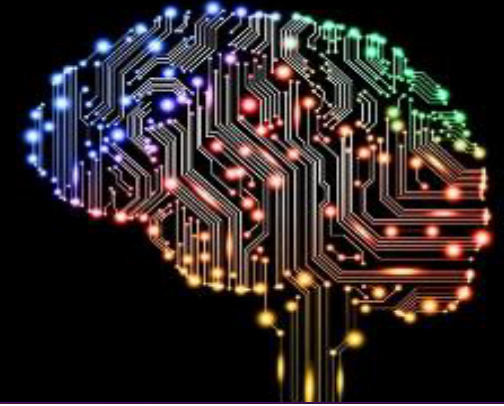


JAN 15, 2019



# ARTIFICIAL INTELLIGENCE



**PRASANNA BALAPRAKASH**

Computer Scientist

Mathematics and Computer Science Division &

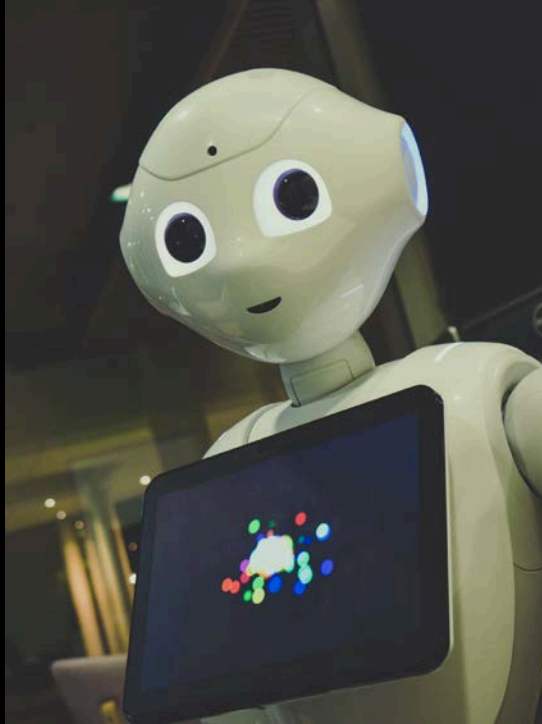
Leadership Computing Facility

Argonne National Laboratory

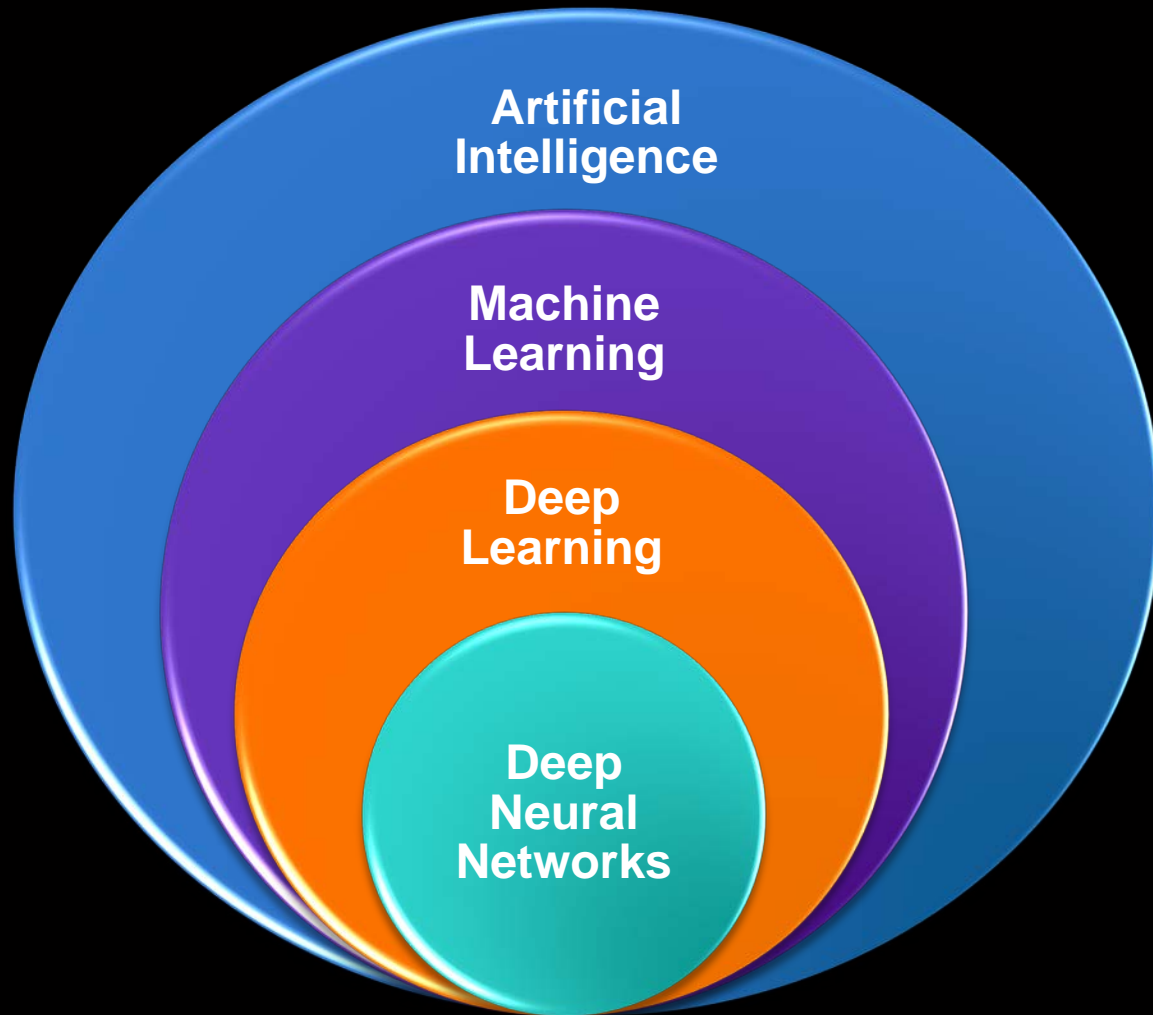
TRB ExComm A.I. Policy Session, 2020

Washington DC

# ARTIFICIAL INTELLIGENCE



**Automation of intelligence**



# WHY NOW?



Peta to exa bytes of data per day

**Big data**



Billion billion operations per sec

**Big (cheap) compute**

# MACHINE LEARNING



Supervised  
learning



Unsupervised  
learning



Reinforcement  
learning

# WHAT IS DIFFICULT FOR A COMPUTER?



# SUPERVISED LEARNING

Inputs

Outputs



Cat



Dog



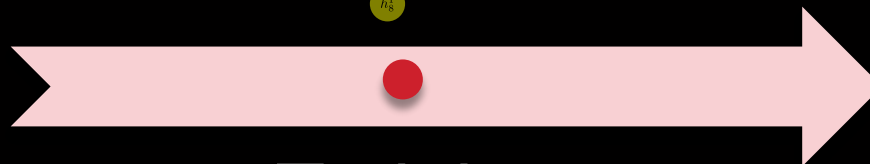
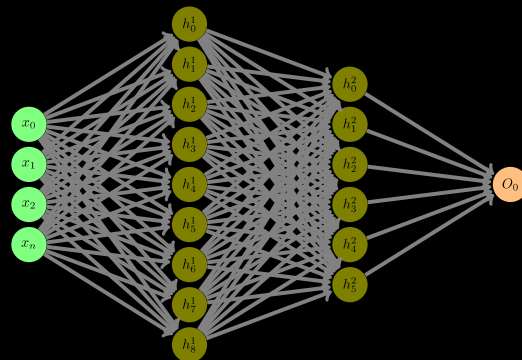
Horse



Elephant



Tiger



Training

# SUPERVISED LEARNING

```
a = int(input("enter first number: "))
b = int(input("enter second number: "))

sum = a + b

print("sum:", sum)
```

Human generated

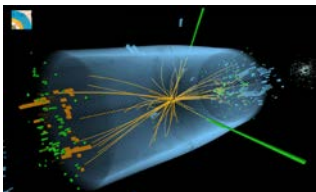


11 011101 01000 011110 01110101 0011 00110001 010110000 0101 111 1111 0111  
11 000 00100110111110 011101011 0111 111 1110 0110100001 00 11 000111 0000  
1100 00001 111111 1101111 11 11 01101 00110 01 11 010001 0011111 01 1010  
111 01 101000 1001100100 001 001 1110 0111110111 10 01 011100 00001 1111111  
11101 01000 011110 01110101 0011 00110001 010110000 0101 111 1111 011101  
00 0010011011110 01110101 0111 111 1110 0110100001 00 11 000111 00000 11  
00 00001 111111 1101111 11 11 01101 00110 01 11 010001 0011111 01 101000 0  
11101 00110 01 111 0100010011111 01 101000 1001100100 001 001 1110 0111110  
1 0100010011111 01 101000 1001100100 001 001 1110 0111110111 10 01 0111000  
011111 01 1100 00100 11011110 011101011 0 111 111 1110 0110100001 0011 000  
1101 00110 01 11 01 00010011 111 01 101000 1001100100 001 001 1110 01111101  
00110001 010110000 0101 111 1111 011101011 01 00000100 00000 111111 0111  
01 011100 00001 111111 1101111 11 11 01101 00110 01 11 010001 0011111 01  
111 01 1100 0010011011110 011101011 0 111 111 1110 0110100001 00 11 00011  
1 00110001 010110000 0101 111 1111 011101011 01 00000100 00000 111111 01  
01 011100 00001 111111 1101111 11 11 01101 00110 01 11 010001 0011111 01  
11111 1101111 11 11 01101 00110 01 11 010001 0011111 01 101000 1001100101  
01 00110 01 111 01000100 1111 01 101000 1001100100 001 001 1110 011111011  
01 1100 00100 11011110 011101011 0 111 111 1110 0110100001 00 11 000111 0001

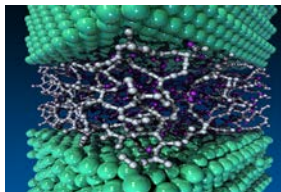
Computer generated  
(model)



# SUPERVISED LEARNING



**Subatomic  
Studies**



**Molecular  
Dynamics**



**Transportation**

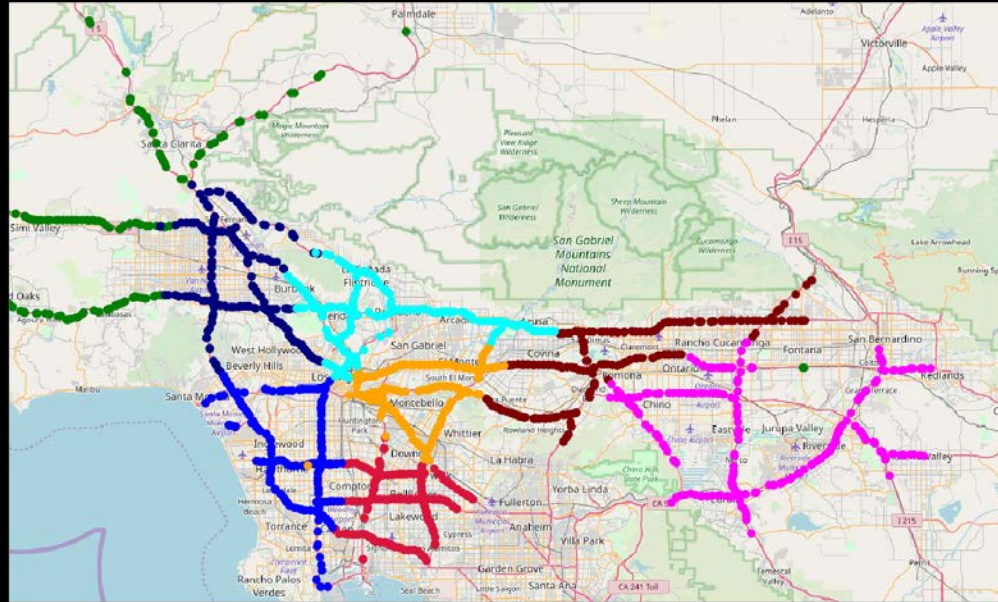


**Weather**



**Cosmology**

# MOBILITY DESIGN AND PLANNING



AI methods predict traffic flow patterns and congestions

# BIG DATA SOLUTIONS FOR MOBILITY

Energy Efficient Mobility Systems (EEMS) Program, DOE Vehicle Technologies Office



# MACHINE LEARNING



Supervised  
learning



Unsupervised  
learning



Reinforcement  
learning

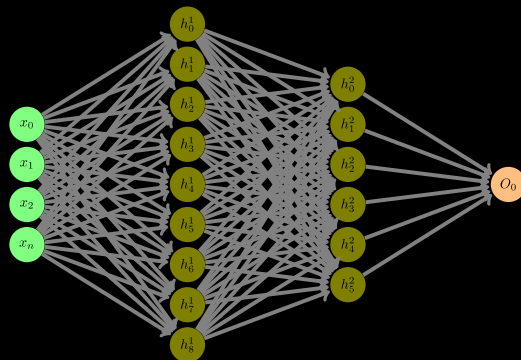
# UNSUPERVISED LEARNING



Karras, T., Aila, T., Laine, S. and Lehtinen, J., 2017. Progressive growing of GANs for improved quality, stability, and variation. arXiv preprint arXiv:1710.10196.

# UNSUPERVISED LEARNING

Input

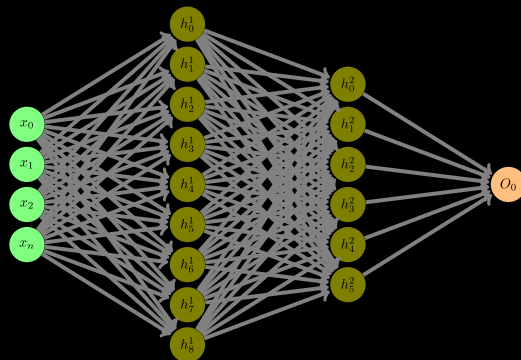
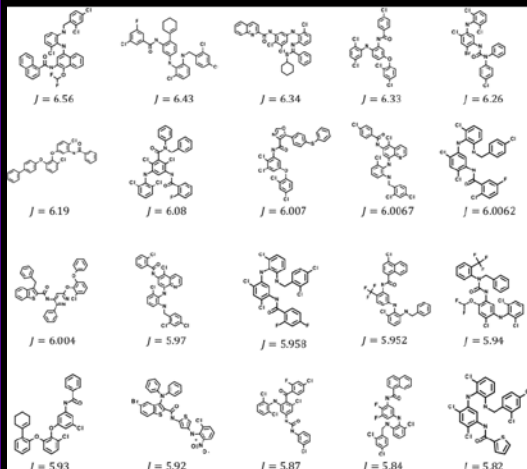


Training

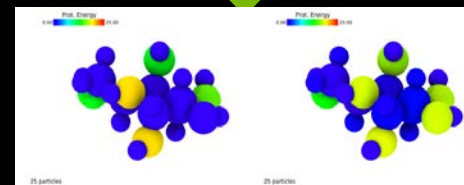


# UNSUPERVISED LEARNING

Input



Training



AI methods can generate synthetic novel molecules and materials

# UNSUPERVISED LEARNING



AI methods can generate synthetic data for self-driving cars



# MACHINE LEARNING



Supervised  
learning

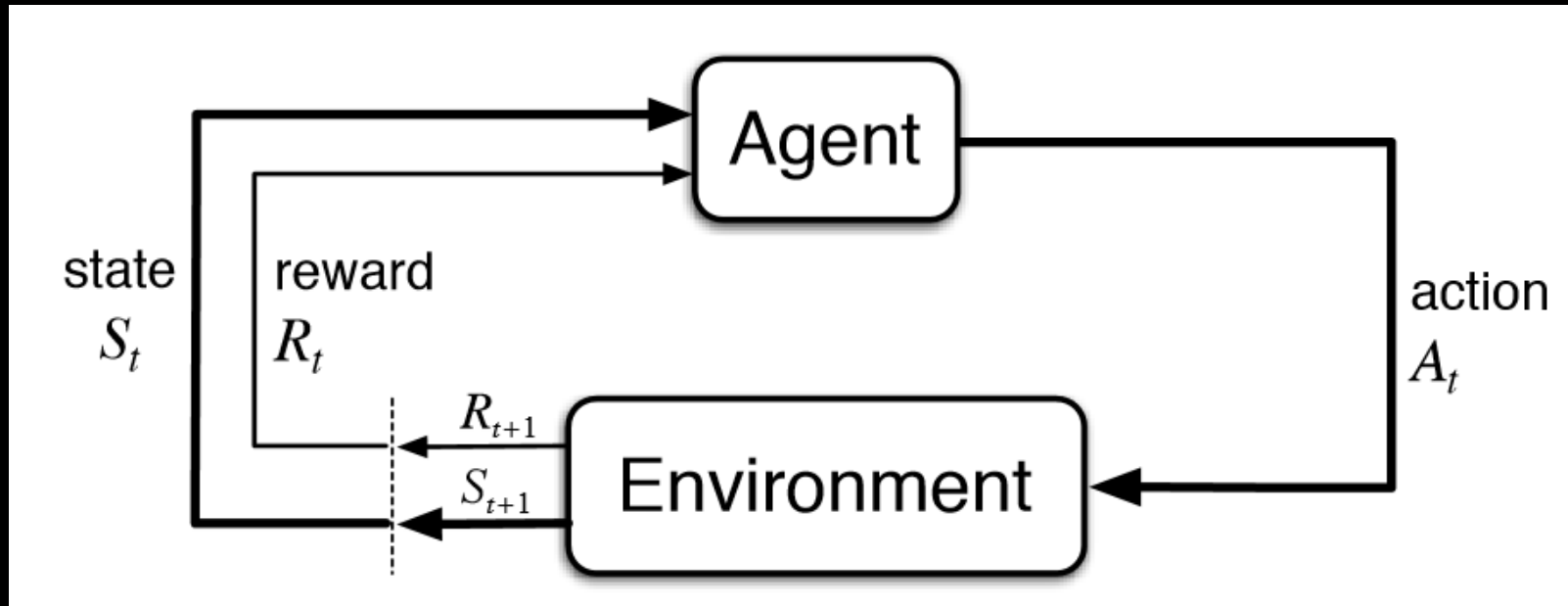


Unsupervised  
learning

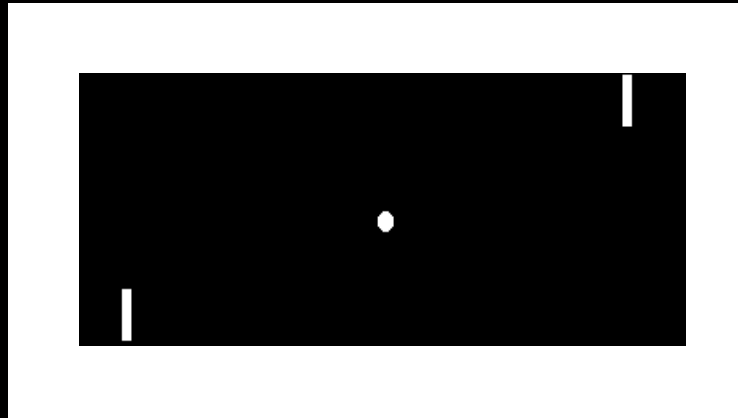


Reinforcement  
learning

# REINFORCEMENT LEARNING



# REINFORCEMENT LEARNING



# SUPERVISED LEARNING

Inputs

Outputs



Down



Down



Up

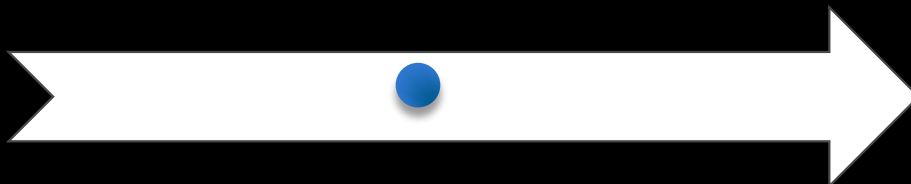


Down

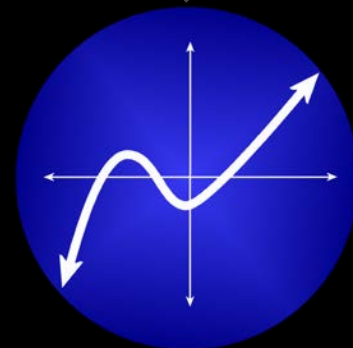


Up

Training

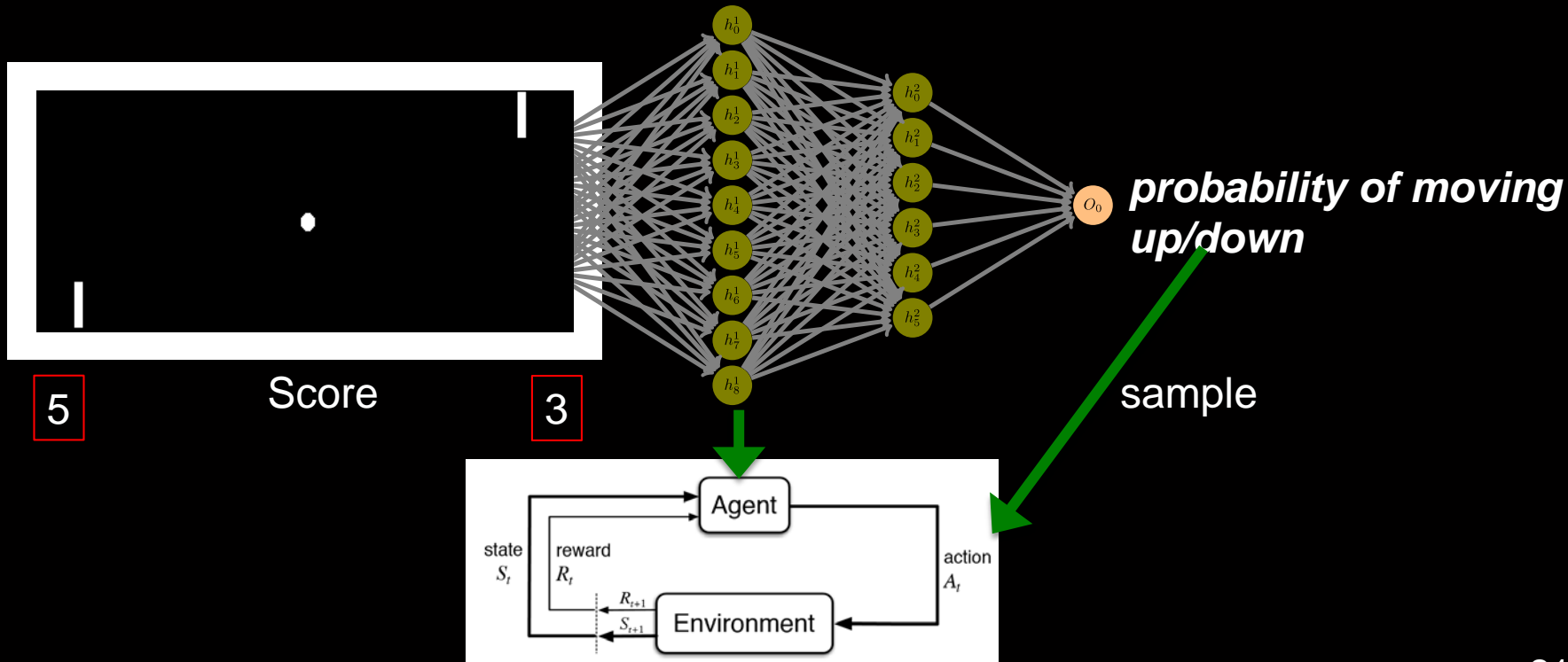


- Large amount of training data
- As good as the human

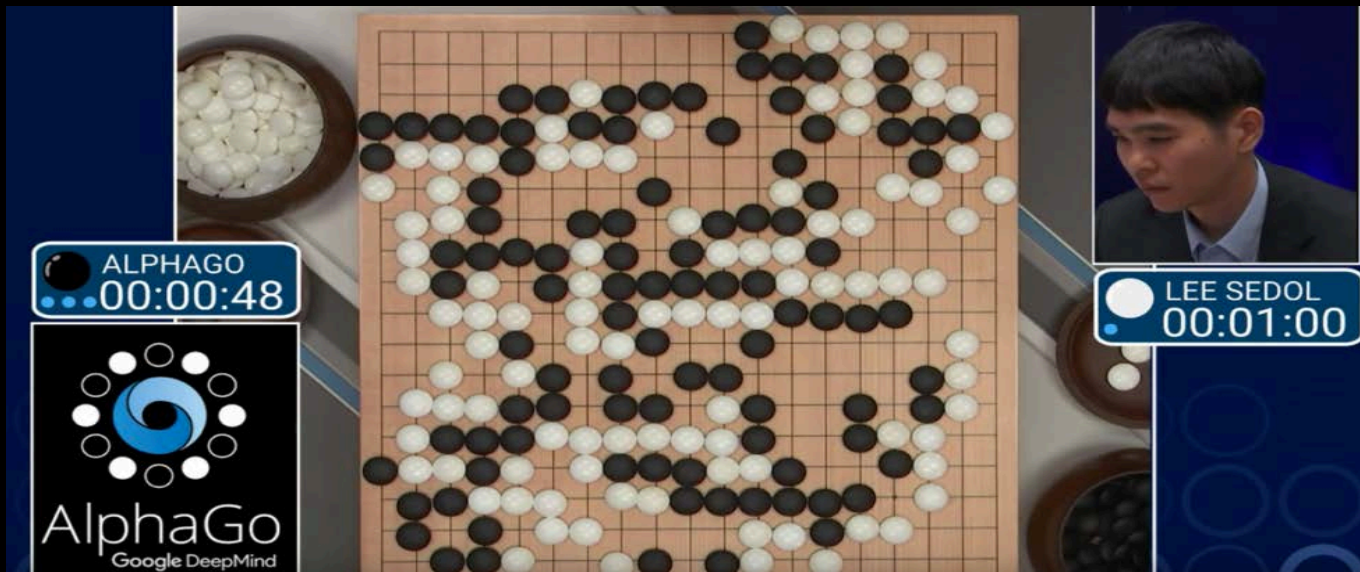


?

# REINFORCEMENT LEARNING



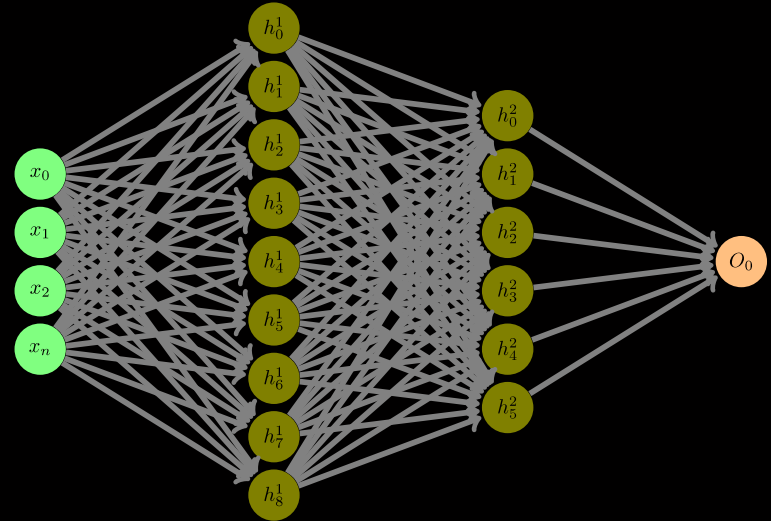
# REINFORCEMENT LEARNING



**AlphaGo beats Lee Sedol (18 times world champion)**

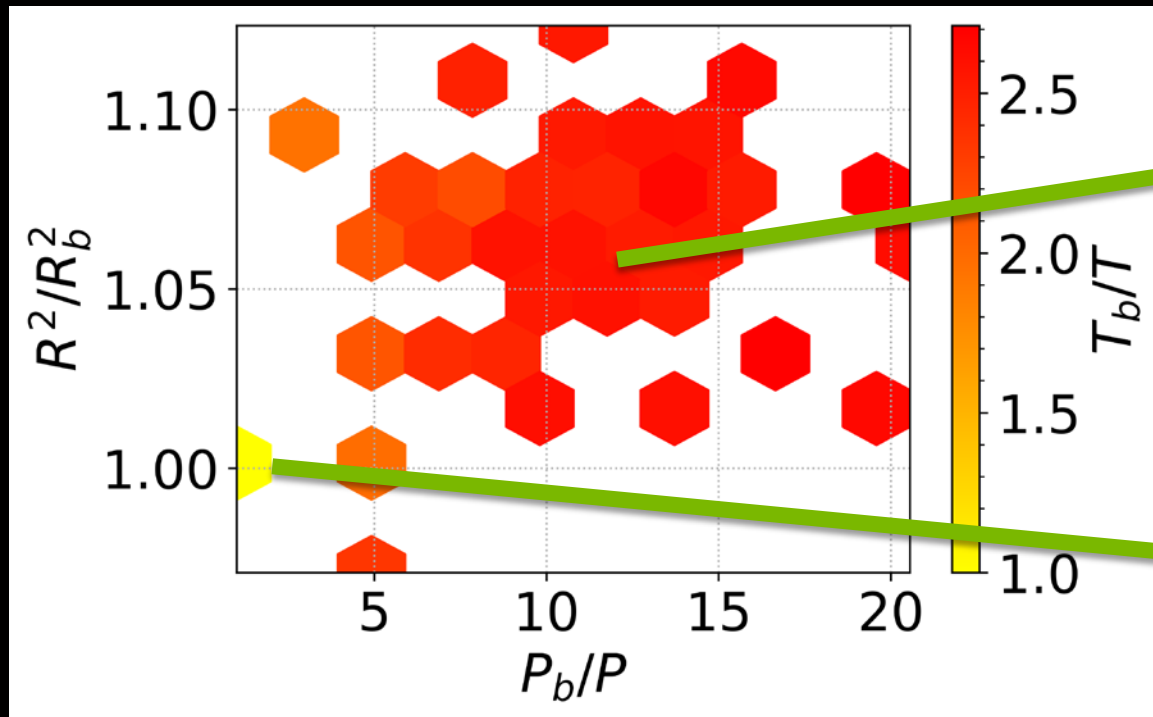
**4 – 1**

# NEURAL NETWORK DESIGN IS COMPLEX



1000000000 possible network designs

# AI FOR AI: CANCER DRUG DISCOVERY



Automatically  
generated  
(6 hours)

Manually  
designed  
(several weeks)

**Higher the better**

AI methods automate and accelerate neural network development



# IF INTELLIGENCE IS A CAKE...

Supervised learning  
(icing)

Unsupervised and  
Reinforcement learning  
(cake)



LeCun, NeurIPS 2016 (adapted)

AI

I can't wait to see...



AI winning a Nobel prize

# ACKNOWLEDGEMENTS



Energy Efficient Mobility Systems (EEMS) Program, DOE Vehicle Technologies Office

Early Career Award, ASCR within the DOE Office of Science



RAPIDS: A SciDAC Institute for Computer Science and Data



Laboratory Directed Research and Development (LDRD)

**THANK YOU**