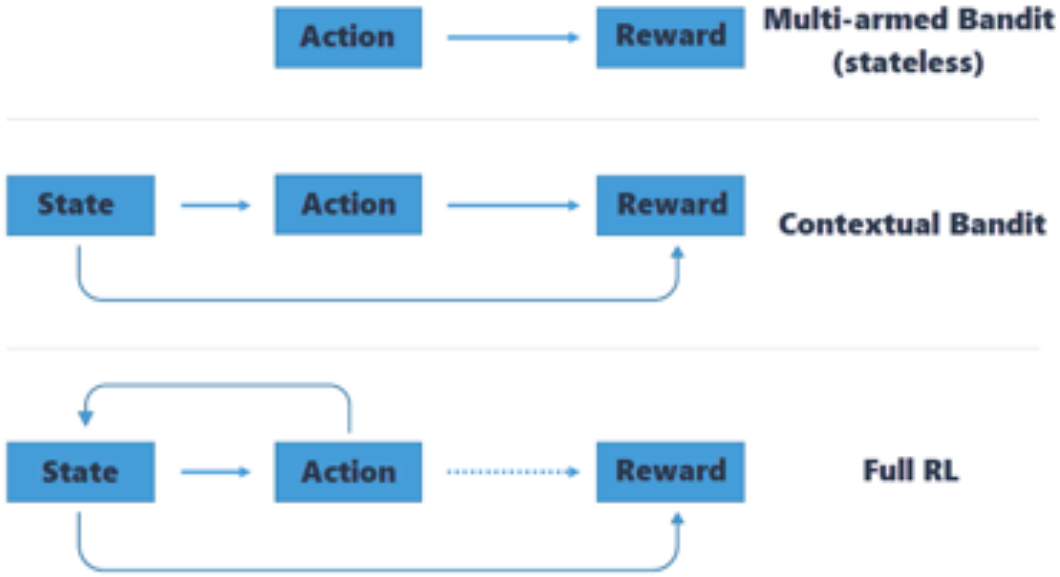
- We are running a sports news website. Today, there are K big sports related news stories.
- Every time a user visits our set, we must decide then and there which headlines to display to him/her on the front page.
- The goal is to maximize the number of clicks.

Contextual Bandits

Repeatedly:

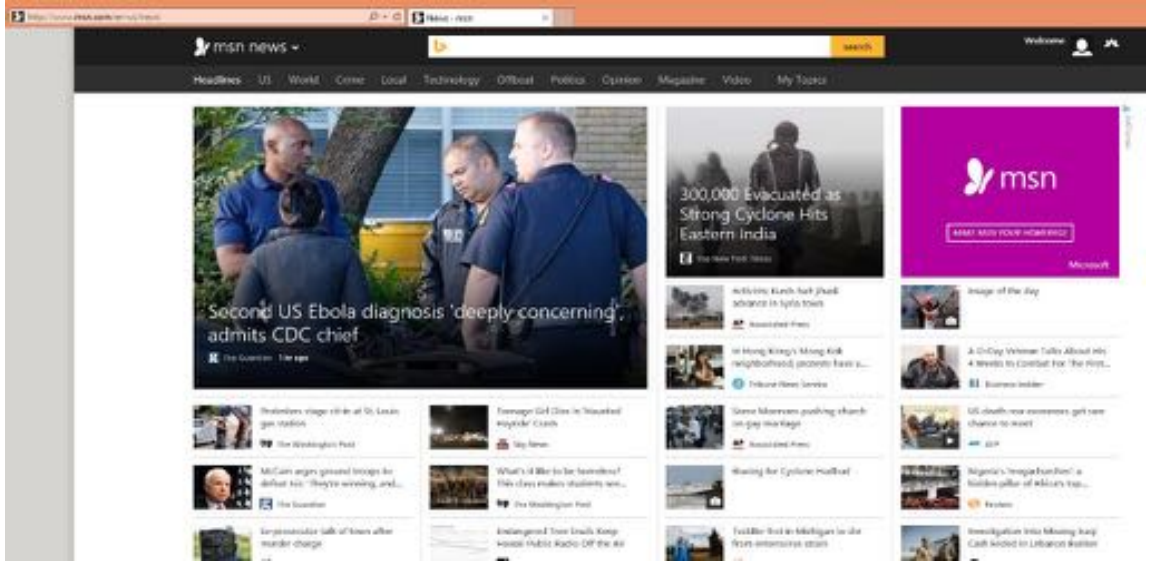
1. Observe features x
2. Choose action $a \in A$
3. Observe reward r

Goal: Maximize expected reward



Contextual bandit can be considered as one-step RL

News Recommendation



1. Use contextual bandit to learn best action for top slot
   - with a score-based policy, i.e. $\pi(x) = \underset{a}{\operatorname{argmax}}\, f(x, a)$
2. Use the ordering from f for actions in other slots

SIGAI Industry Award to Real World Reinforcement Learning Team from **Microsoft**

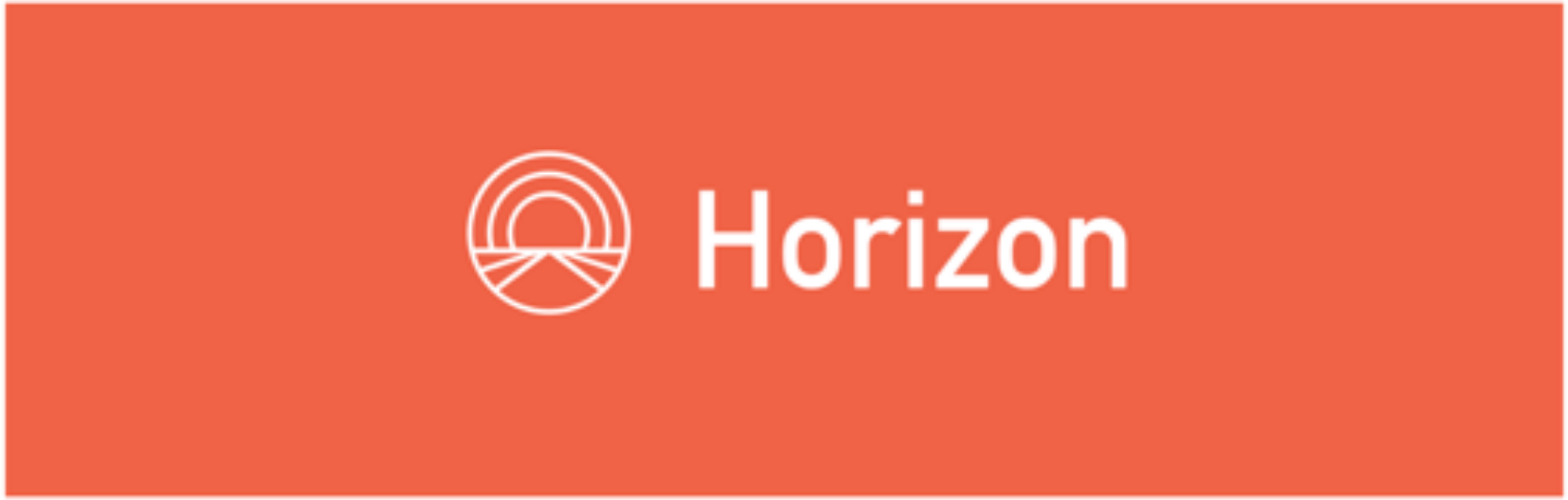
- Decision Service created by the Real World Reinforcement Learning Team from Microsoft, has been chosen as the winner of the inaugural 2019 award.
- Identification and development of cutting-edge research on contextual-bandit learning throughout the broad range of Microsoft products

https://www.microsoft.com/en-us/research/project/real-world-reinforcement-learning/

Facebook's RL system in production

POSTED ON NOV 1, 2018 TO AI RESEARCH, ML APPLICATIONS

Horizon: The first open source reinforcement learning platform for large-scale products and services



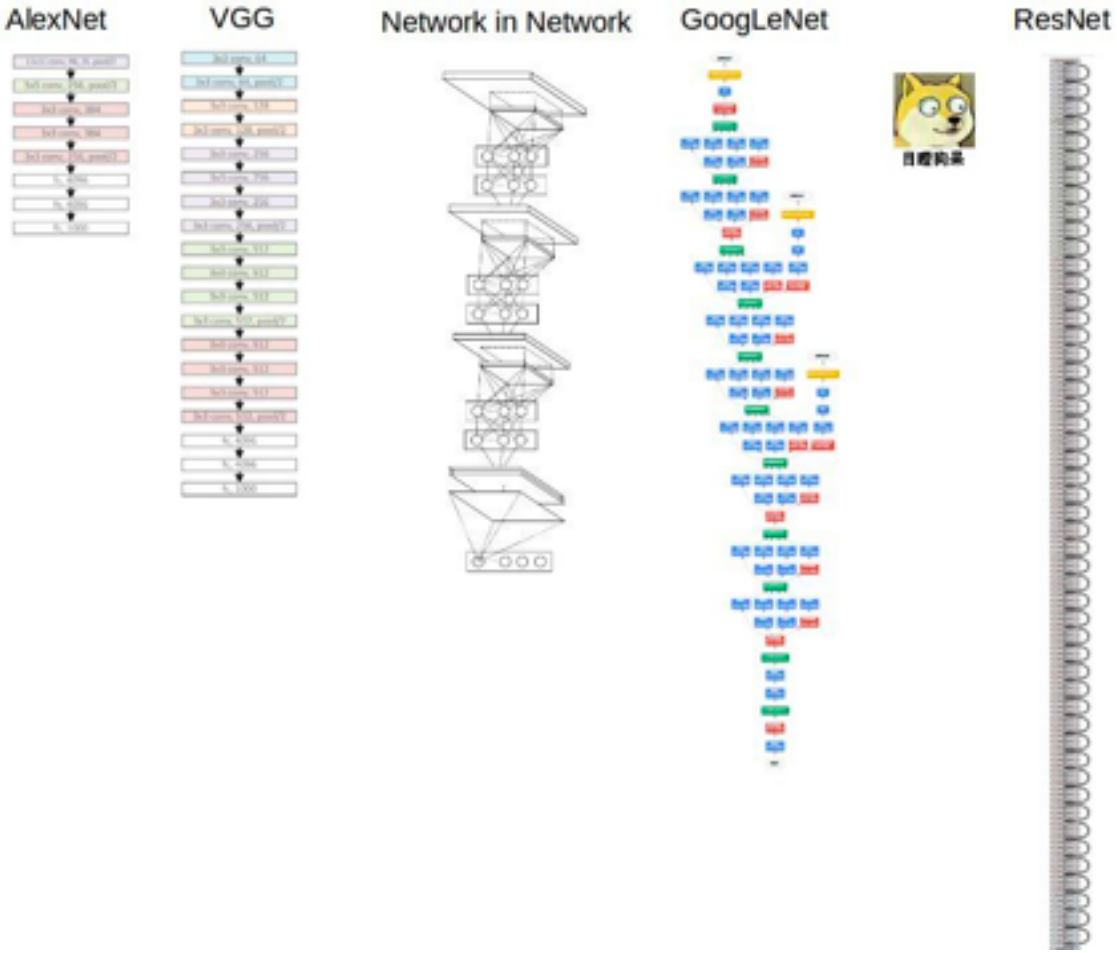
By Jason Gauci, Edoardo Conti, Kittipat Virochsiri

https://github.com/facebookresearch/ReAgent
https://research.fb.com/wp-content/uploads/2018/10/Horizon-Facebooks-Open-Source-Applied-Reinforcement-Learning-Platform.pdf?

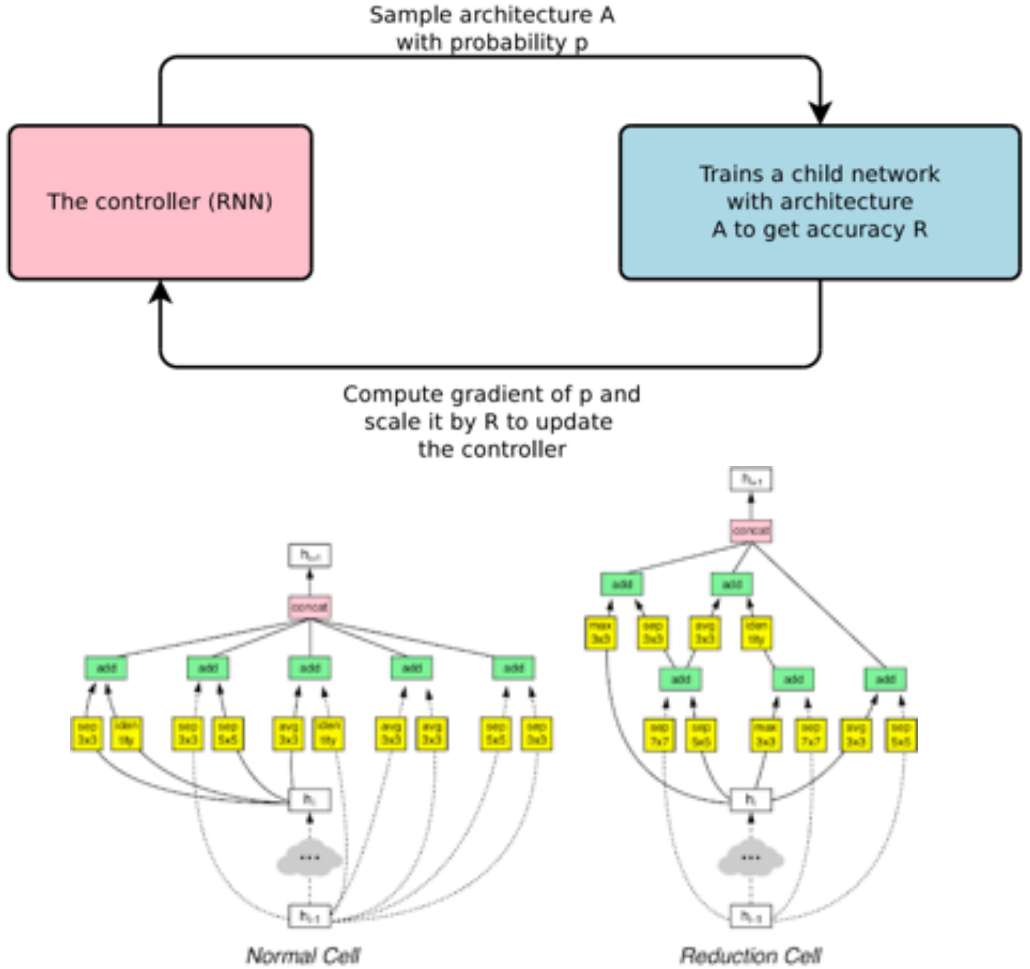
Application to Deep Learning

AutoML: Neural Architecture Search

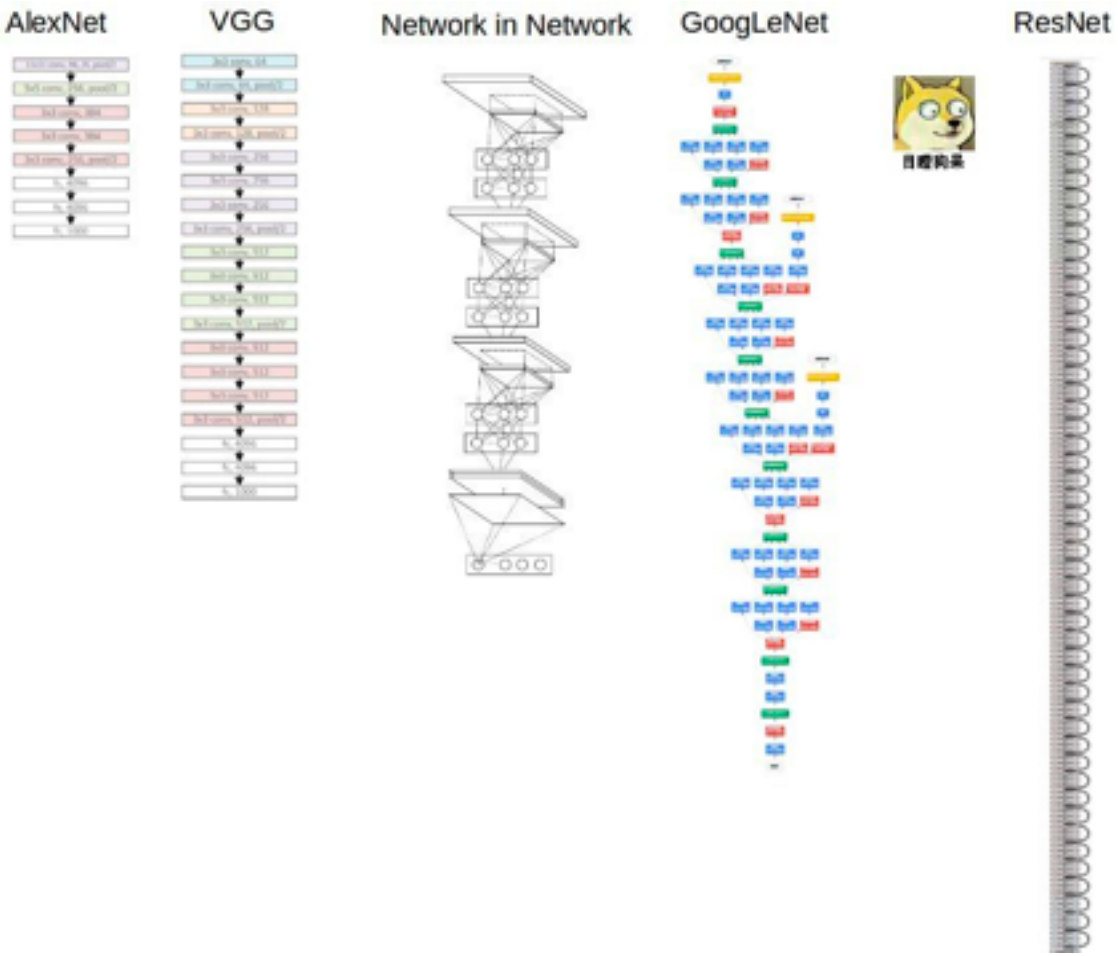
Manually designed networks

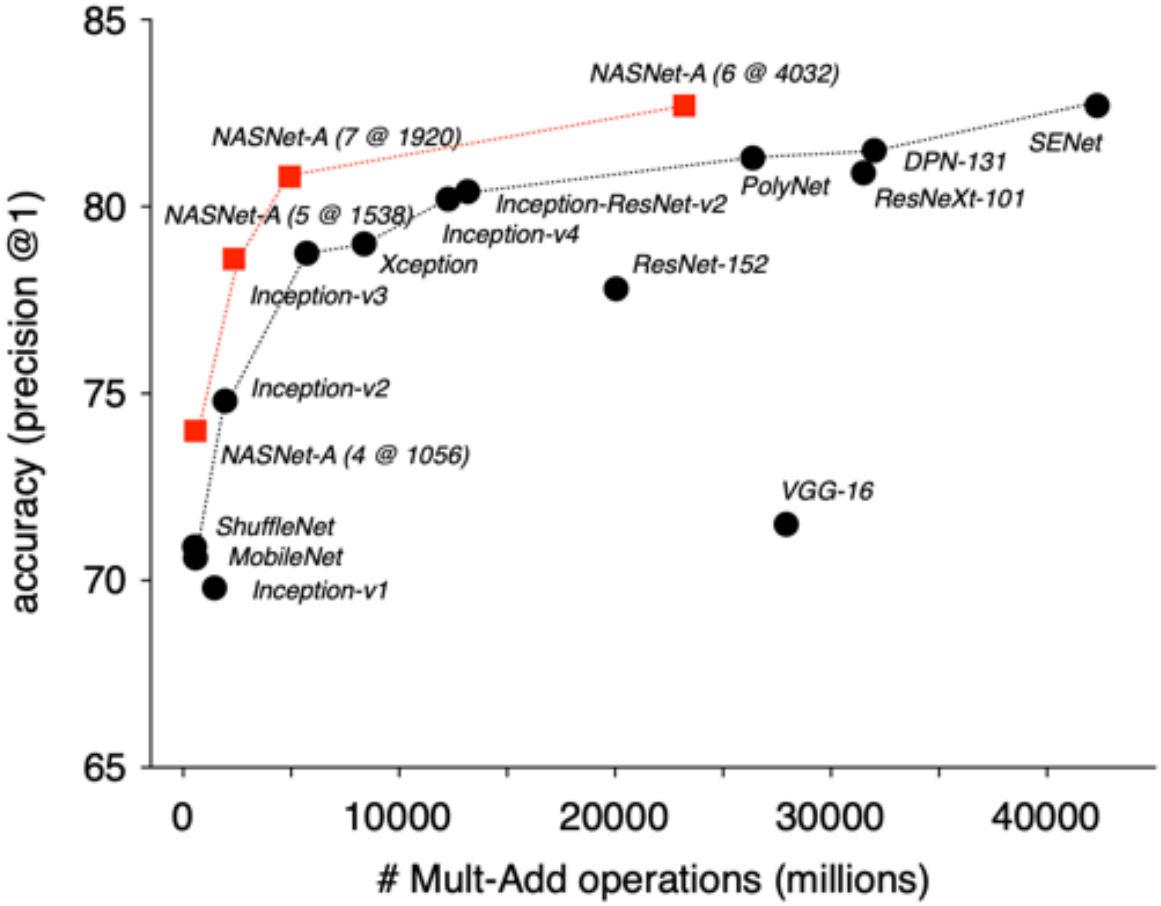


RL for network architecture search



AutoML: Neural Architecture Search





https://ai.googleblog.com/2017/11/automl-for-large-scale-image.html

AutoML

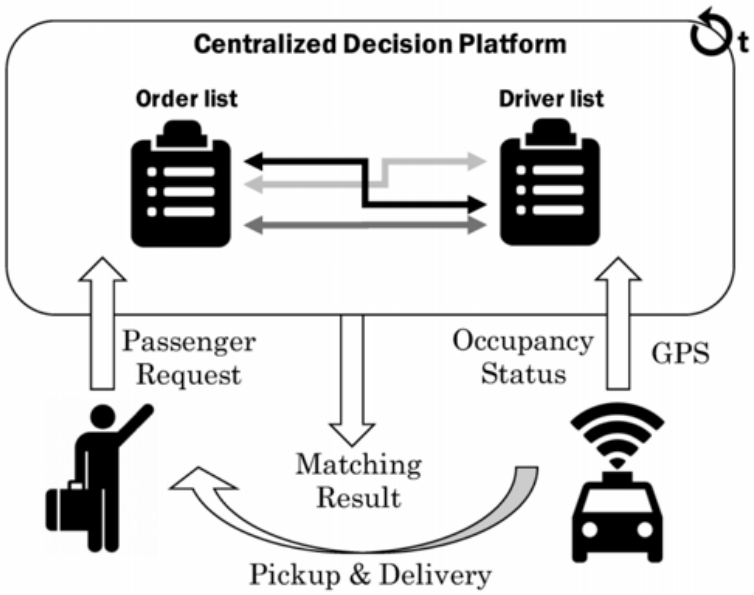
Winter is coming for some of the ML researchers/engineers

Jeff Dean's talk at ICML'19
https://slideslive.com/38917526/an-overview-of-googles-work-on-automl-and-future-directions

Application to Transportation

Large-scale Order Dispatch for Taxis

- NP-hard/combinatorial optimization



KDD 2018 paper from DiDi Research Institute

https://zhuanlan.zhihu.com/p/47193506 https://drive.google.com/file/d/17BoHSK-js0NPwOWJQzEFATINfbYj4OKR/view

Large-scale Order Dispatch for Taxis

Offline learning + Online planning

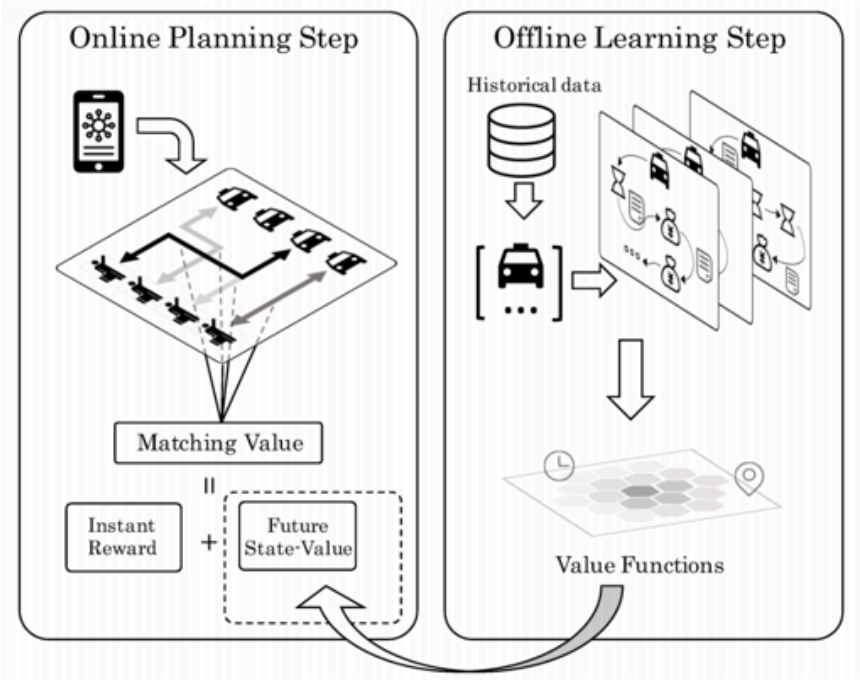
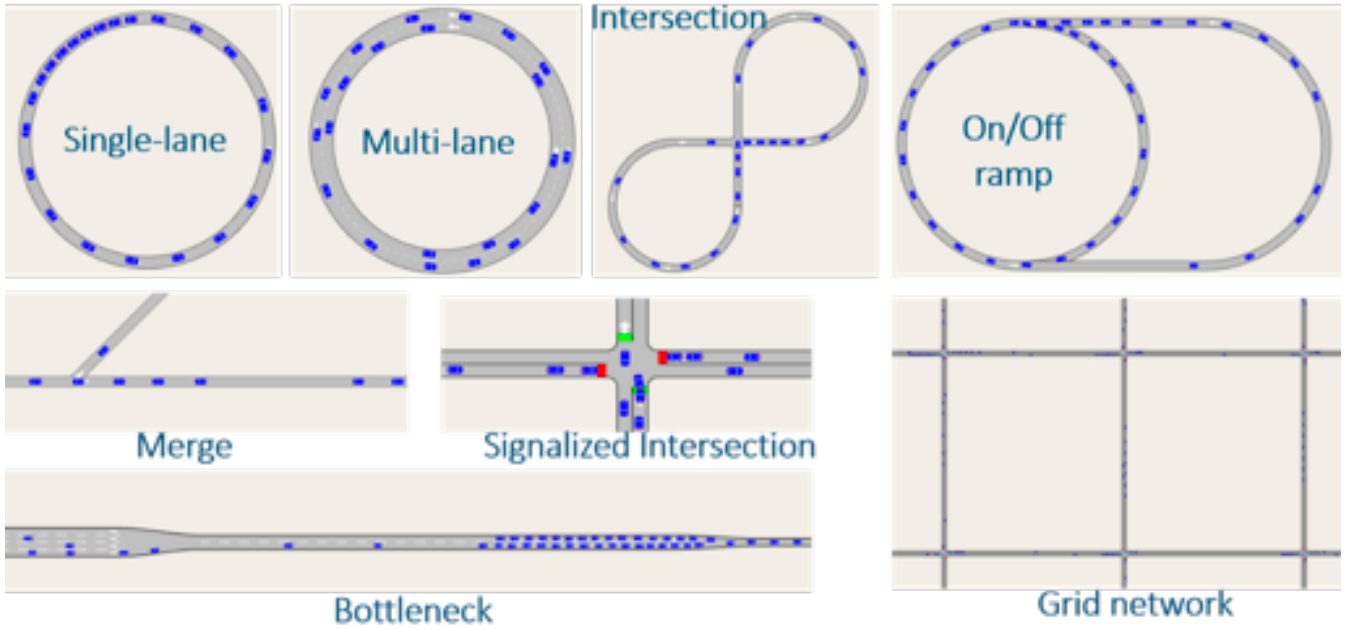


Figure 1: Illustration of the proposed algorithm.

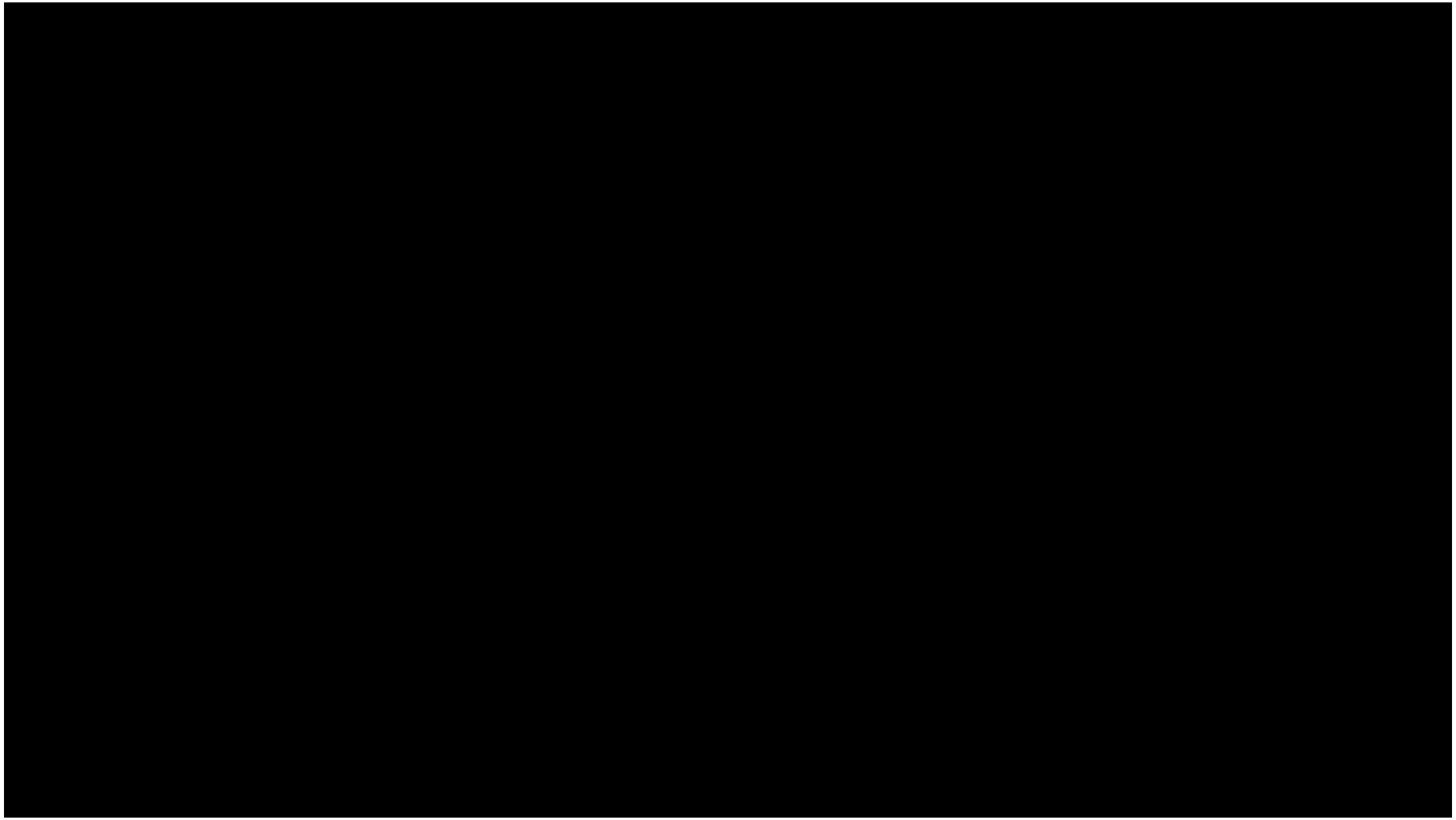
https://drive.google.com/file/d/17BoHSK-js0NPwOWJQzEFATINfbYj4OKR/view

Multi-agent system for traffic simulation



https://flow-project.github.io/index.html

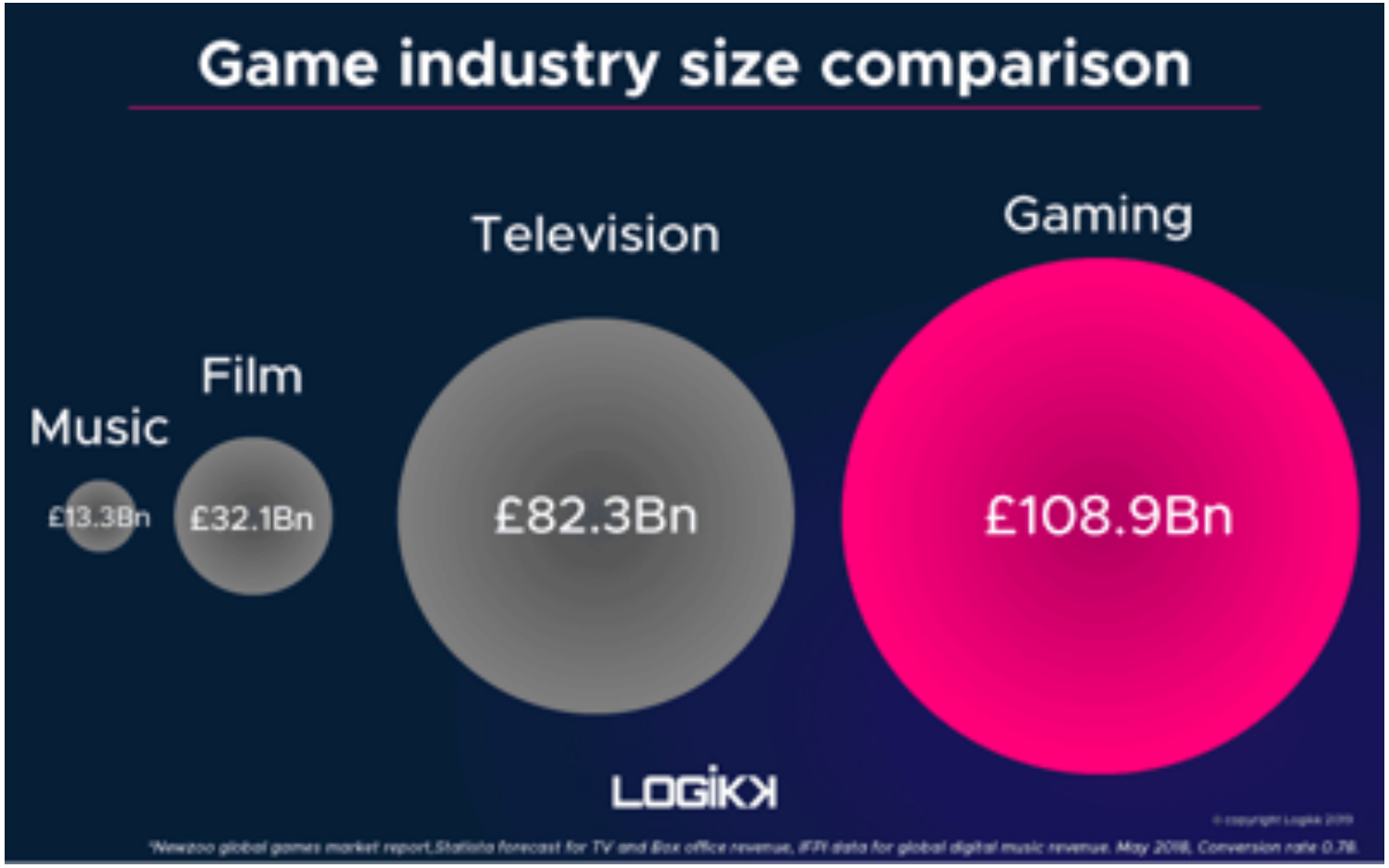
Multi-agent system for traffic simulation



https://flow-project.github.io/index.html

Application to Gaming Industry

Machine Learning in Gaming Industry



Machine Learning in Game Development

Algorithms Playing as NPCs
NPCs will respond to your actions in unique, unexpected ways.

Modelling Complex Systems
The game could predict and alter downstream effects.

Making Games more Beautiful
Textures and objects will render dynamically as you get closer

More Realistic Interactions
NLP will create more realistic conversations and responses.

Universe Creation on the Fly
Open world games have the potential to be unlimited in size.

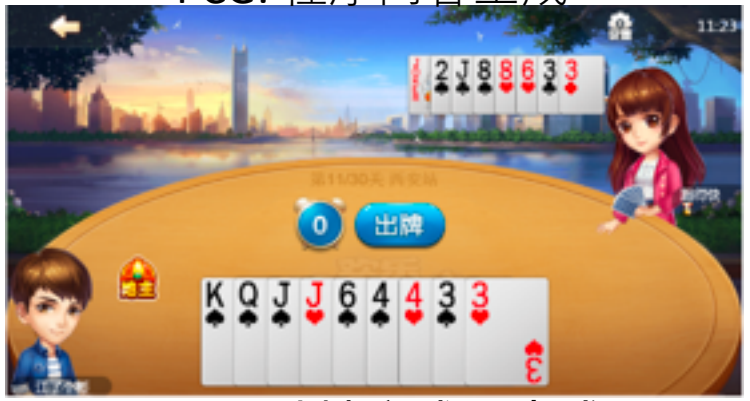
More Engaging Mobile Games
AI chips in phones will bring the power of ML to phones.

www.logikk.com LOGIKK

Training gaming AI bots

腾讯AI在QQ飞车手游的应用

PCG: 程序内容生成



QQ斗地主残局生成

Training gaming AI bots for imperfect information games

NEWS · 11 JULY 2019

No limit: AI poker bot is first to beat professionals at multiplayer game

Triumph over five human opponents at Texas hold'em brings bots closer to solving complicated real-world problems.

Douglas Heaven

Multiplayer poker has fallen to the machines. Credit: Alexandre Rotenberg/Alamy

PDF versio

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https://science.sciencemag.org/content/early/2019/07/10/science.aay2400.full.pdf

Suphx: Mastering Mahjong with Deep Reinforcement Learning

rated above 99.99% of all ranked human players on Tenhou, a Japan-based global online Mahjong competition platform with over 350,000 members.

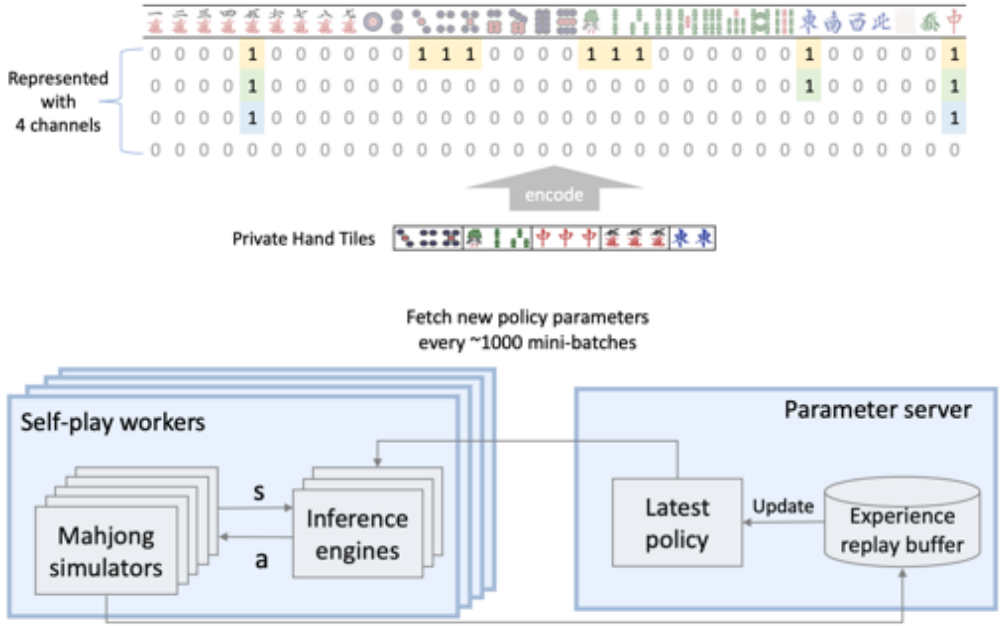


Figure 6: Distributed RL system in Suphx

April 1, 2020. https://arxiv.org/pdf/2003.13590.pdf

Application to Robot Learning

Dexterous Manipulation from OpenAI

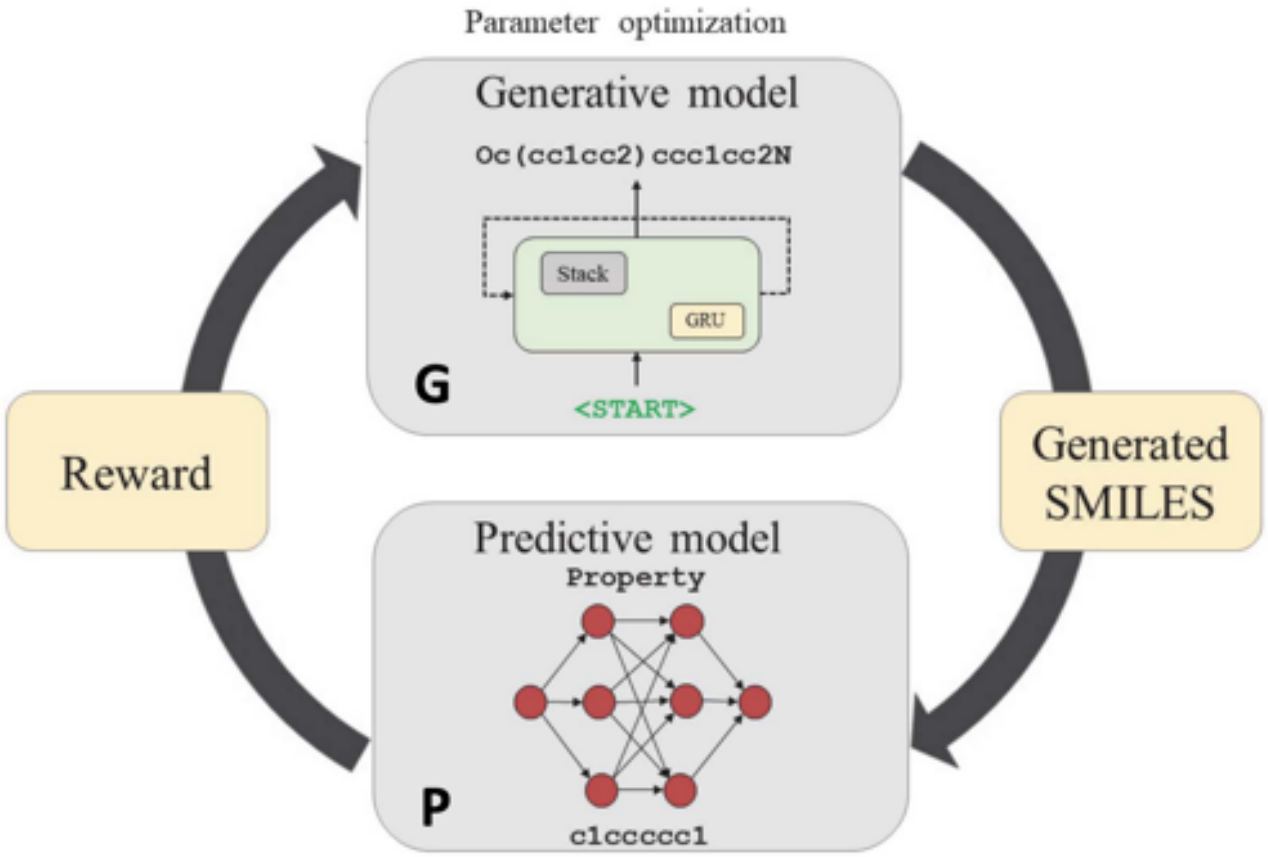
https://openai.com/blog/learning-dexterity/

CoRL (new annual conference on robot learnings ince 2017)

https://sites.google.com/robot-learning.org/corl2019

CoRL 2019

Application to Drug Design



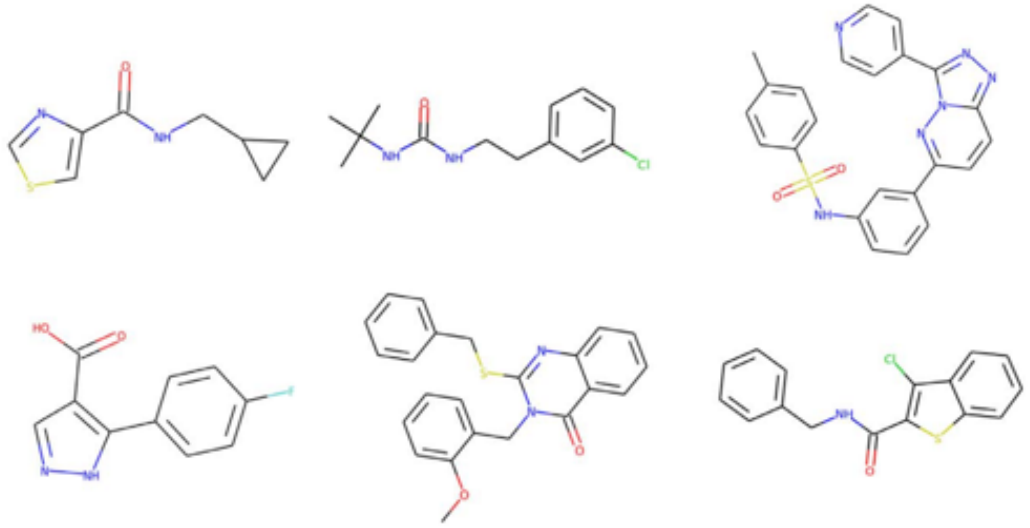


Fig. 2. A sample of molecules produced by the generative model.

Popova, M., Isayev, O., and Tropsha, A. (2018). Deep reinforcement learning for de novo drug design. Science Advances, 4(7).

Application to Drug Design

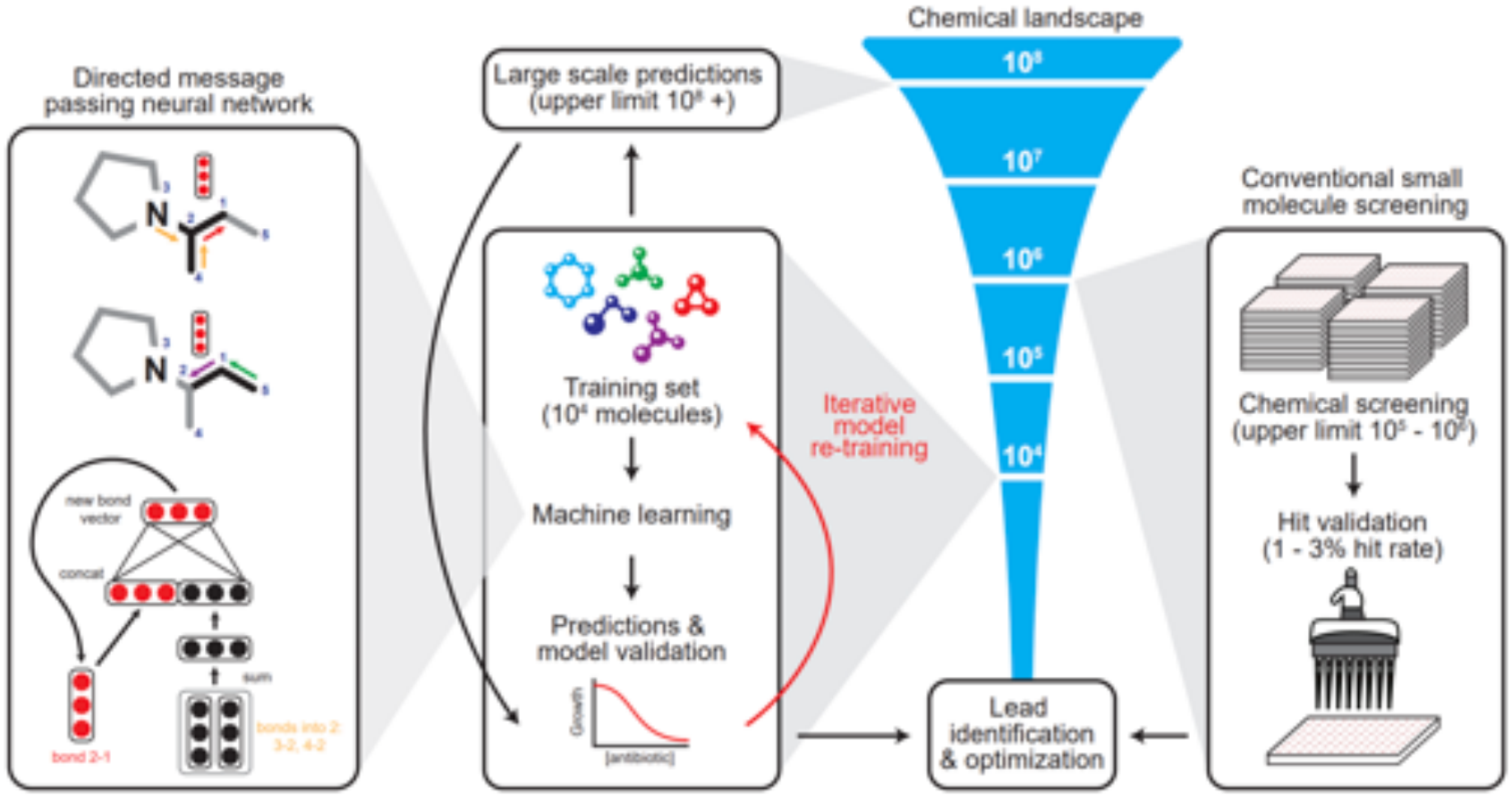


Figure 1. Machine Learning in Antibiotic Discovery

https://www.cell.com/cell/pdf/S0092-8674(20)30102-1.pdf

A Deep Learning Approach to Antibiotic Discovery. Stokes, et al. Cell 2020.

Application to Finance

- TensorTrade is an open source Python framework for building, training, evaluating, and deploying robust trading algorithms using reinforcement learning
- https://towardsdatascience.com/trade-smarter-w-reinforcement-learning-a5e91163f315
- https://github.com/tensortrade-org/tensortrade

Other Resources on Real-World RL

- RL for Real Life ICML'19 Workshop: https://sites.google.com/view/RL4RealLife
- Recent survey essay: https://medium.com/@yuxili/rl-applications-73ef685c07eb
  - Huge amount of applications in NLP