

Introduction to Deep Learning

Elena Congeduti, 11-11-2024









Who am I?

- BSc and MSc, Mathematics, Rome and Leiden University
- MSc Data Science, Bologna University
- Data Scientist, ENG in Rome
- PhD Reinforcement Learning, Computer Science, TU Delft
- Lecturer, Computer Science, TU Delft



Lecture Agenda

1. Logistics
2. Prior knowledge refresh
3. Machine Learning vs Human Learning
4. Towards Deep Learning

Schedule

Week	Monday	Tuesday	Wednesday	Thursday	Friday
2.1	Lecture 1 Lab 1		Lecture 2 Lab 2	Lecture 3 Lab 3	
2.2	Lecture 4 Lab 4		Lecture 5 Lab 5	Lecture 6 Lab 6 + Assignment 1 Release - Assignment 1	
2.3	Lecture 7 Lab 7		Buffer - Q&A Lab - Assignment 1	Lecture 8 Lab 8	
2.4	Deadline - Assignment 1 Lab - Assignment 1 feedback Release - Assignment 2		Buffer - Q&A Lab - Assignment 2	Lecture - Revision Assignment 1 Lab - Assignment 2	
2.5	Lecture 9 Lab 9		Buffer - Q&A Lab - Assignment 2	Buffer - Q&A Lab - Assignment 2	
2.6	Deadline - Assignment 2		Exam 18:30 - 21:30		<p>Legend</p> <ul style="list-style-type: none"> Lecture Regular Lab Assignments Deadlines/Exam Buffer - Q&A
Christmas Break					

Regular Lectures and Labs

Participation in lectures and labs is not mandatory but all the lectures and labs are part of the exam

Lectures will not be recorded

During the labs, you work autonomously at lab notebooks

Check [brightspace](#) for slides, lab notebooks and solutions

Beginning of the week → slides (short version), lab notebooks, previous week lab solutions

After each lecture → slides (complete version)

Regular Lectures and Labs

Notation between labs, lectures and books might not always be perfectly aligned, so pay attention!

Lab location:

- On Mondays in [Dreibelweg-PC Hall 1 \(building 35\)](#)
- On Wednesdays in [Dreibelweg - PC Hall 2 \(building 35\)](#)
- On Thursdays in [Dreibelweg - Instruction Room 1 \(building 35\)](#)

Topics

Topic	Lecture	Lab
Introduction to Deep Learning	1	1
Feed Forward Neural Networks	2	2
Gradient-based learning	3	3
Optimization	4	4
Convolutional Neural Networks	5	5
Advanced Techniques & Good Practices	6	6
Regularization	7	7
Recurrent Neural Networks	8	8
Reinforcement Learning	9	9

Material

Lab Notebook

Python Notebook (Kaggle)

PyTorch as Deep Learning framework

First your implementation, then PyTorch functions

Books

- *Deep Learning*, by I. Goodfellow, Y. Bengio and A. Courville (2016),
<https://www.deeplearningbook.org/>
- *Understanding Deep Learning*, by Simon J. D. Prince (2023),
<https://udlbook.github.io/udlbook/>
- *Reinforcement Learning: An Introduction*, by R.S. Sutton and A. G. Barto (2018),
<https://inst.eecs.berkeley.edu/~cs188/fa19/assets/files/SuttonBartoIPRLBook2ndEd.pdf>

Check always brightspace for each topic!

Assignments

- Two programming assignments from week 2.2 until week 2.6
- Assignment 1 is not mandatory but good preparation for Assignment 2 that is mandatory and graded
- Labs for both assignments and a peer feedback lab for Assignment 1
- You can participate to the peer feedback lab **only if** you submit the deliverables of Assignment 1 by the deadline (2nd of December)
- Assignment 2 deadline 16th of December
- Repair opportunity for Assignment 2 **only if** you have obtained a grade between 4.0 and 5.7 for a max grade of 6.

Exam

- Wednesday 18th of December from 18:30 - 21:30
- Deadline for the exam registration on Tuesday 3rd of December (14 calendar days in advance)
- Computer-based closed-book test in WebLab
- Open questions and programming questions
- Old and practice exams in [WebLab](#)

Assessment

Final grade = $0.4 * \text{Assignment 2} + 0.6 * \text{Exam}$

Minimum final grade 5.8 to pass the course

Assignment 2

Minimum grade 5.0 to pass the course

Week 2.6 Monday 16th of December - Submission deadline

Exam

Minimum grade 5.0 to pass the course

Week 2.6 Wednesday 18th of December 18:30 - 21:30

Partial grades (Assignment and Exam) are rounded to 0.1 and not valid for future course editions

Final grade will be rounded to 0.5 in Osiris

Teaching Team



Elena Congeduti
Responsible Professor, Lecturer



Taico Aerts
Coordinator

Ali Alper Ataşoğlu
Simina Dragotă
Nicoleta Dobrică
Henk Jekel
Oliwia Książek
Koen Tuin

Teaching Assistants

Questions and Communication

- Ask me during or after lectures, coffee breaks, Q&A sessions
- Come to my office hours on Thursdays from 15:45 - 16:45 (week 2.1 - 2.5) in the lab room [Drebbelweg - Instruction Room 1 \(building 35\)](#)
- Ask TAs during labs (no administration questions)
- Do not email us personally; instead use dl-ai-minor-ewi@tudelft.nl (only administration questions)

But please do ASK!

Course Feedback

I highly value and use constructive feedback to improve the course

- **In-person:** feel free to approach me or the TAs with (respectful) feedback
- **After each lab:** a brief feedback form will be available at the end of each lab notebook
- **End of the course:** a final feedback form will be shared

Code of Conduct

We DO encourage you to help each other, get inspiration from external sources and active participation

- You can compare and discuss lab practicals and Assignment 1
- Peer-feedback session for Assignment 1
- In-class examples and exercises in group

We DO NOT tolerate blind copy, not from online/offline sources, not from AI tools, not from each other

- Work at the mandatory Assignment 2 individually
- Do not share (part) of your solutions to the mandatory Assignment 2
- Focus on understanding more than on finding an easy solution

Questions?

Prior Knowledge

Probability and Statistics: random variables, mean, variance, distributions

Calculus: multiple variable functions, partial derivatives, gradient

Linear Algebra: vectors, matrices, operations

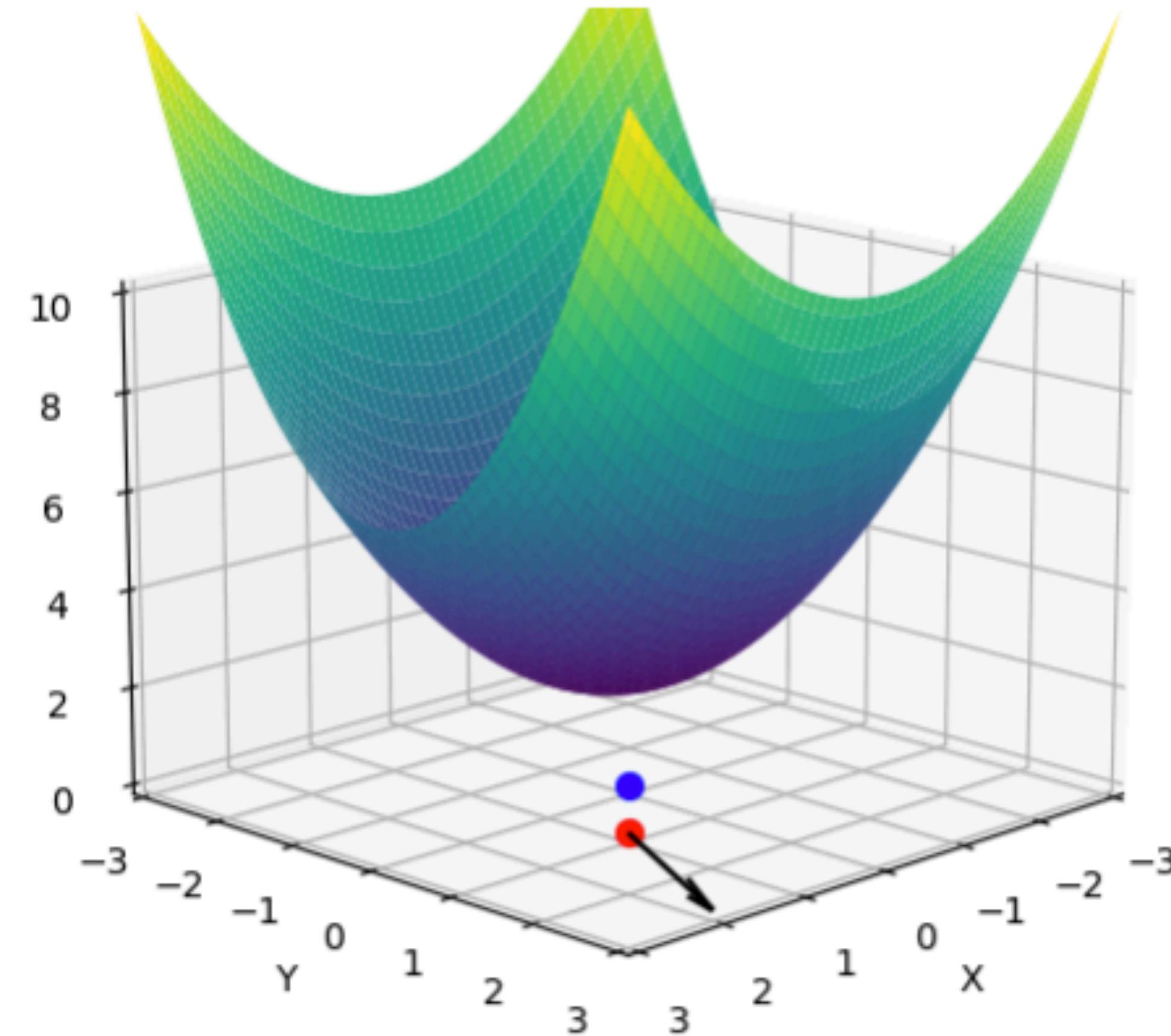
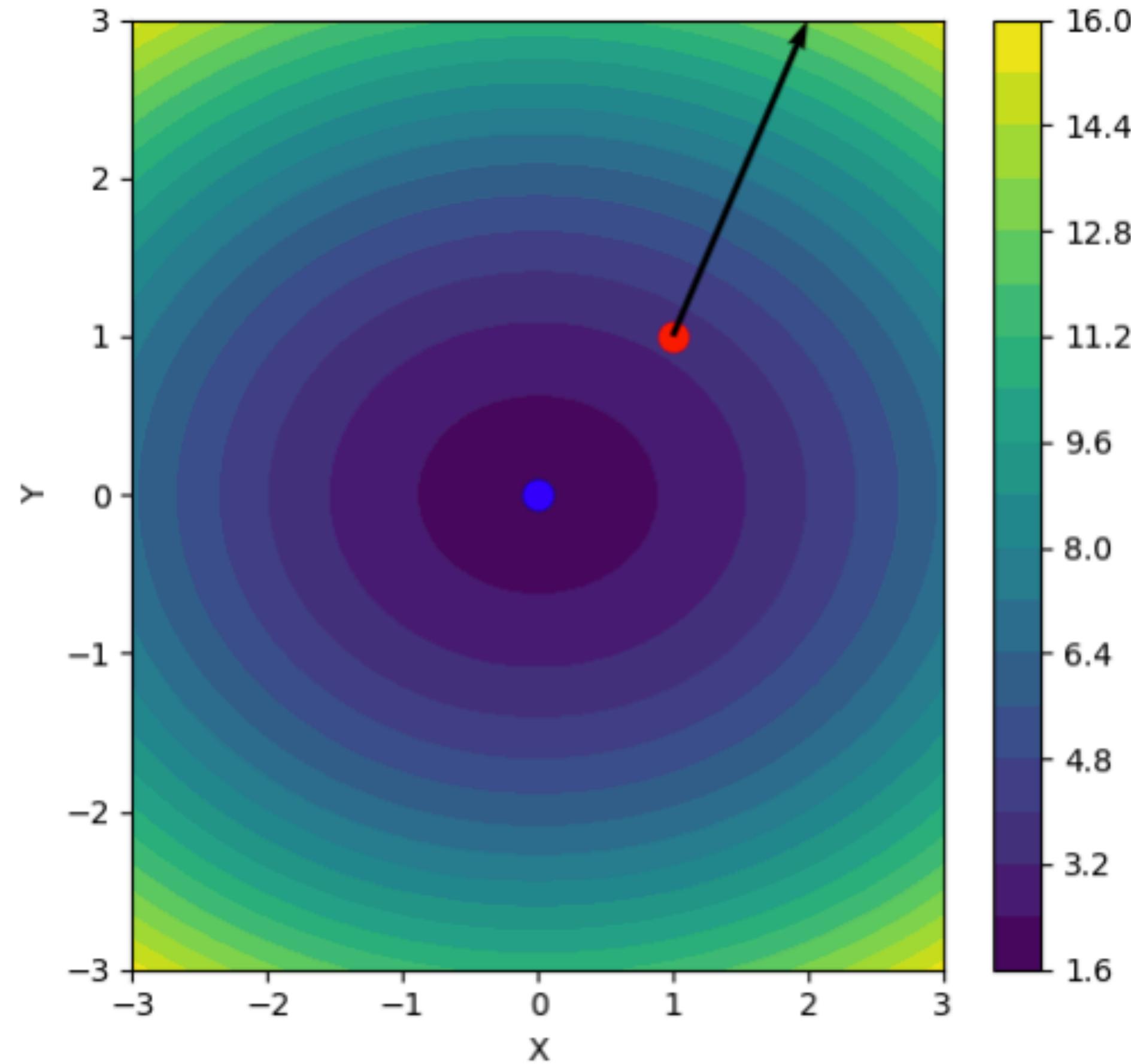
Python Programming: Numpy

Check Brightspace for the material

Probability and Statistics Refresh

- Go to Brightspace → Introduction to Deep Learning → Probability and Statistics refresh - Notebook
- Work in group of 2 or 3
- Go through the notebook and answer the questions with your peers
- If you have doubts, raise your hand or come to me
- Around 15 minutes then discuss together

Calculus Refresh



$$f(x, y) = \frac{x^2}{2} + y^2 + 2$$

Machine Learning vs Human Learning

Super-human capacity to solve complex tasks



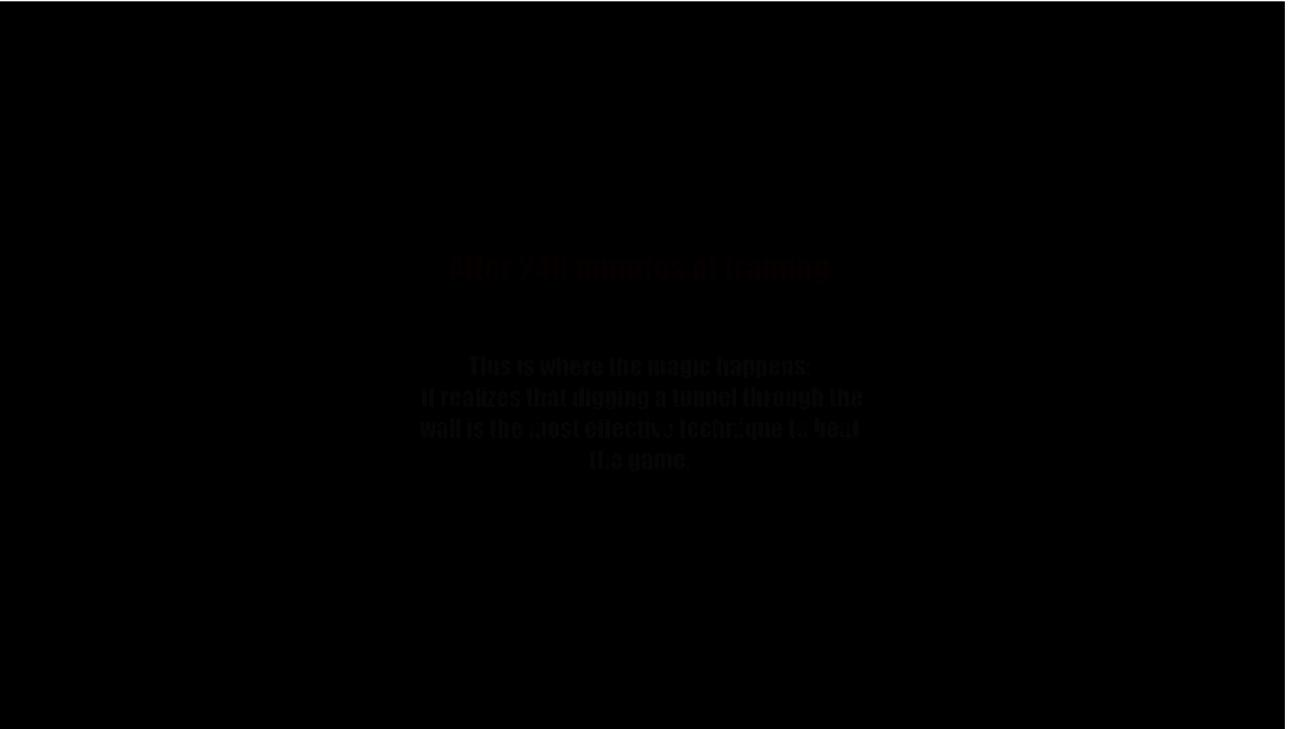
Google DeepMind AlphaGo for the game of Go

Machine Learning vs Human Learning

Super-human capacity to solve complex tasks



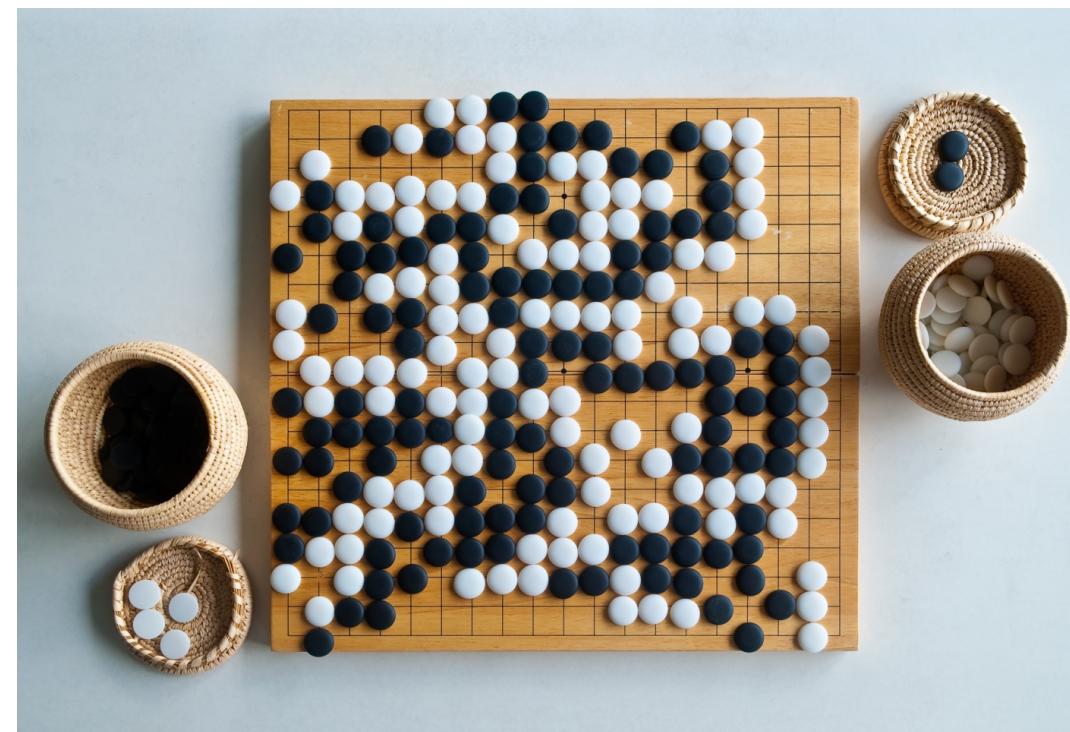
Google DeepMind AlphaGo for the game of Go



Google DeepMind's Deep Q-network for Atari Breakout

Machine Learning vs Human Learning

Super-human capacity to solve complex tasks



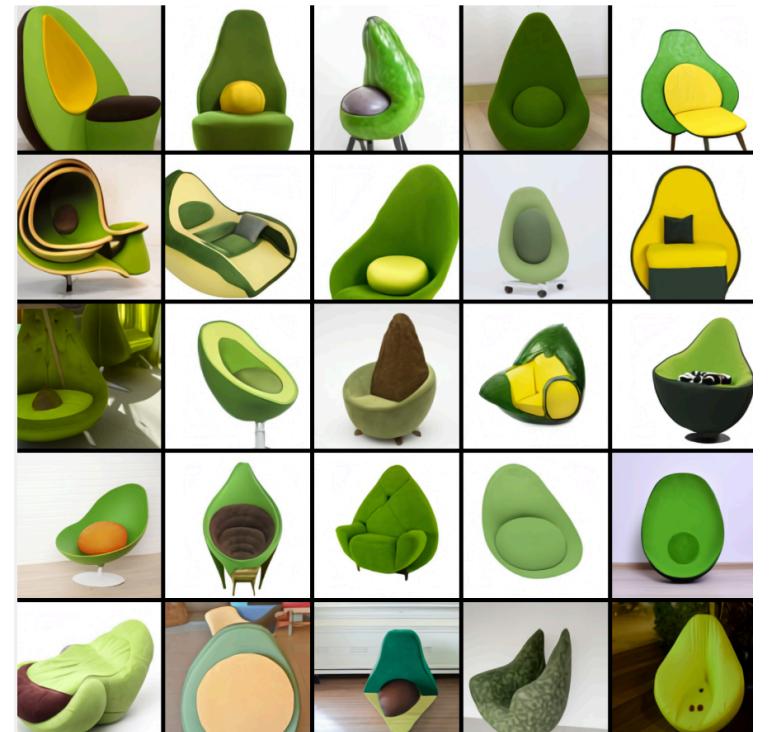
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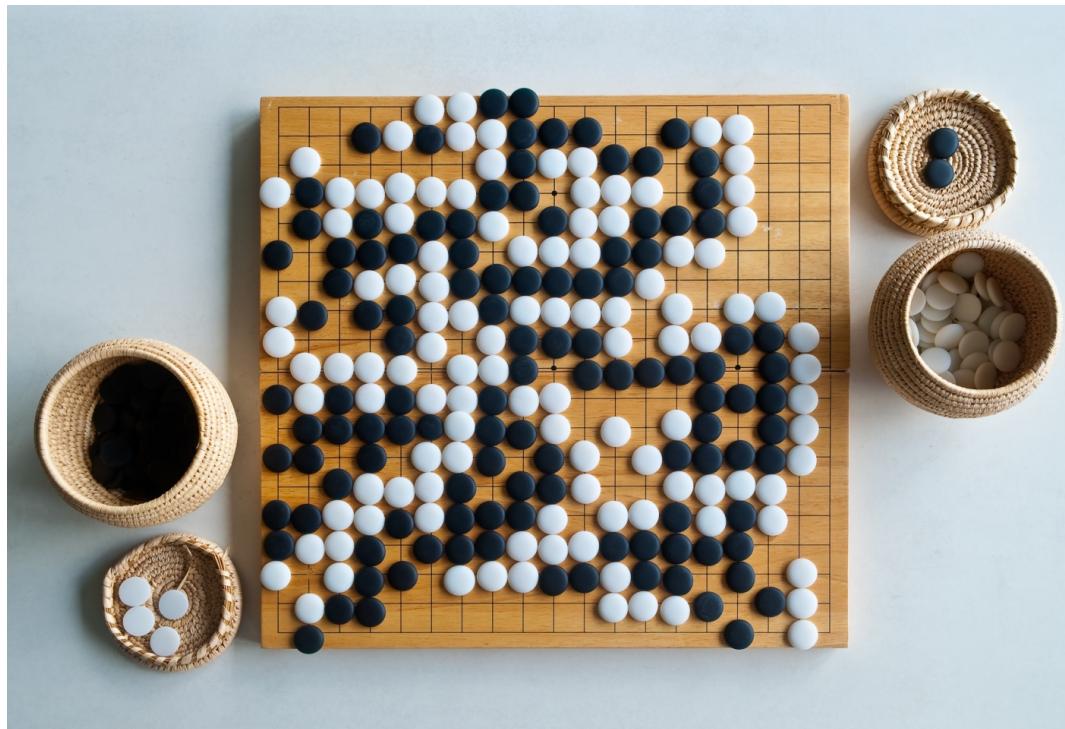
The image shows a screenshot of a ChatGPT interface. At the top, there is a green button labeled "EC" and a text input field asking for a description of an image suitable for representing ChatGPT. Below this, a message from ChatGPT is displayed: "The image features a clean and modern chat interface displayed on a smartphone or computer screen. The chat window shows a conversation between a user and ChatGPT, with the ChatGPT logo or name visible at the top. The user avatar is a simple person icon, and on the other side, the ChatGPT avatar represents a friendly and approachable AI assistant. The conversation content demonstrates ChatGPT's helpful responses and intelligent interactions. The background is professional, and subtle design elements like speech bubbles and chat indicators enhance the conversational theme. Overall, the image portrays ChatGPT as a user-friendly and capable chatbot." There is also a "Regenerate" button and a "Send a message" input field.

OpenAI GPTs for language models and image generation

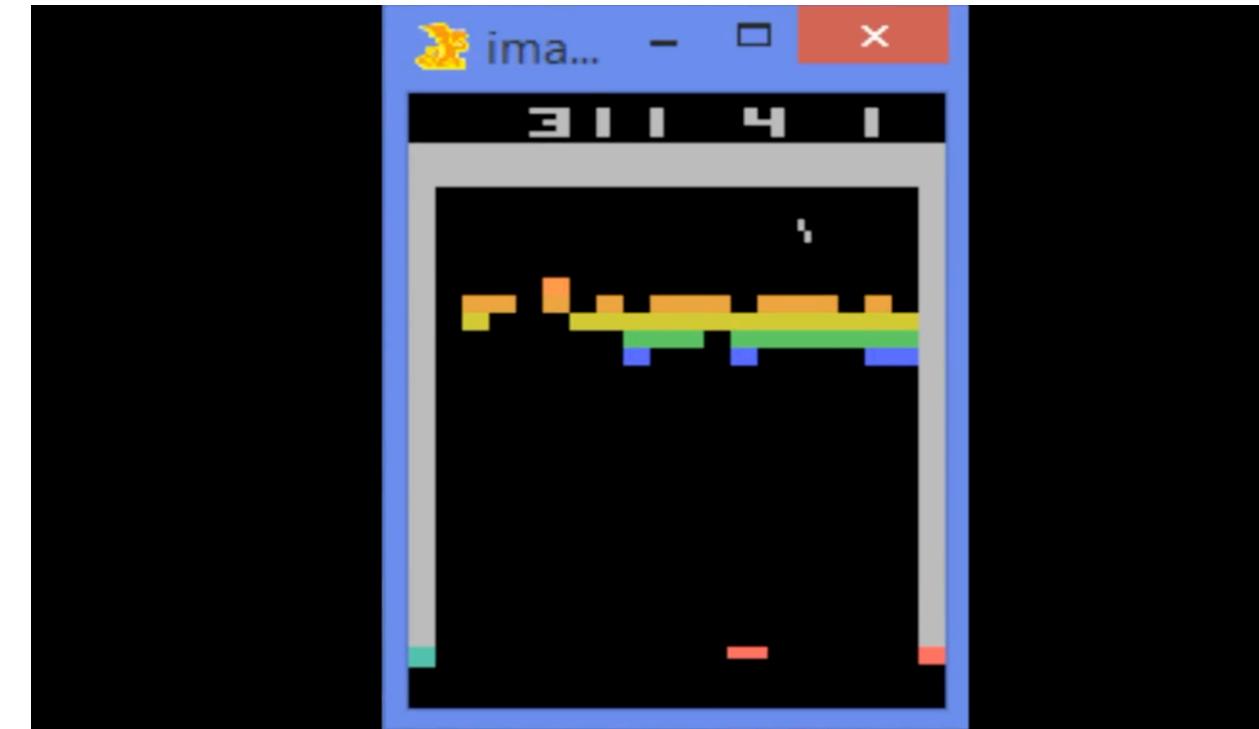


Machine Learning vs Human Learning

Super-human capacity to solve complex tasks



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EC Provide a description of an image suitable for representing ChatGPT in a slide presentation.

2 / 2

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Regenerate

Send a message

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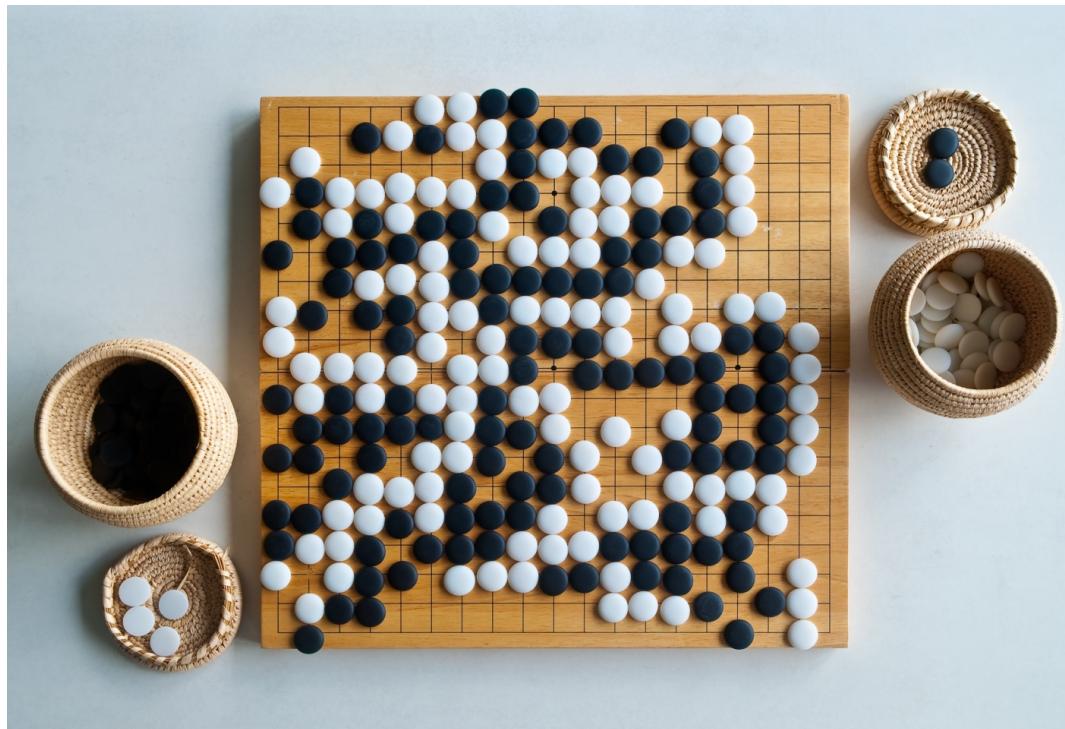
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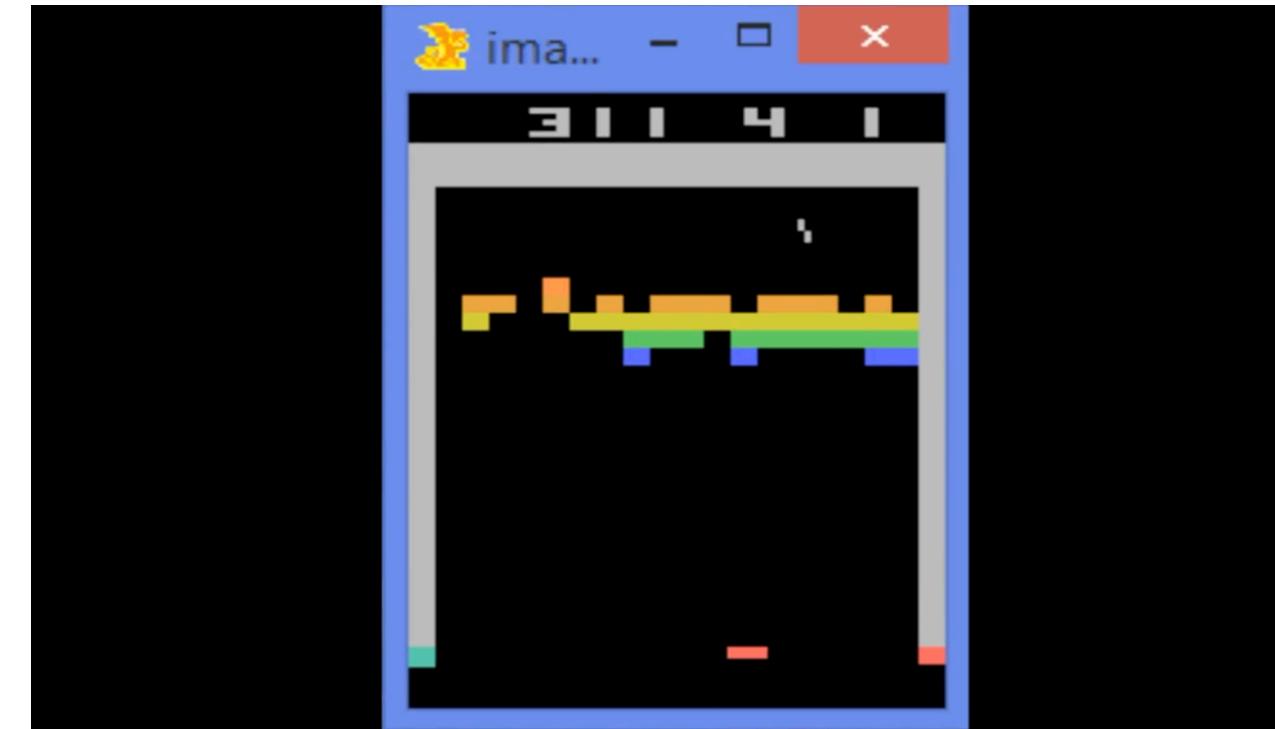
Why is this impressive?

Machine Learning vs Human Learning

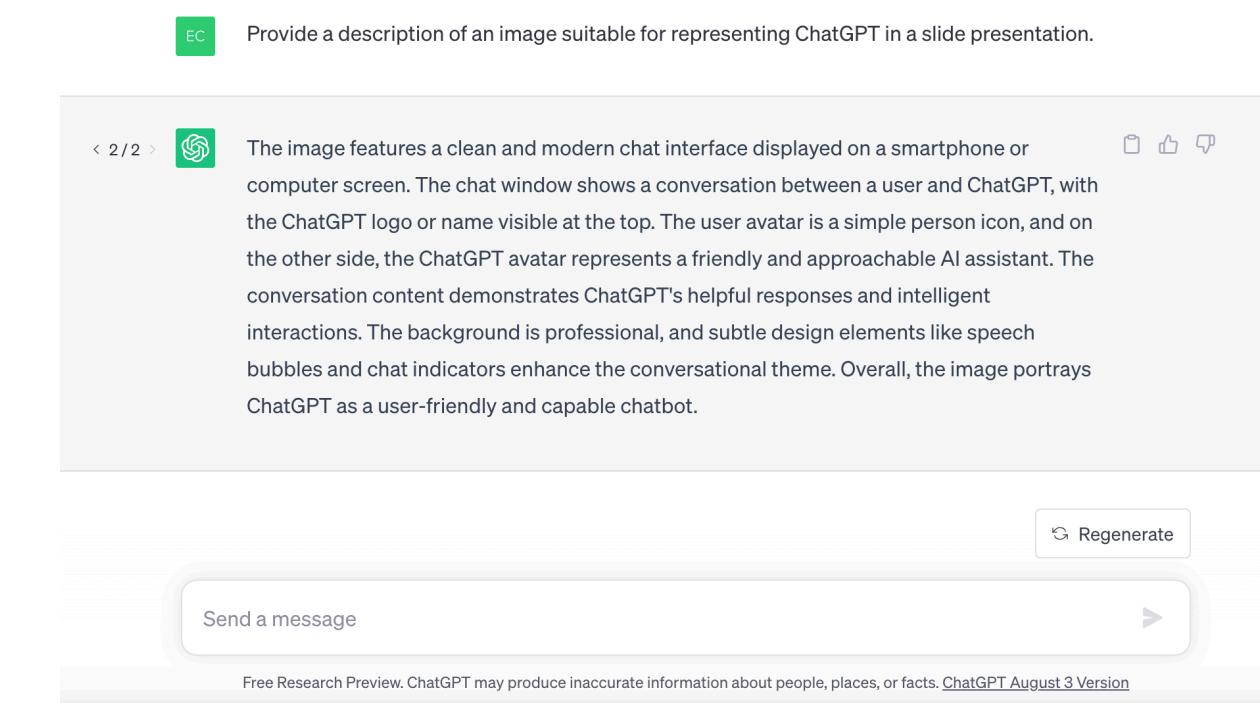
Super-human capacity to solve complex tasks



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OpenAI GPTs for language models and image generation



At least $10^{10^{24}}$ Go games

84×84 resolution, 10^{10^4} possible images

English words are at least 150k

Number of atoms in the observable universe $\approx 10^{80}$

Machine Learning vs Human Learning

Muffins or Chihuahua?

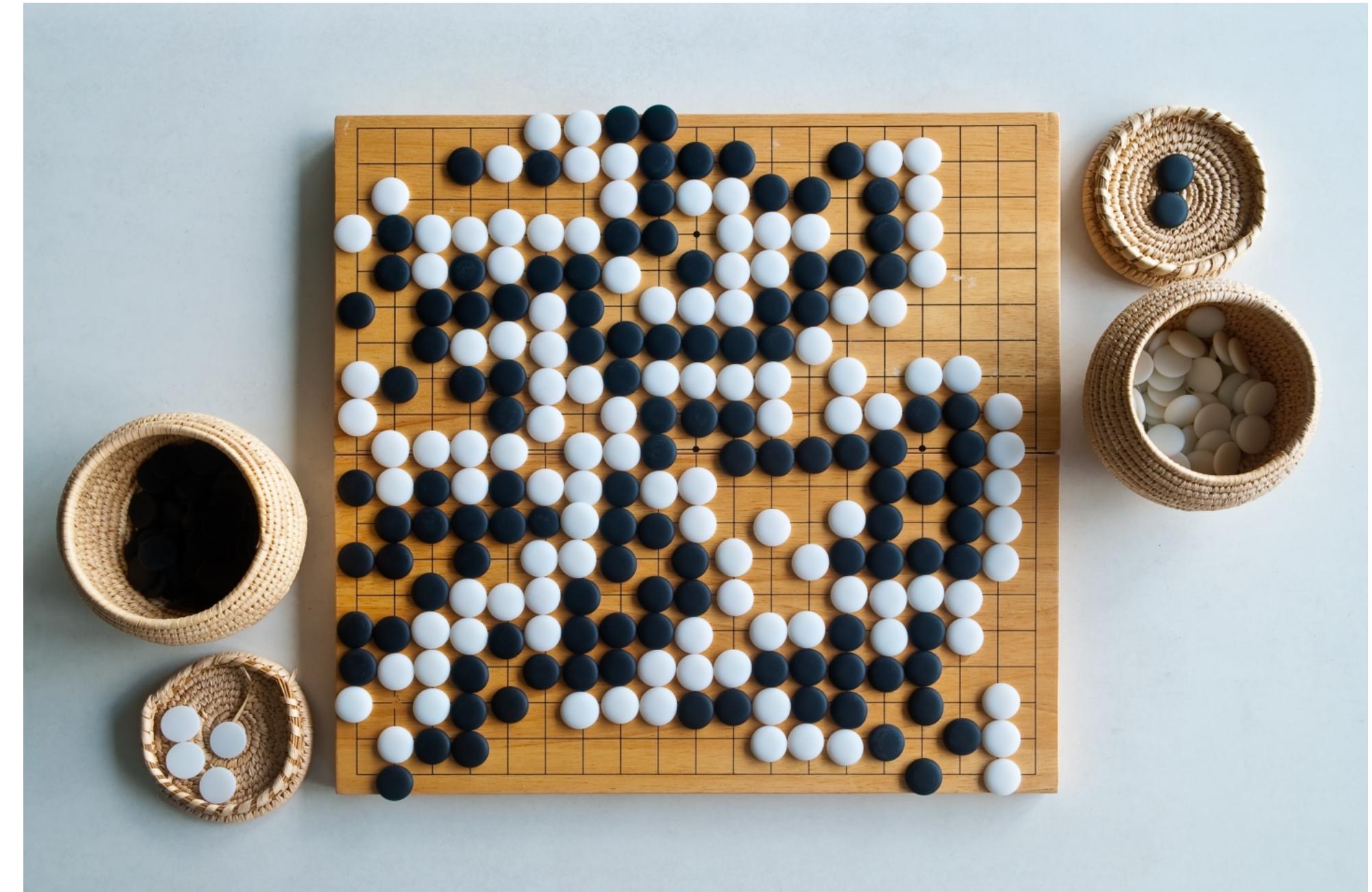


Machine Learning vs Human Learning

Muffins or Chihuahua?



AlphaGo beats the Go world champion



What makes the two tasks different?

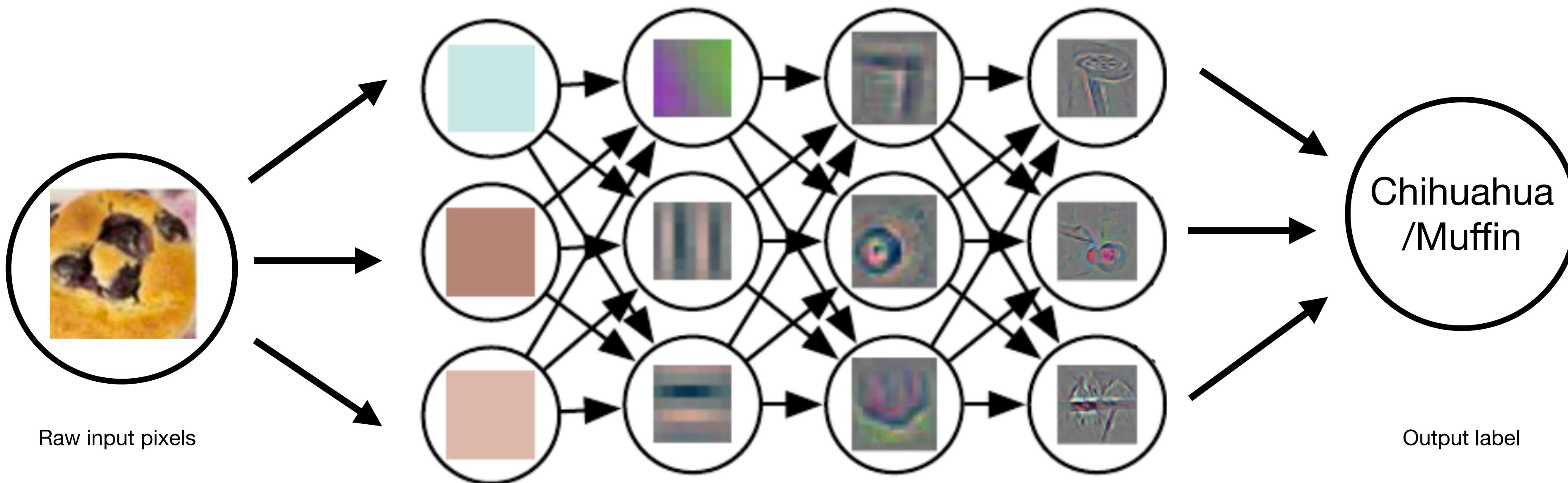
Deep Learning Way

Muffins or Chihuahua?



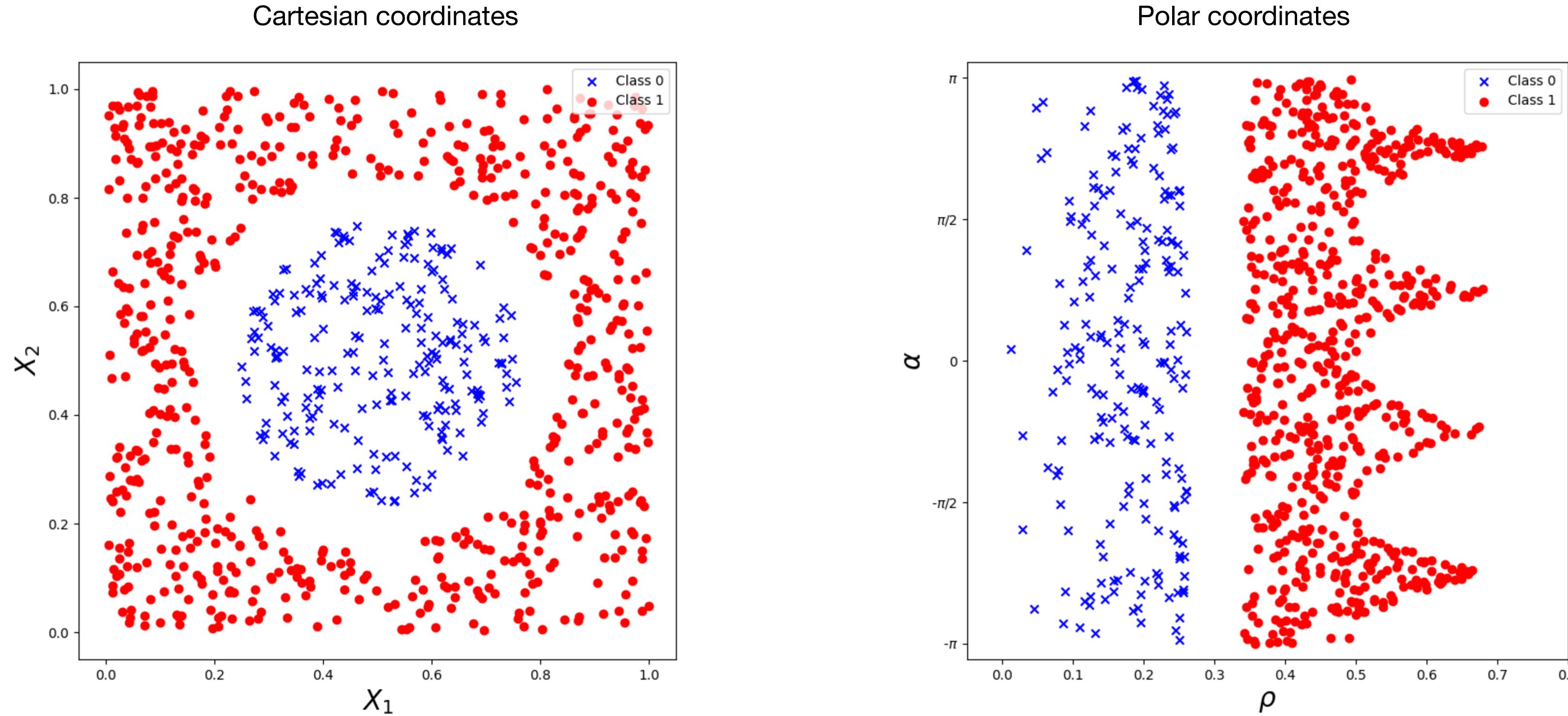
Deep Learning Way

Muffins or Chihuahua?



Forming a deep hierarchical representation

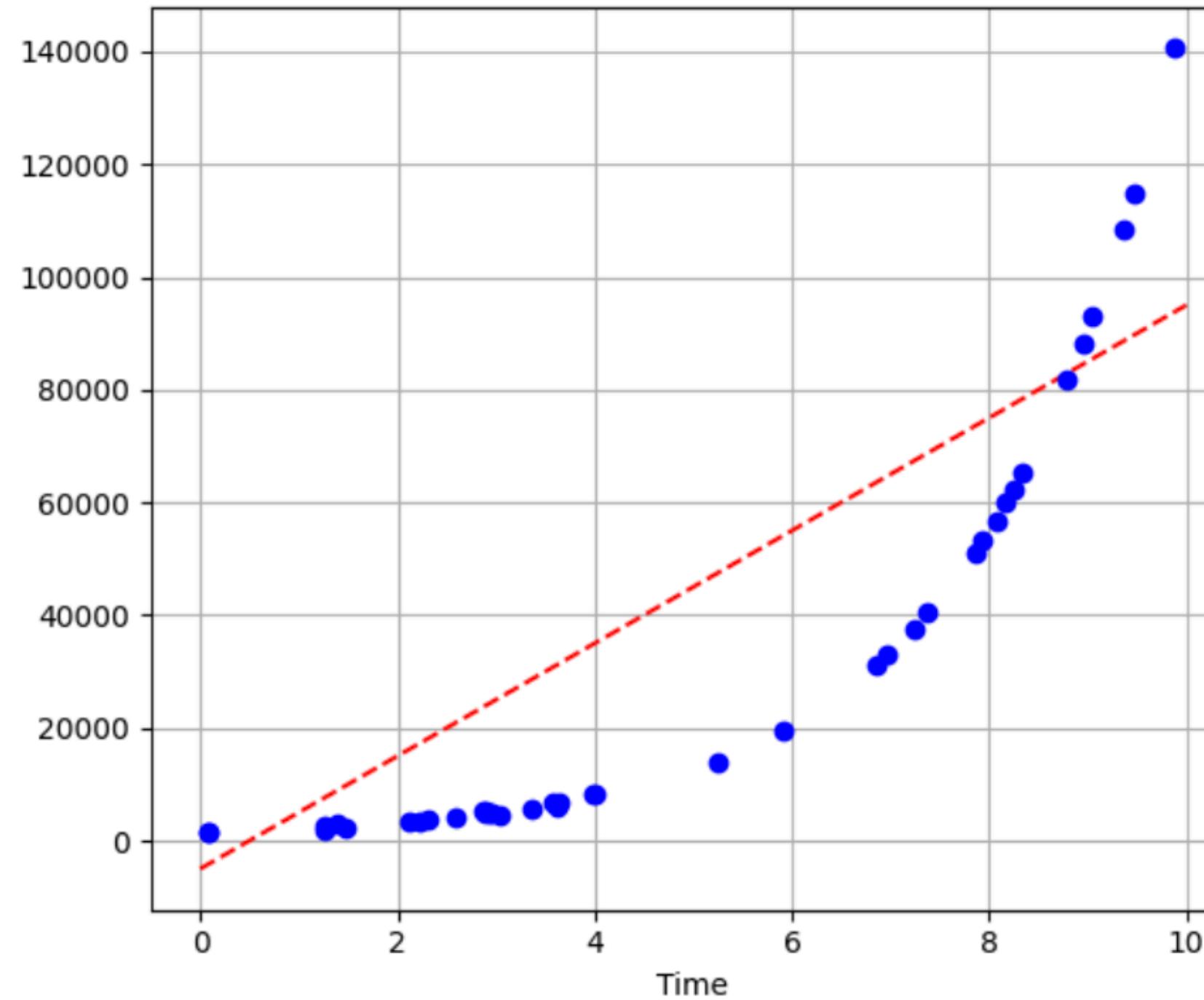
Representation Matters



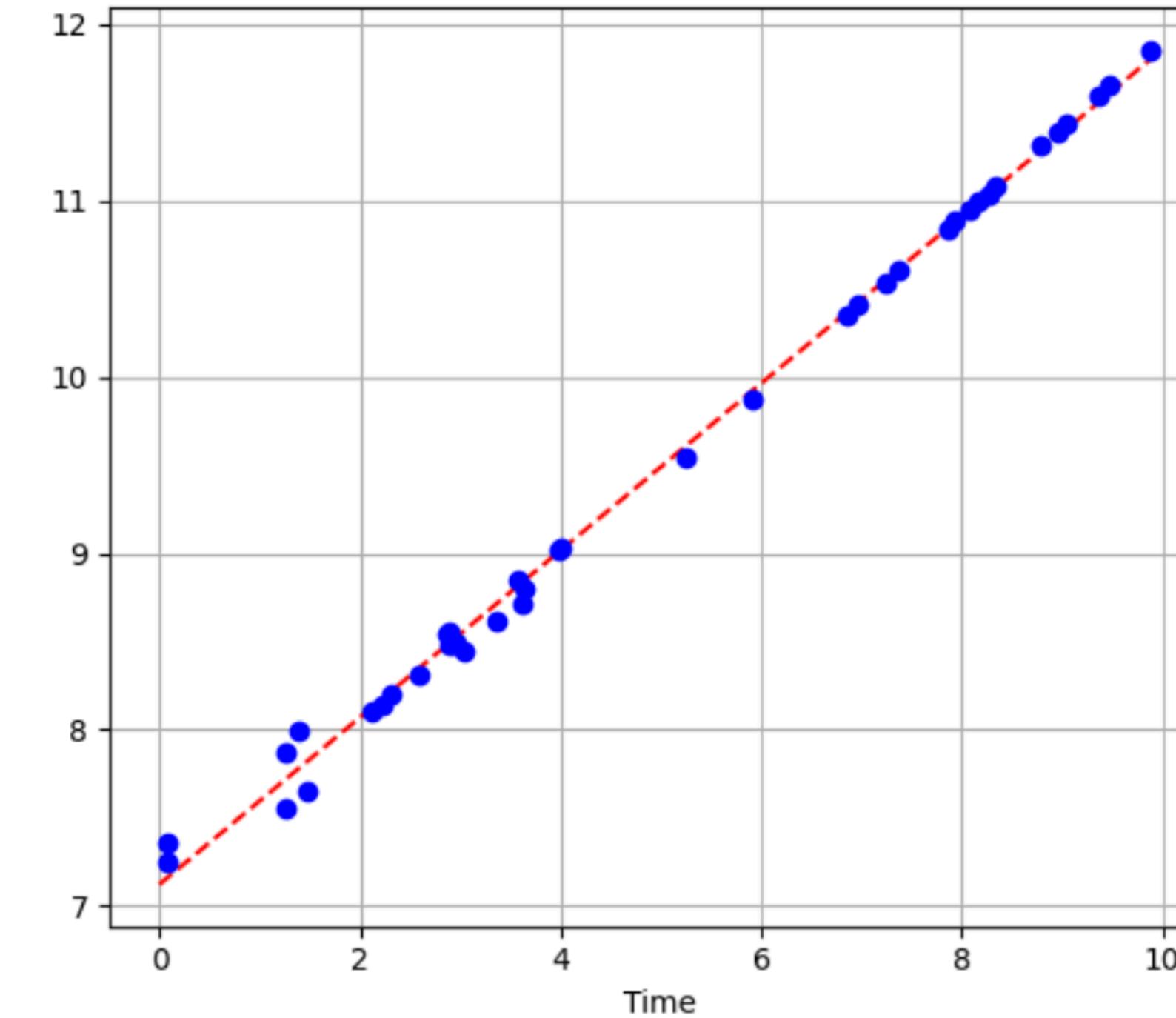
Binary classification task: distinguish between two classes regular devices (class 0) and suspicious devices (class 1)

Representation Matters

Number of bacteria



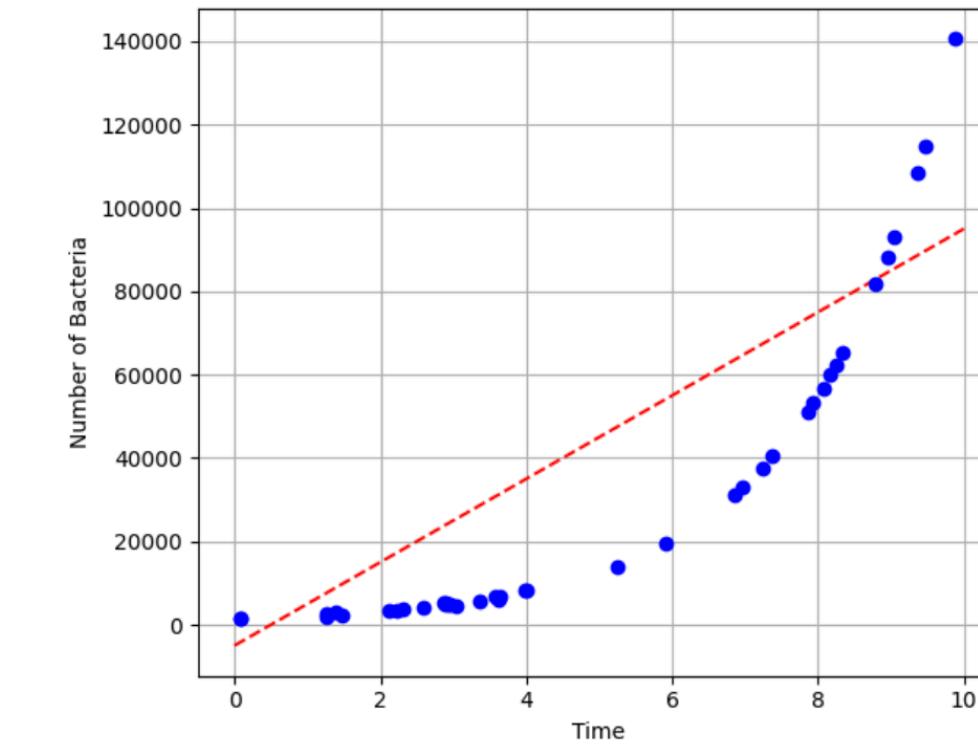
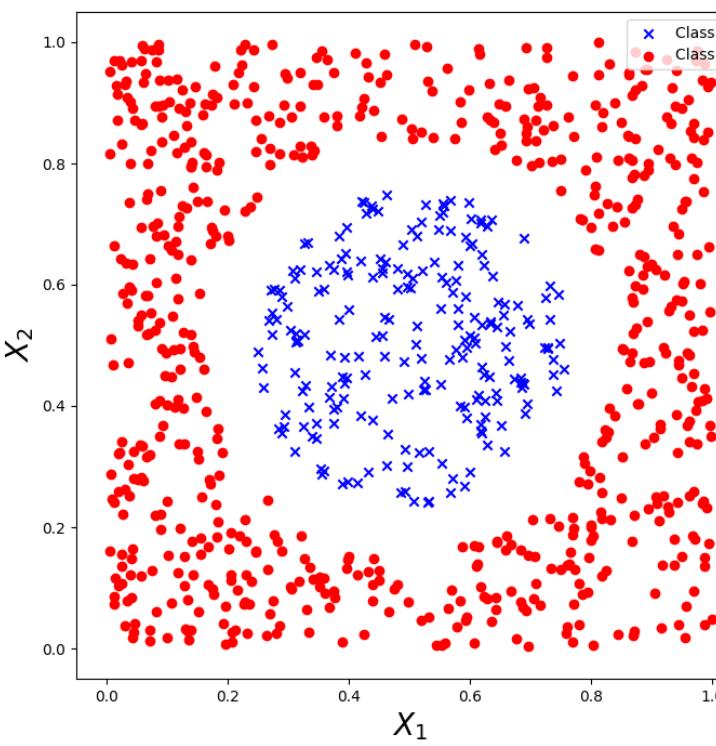
Logarithmic scale



Regression task: predict the growth of bacteria population in time

Learning Tasks

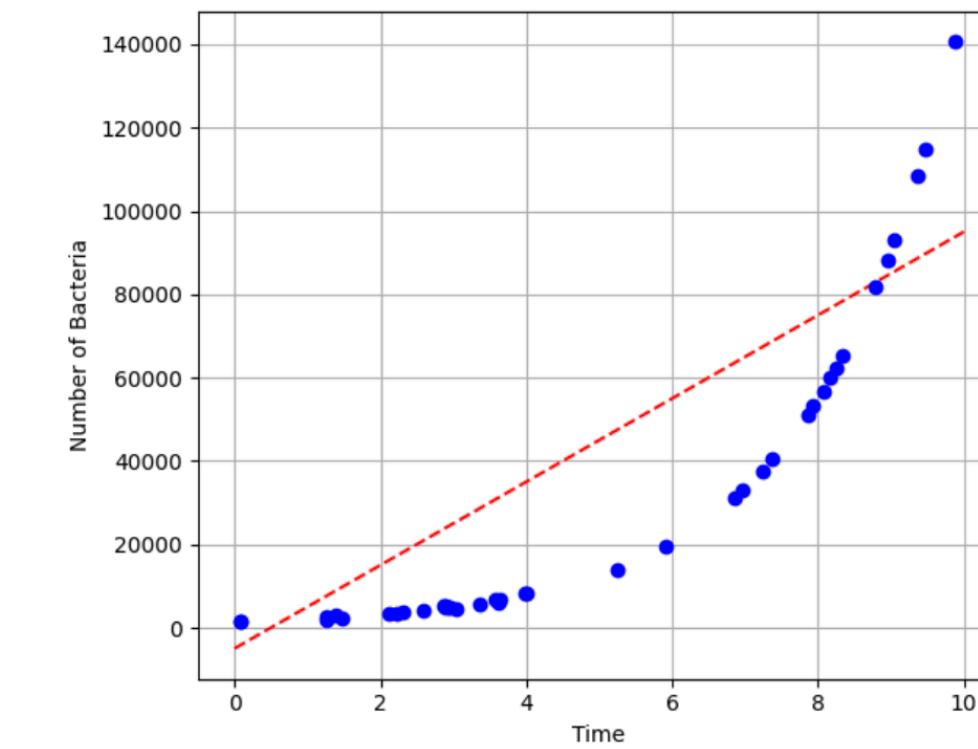
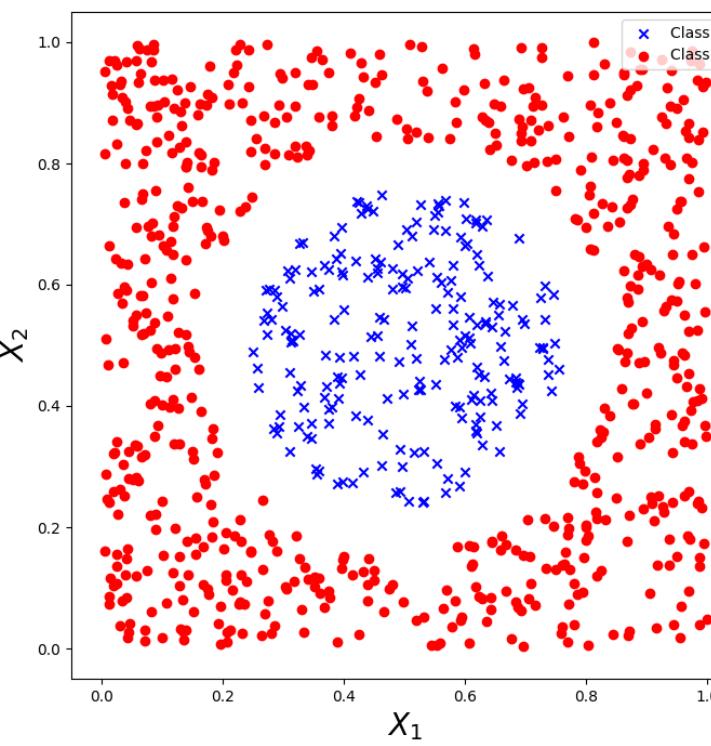
- Supervise learning
 - classification
 - regression



What is the difference between regression and classification?

Learning Tasks

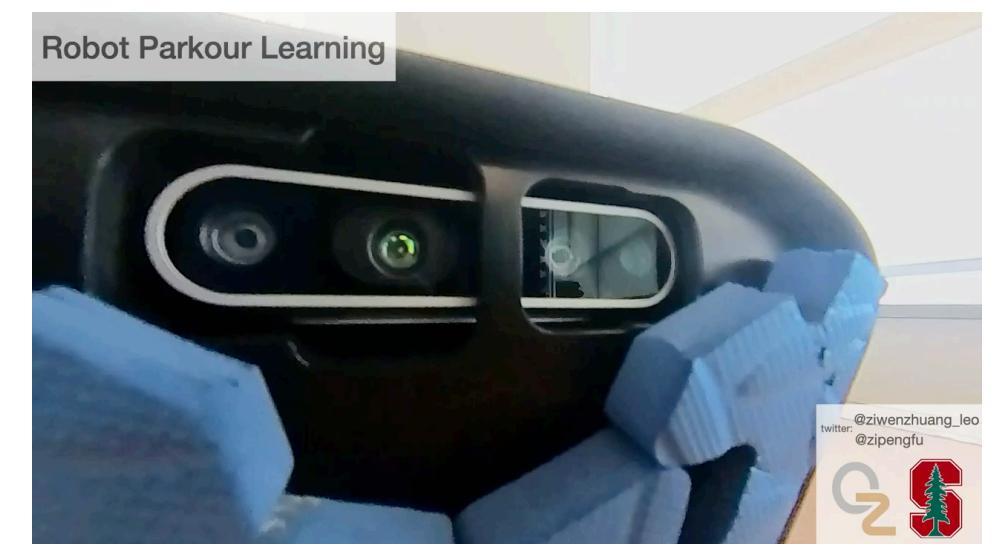
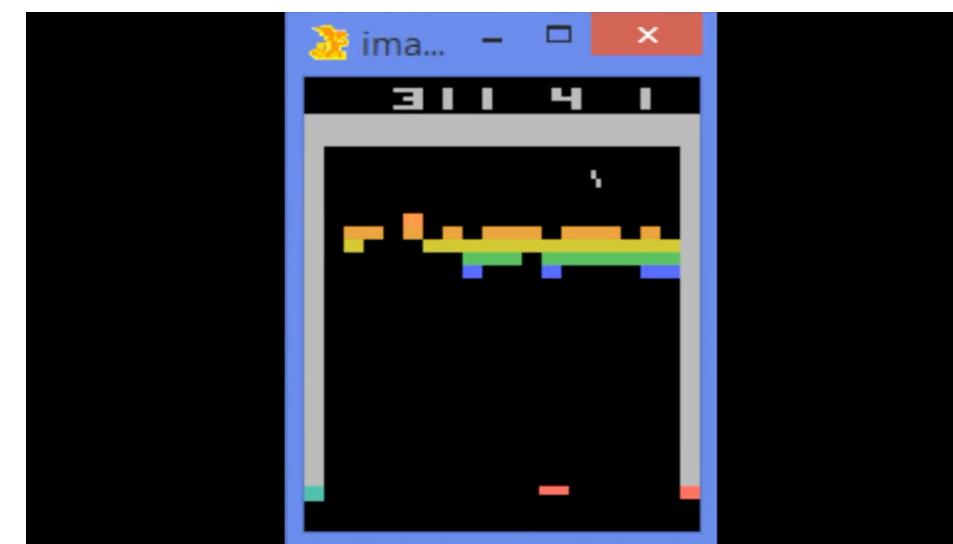
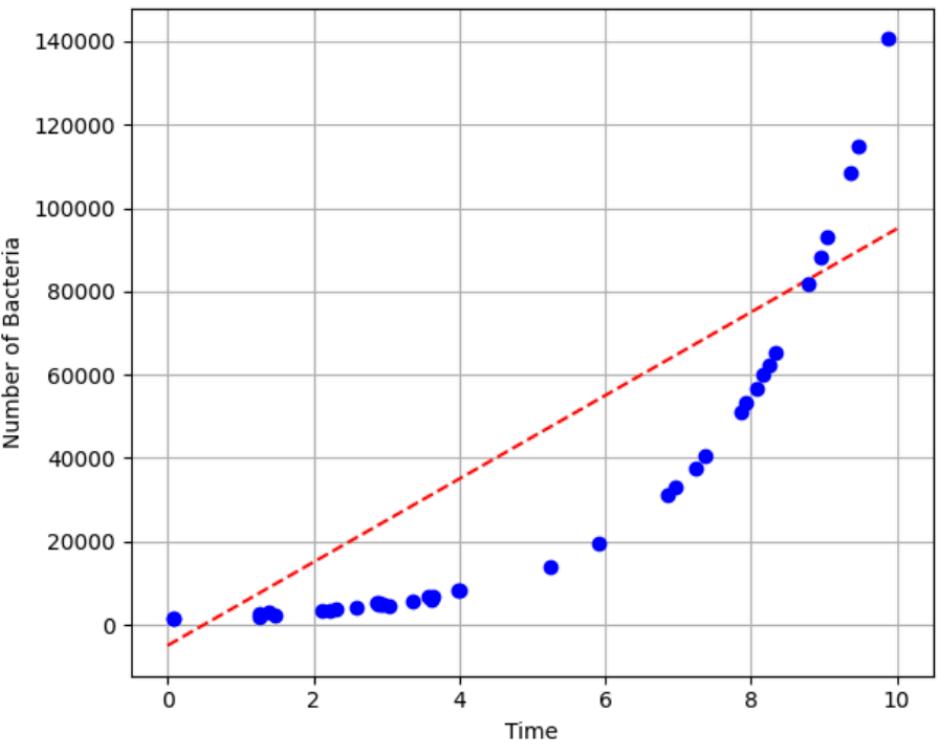
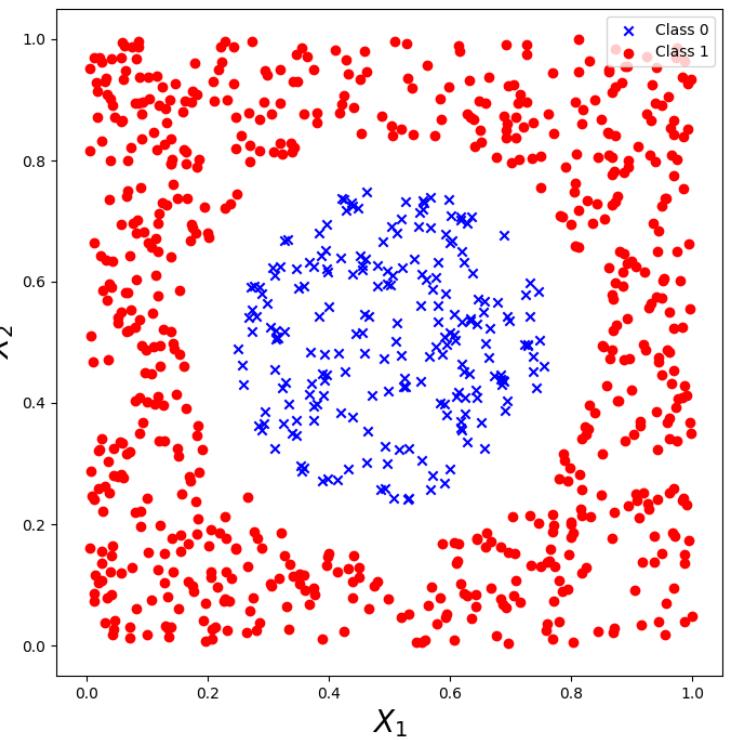
- Supervise learning
- Unsupervised learning
 - clustering
 - dimensionality reduction
 - anomaly detection



What is the difference between supervised and unsupervised?

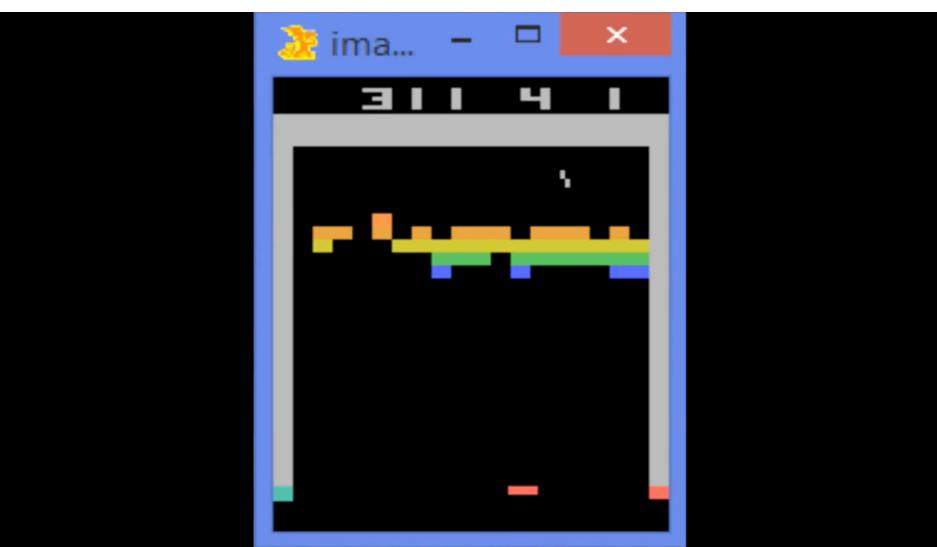
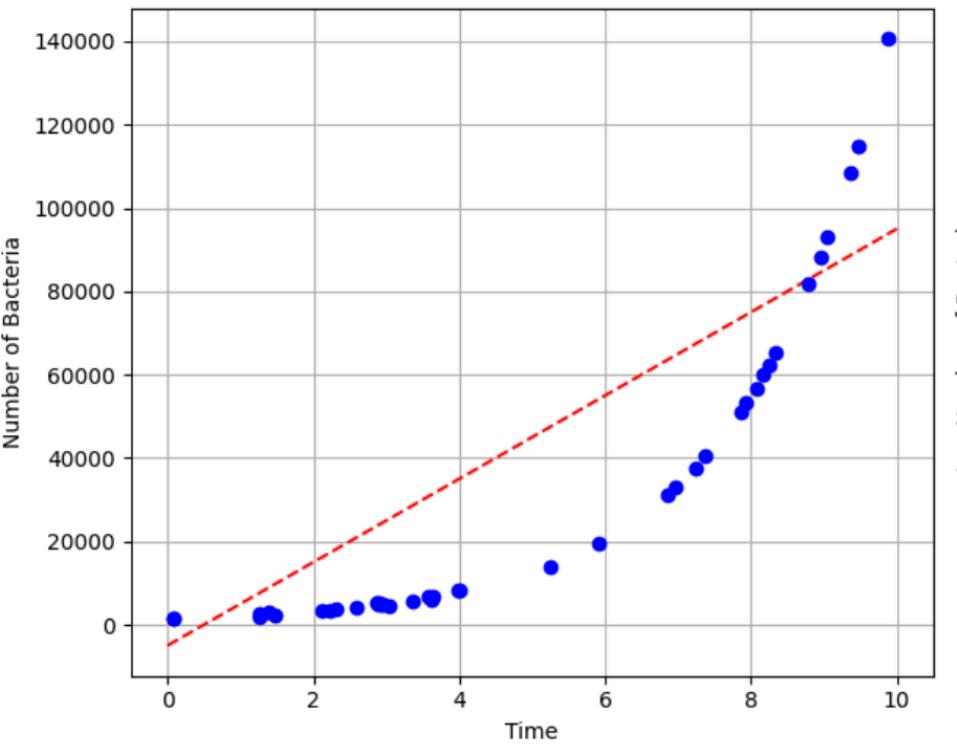
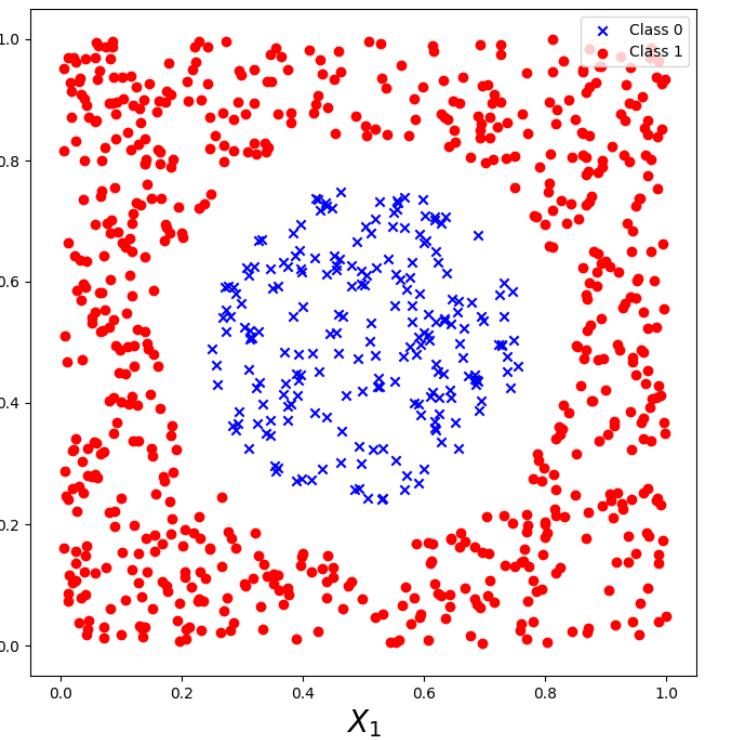
Learning Tasks

- Supervise learning
- Unsupervised learning
- Reinforcement learning



Learning Tasks

- Supervise learning
- Unsupervised learning
- Reinforcement learning
- Generative learning



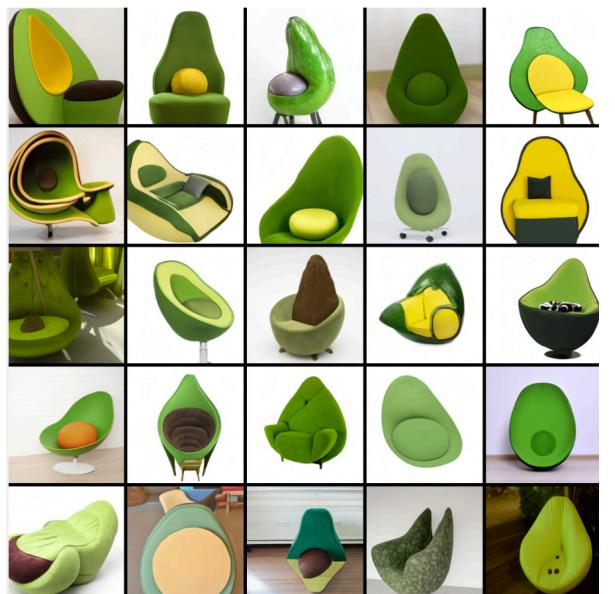
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More Learning Tasks: Object Detection

Summary

Topics

1. Intro to machine vs human learning
2. Probability and Statistics, Calculus Refresh
3. Learning Tasks

Reading material

- *Deep Learning* - [Chapter 1: Introduction](#) pag. 1 - 8
- [Probability and Statistics Refresh - Notebook](#)

