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A DIGITAL HEALTH HUB FOR
THE SOUTH WEST AND WALES

Engineering and
Physical Sciences
Research Council

Artificial Intelligence in Healthcare:

Opportunities, Challenges, and Critical Perspectives

Presenter: Dr Miquel Perelló Nieto

10 March 2025

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About me Dr Miquel Perelló Nieto

Research experience

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sphere

TAILOR
Foundation of Trustworthy AI:
Integrating Learning, Optimisation and Reasoning

Research Interests

- Machine Learning
- Uncertainty quantification
- Optimal decision making
- Real-world applications
- Healthcare

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What is the LEAP Digital Health Hub?

Addressing unmet health and social care needs across South West England and Wales

Connecting industry, academics, and health and social care providers

Increasing regional digital health capability through opportunities for training, research, and innovation

leap-hub.ac.uk

leap-dh-hub@bristol.ac.uk

@LEAP_hub

leap-dh-hub

Sign up to the Hub's mailing list

Collaborative research funding in 4 key themes:

- Care outside of the hospital
- Service and resource planning
- Frailty, fall prediction and fall prevention
- Smartphone and wearable technologies

Ways to get involved

Funded fellowships, internships, networking and development opportunities

Programme of short courses designed for professionals across the digital health community

University of BRISTOL | UWE Bristol University of the West of England | UNIVERSITY OF BATH | CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD | University of Exeter | HDRUK Health Data Research UK | UKRI Engineering and Physical Sciences Research Council

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AI initiatives in the NHS

NHS England

Understand AI

Learn about AI and its potential to transform health and care.

Develop AI

Find resources to help you design and build AI solutions that meet the requirements of the NHS and social care.

Adopt AI

Understand best practice in commissioning AI and get inspired by learning how organisations overcome challenges they faced adopting AI.

https://transform.england.nhs.uk/ai-lab/explore-all-resources/

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Agenda

1. What is AI?
2. AI in healthcare
3. Demistifying AI
4. Ethics and Regulations
5. Conclusion

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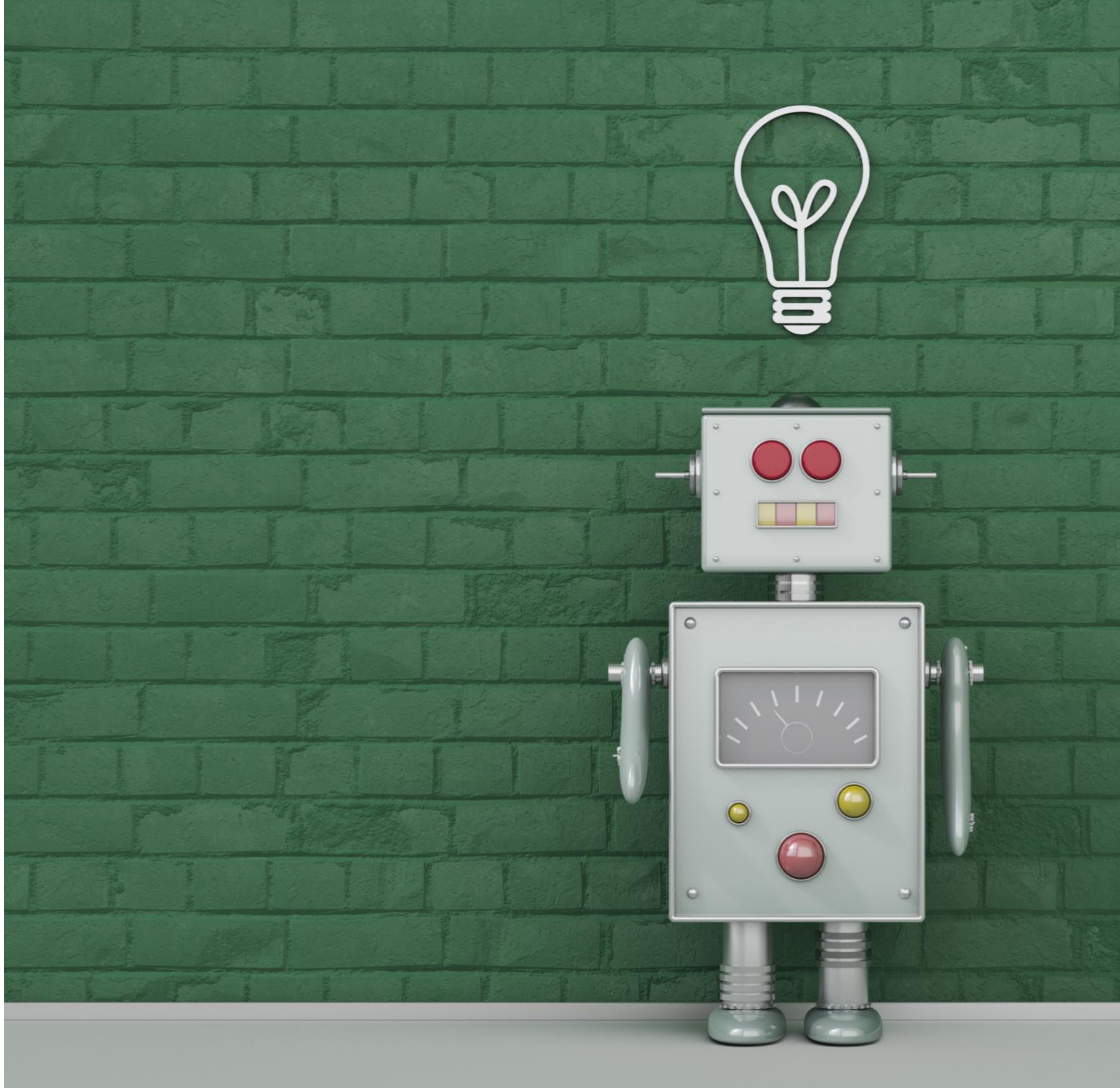
1. What is AI?

a. Examples
b. AI vs Machine Learning



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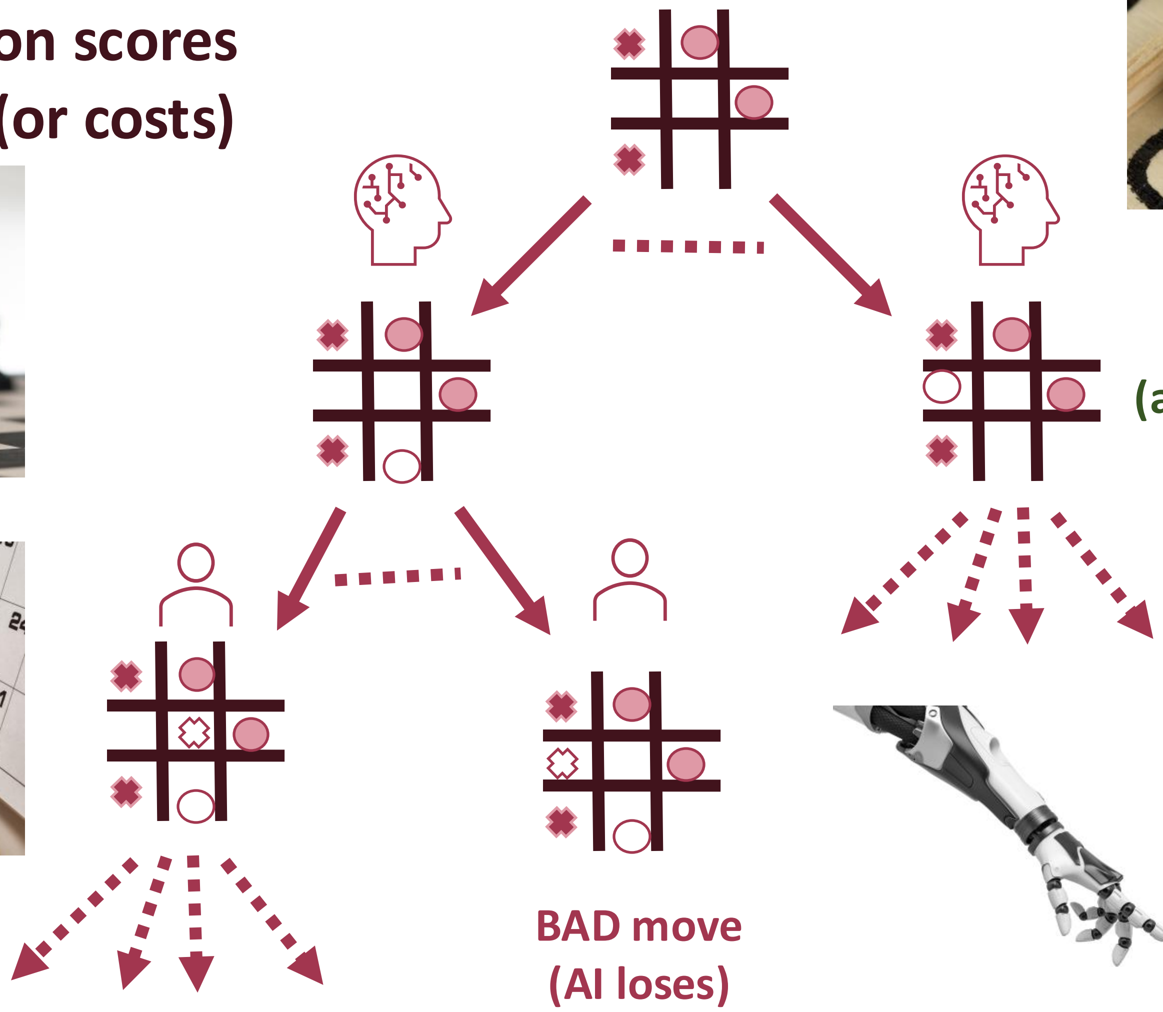
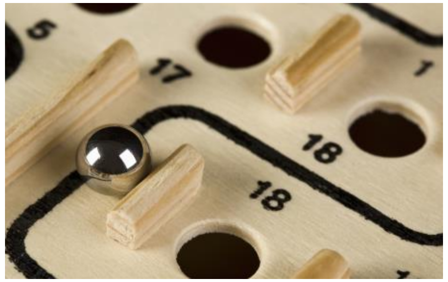
AI example: Search algorithms

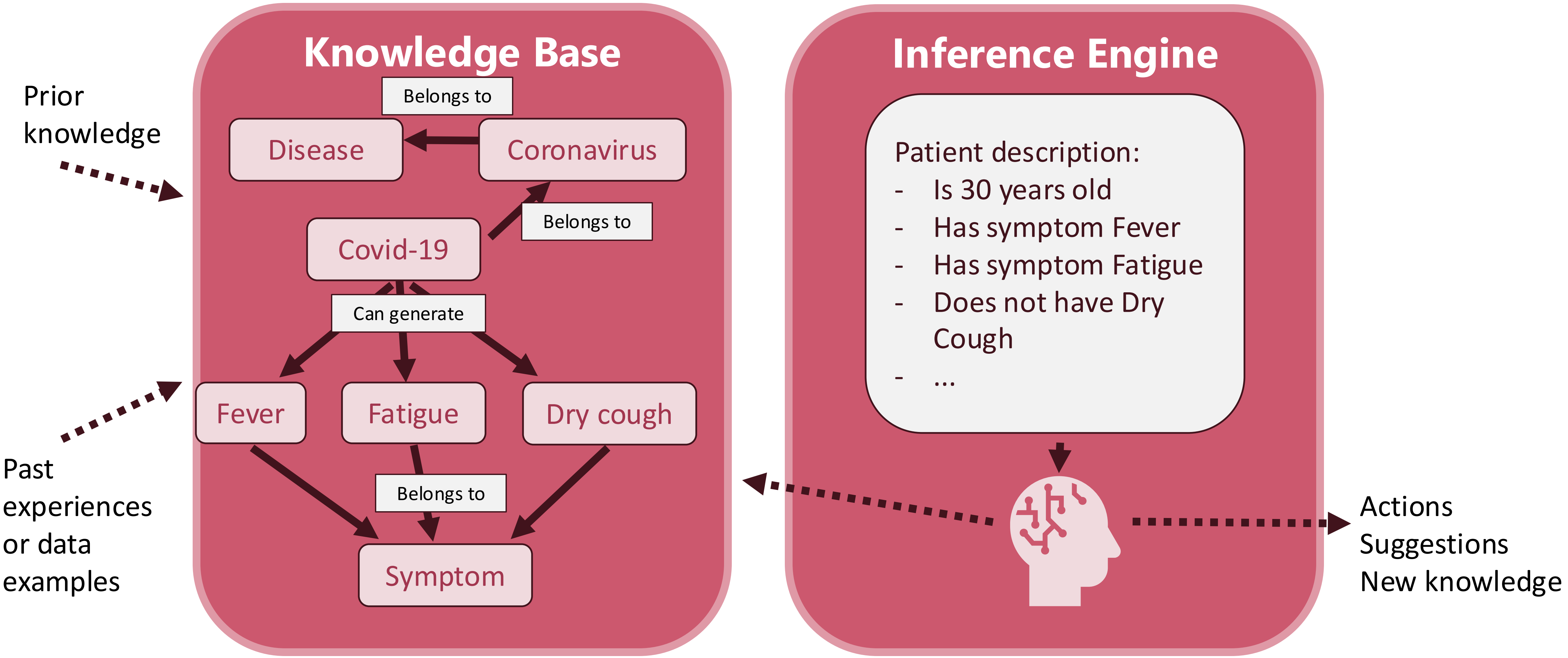
Decisions based on scores (or costs)





Good move (avoids human winning)

AI example: Knowledge base



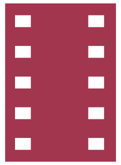
AI examples

Information retrieval

- Google searches
- Online articles
- Restaurants
- Travel agencies


Recomender systems

- Similar to information retrieval but with personal profile
- Movie recommendations
- Music recommendations
- Online shoping



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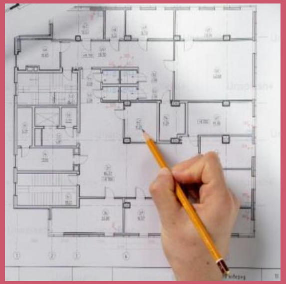
AI and Machine Learning

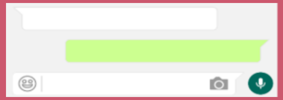
Artificial Intelligence (AI)

Less data requirements



Machine Learning (ML)

Deep Learning



More data

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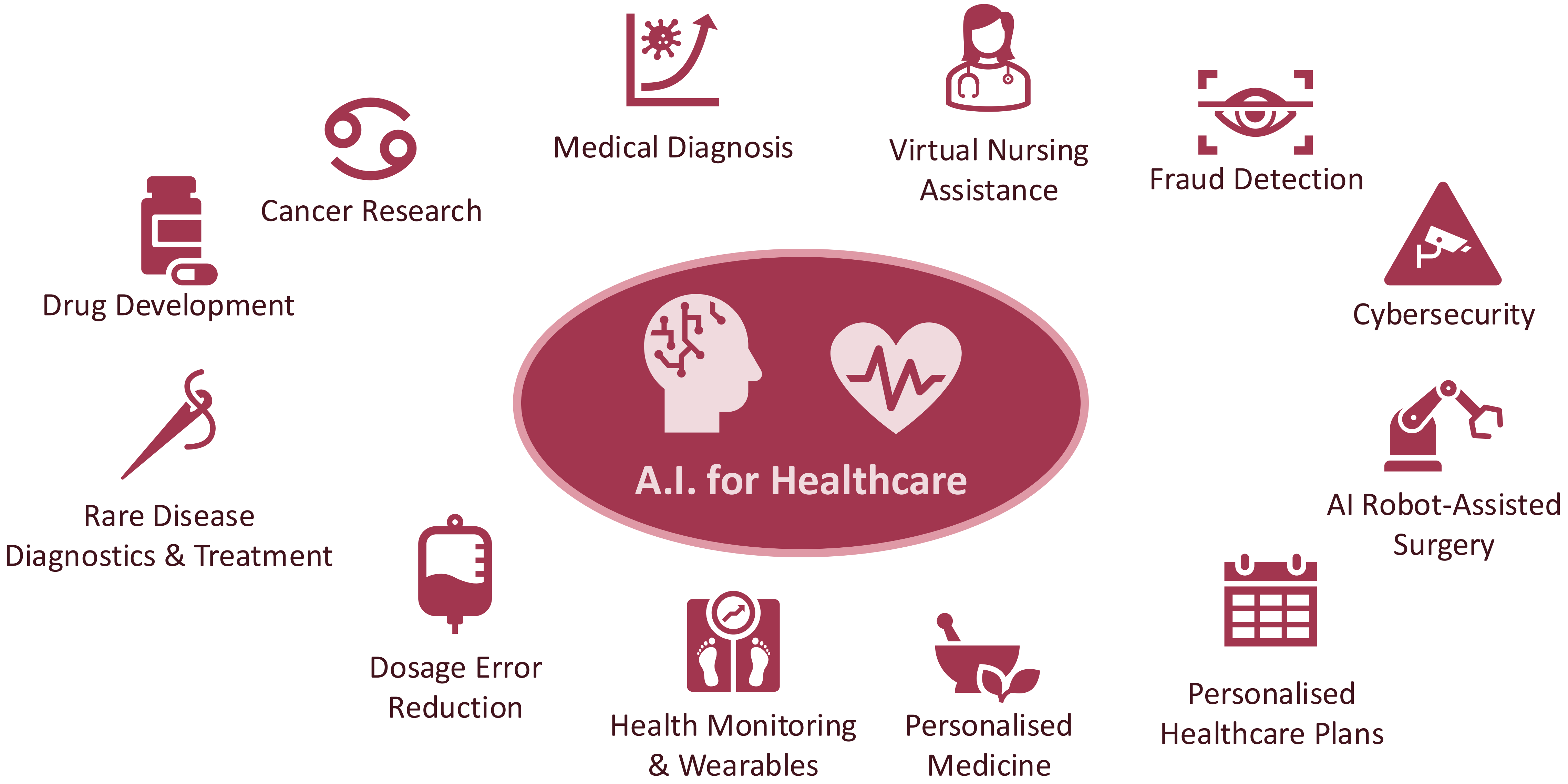
2. AI in Healthcare

a. Applications
b. Examples

Applications of AI in Healthcare



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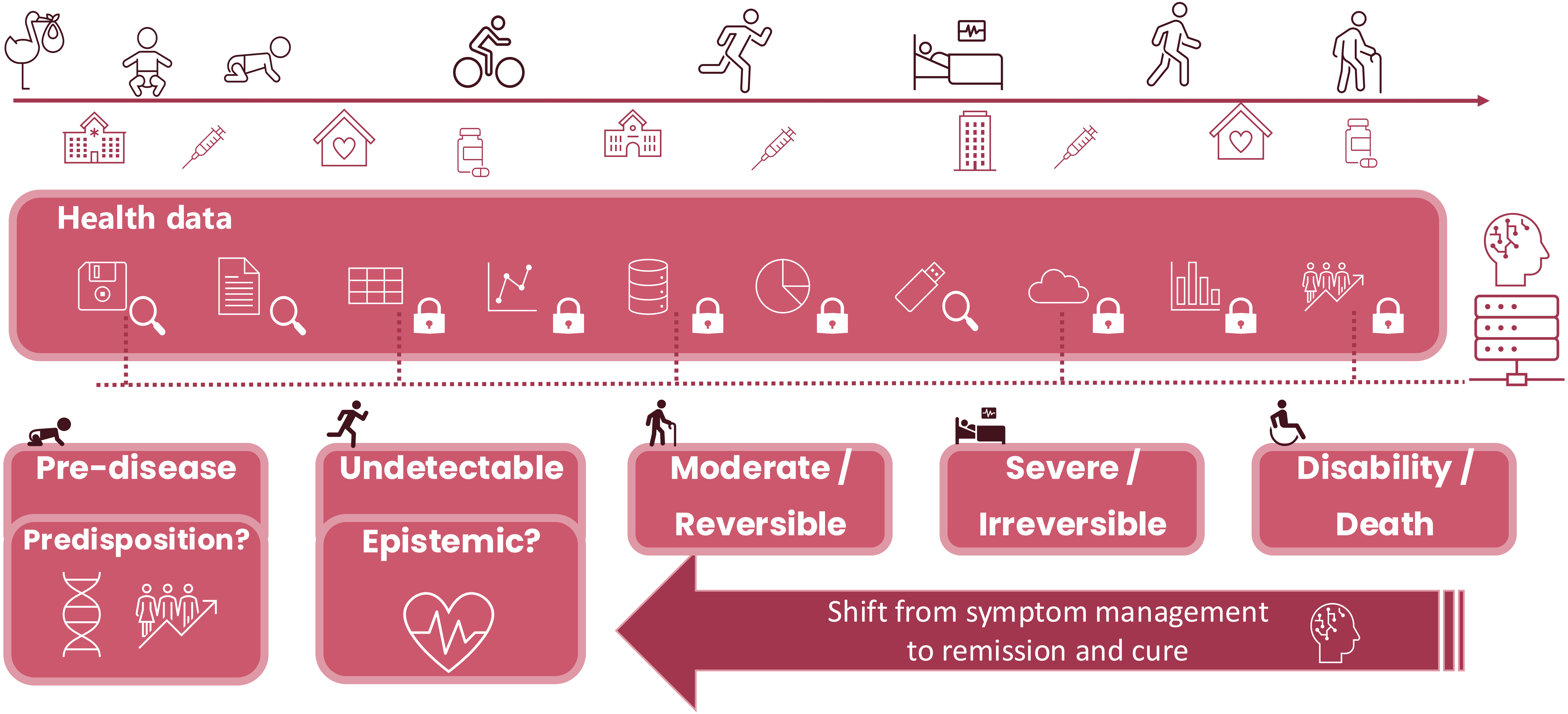
Early diagnosis



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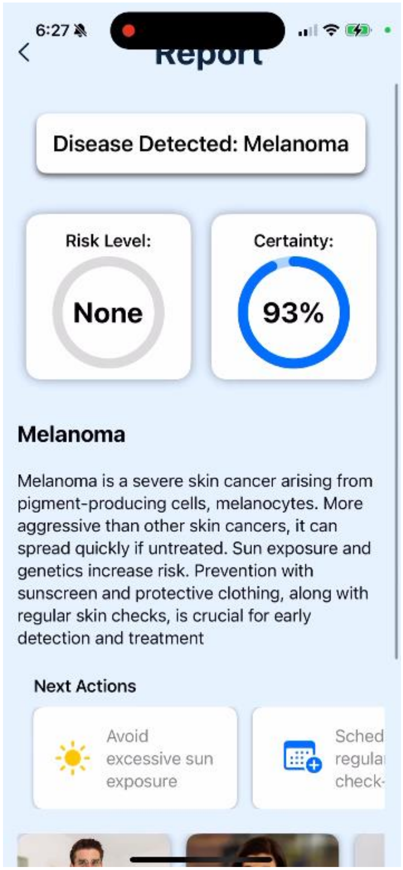
2. AI in Healthcare

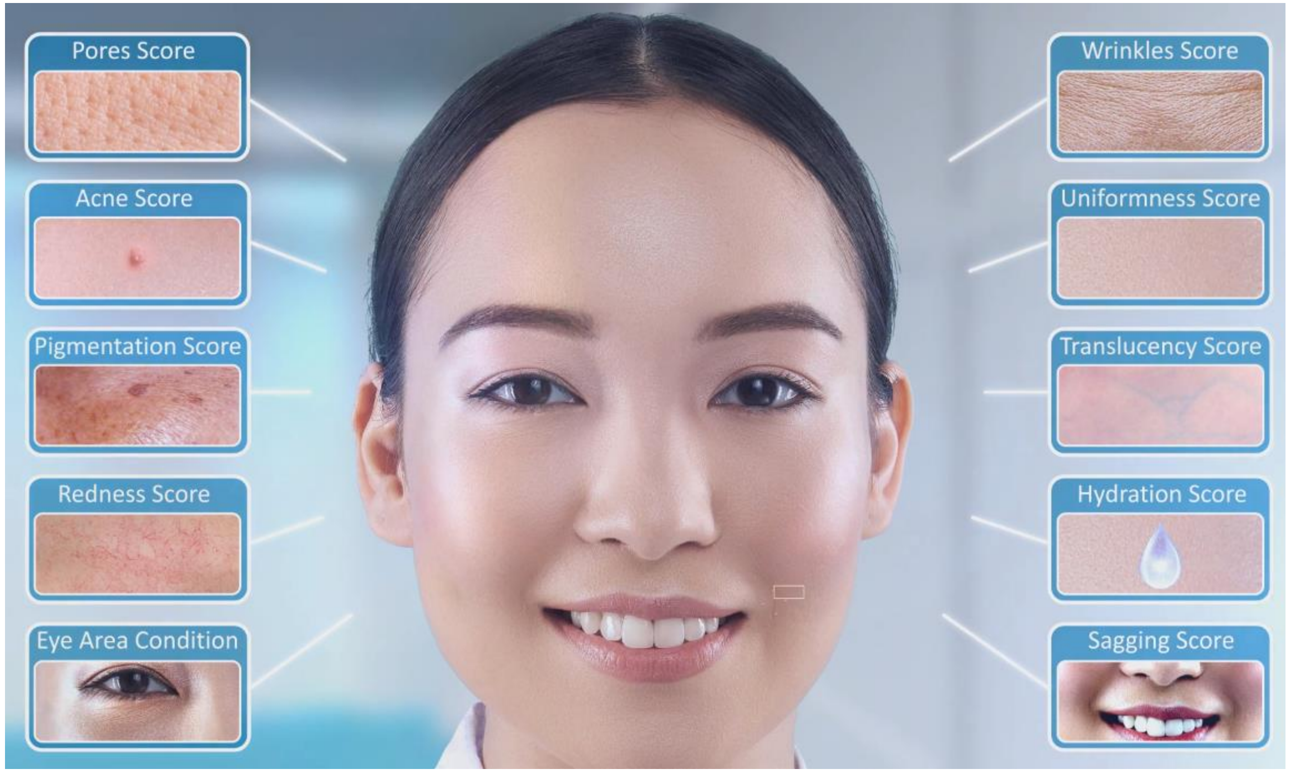
a. Applications
b. Examples

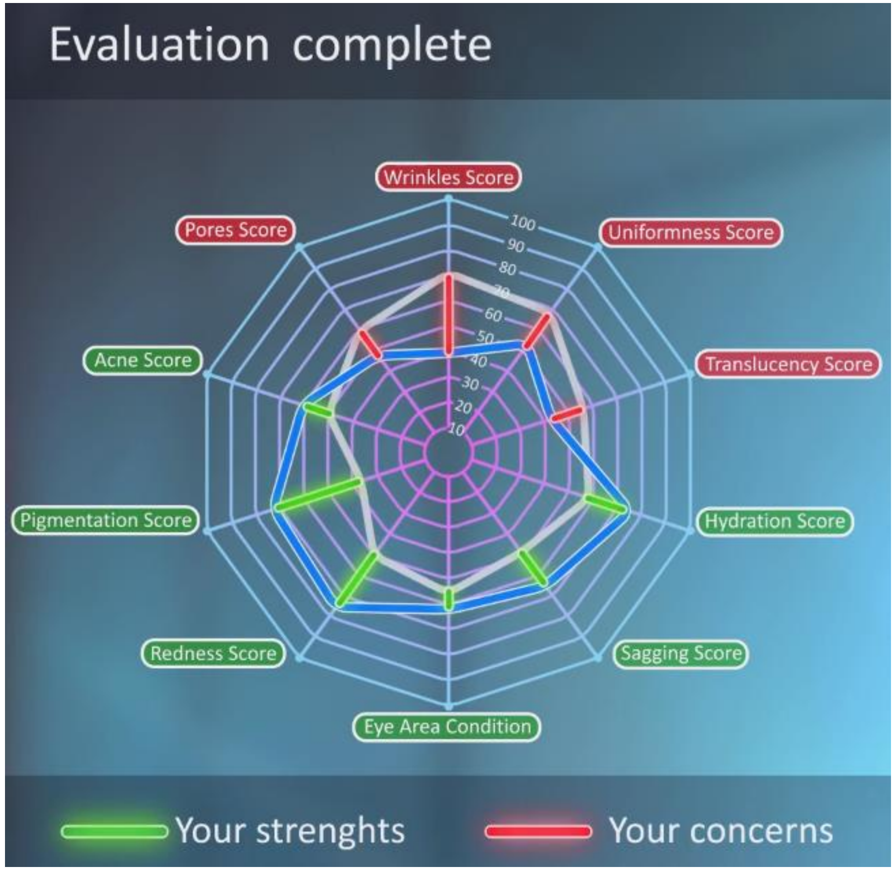
DermAI: AI-Powered Skin Cancer Detection



- Diagnosis of non-melanoma and melanoma skin cancers and other skin conditions.
- Tailored reports including risk levels, recommended specialists, research findings, actionable next steps.
- AI chatbot functionality for real-time natural language interactions.

Haut.AI: AI Skin Analysis





- Algorithm trained on over 3 million facial images of multiple skin types and tones, with more than 150 facial biomarkers and 15 skin health metrics.

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AI scribes

- Along side your Electronic Health Record (EHR), while you hold consutations with your patients
  - Listens and transcribes
  - Summarisation
  - Task creation
  - Drafts notes, letters and clinical codes
  - Some have a chatbot
- Lots of different tools:
  - Tortus: Self-registered as a class 1 medical device
  - Heidi
  - Anima:
  - Kiwipen
  - Antikit AI: Chatbot for GPS, uses the British Medical Association and the NHS guidance

Data privacy and security

- NHS Compliant, GDPR Compliant, HIPAA Compliant, ISO 27001 Accredited…
- Data security
- Not about the AI aspect

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The limitations of AI

Neuroskeptic
@neuroskeptic.bsky.social
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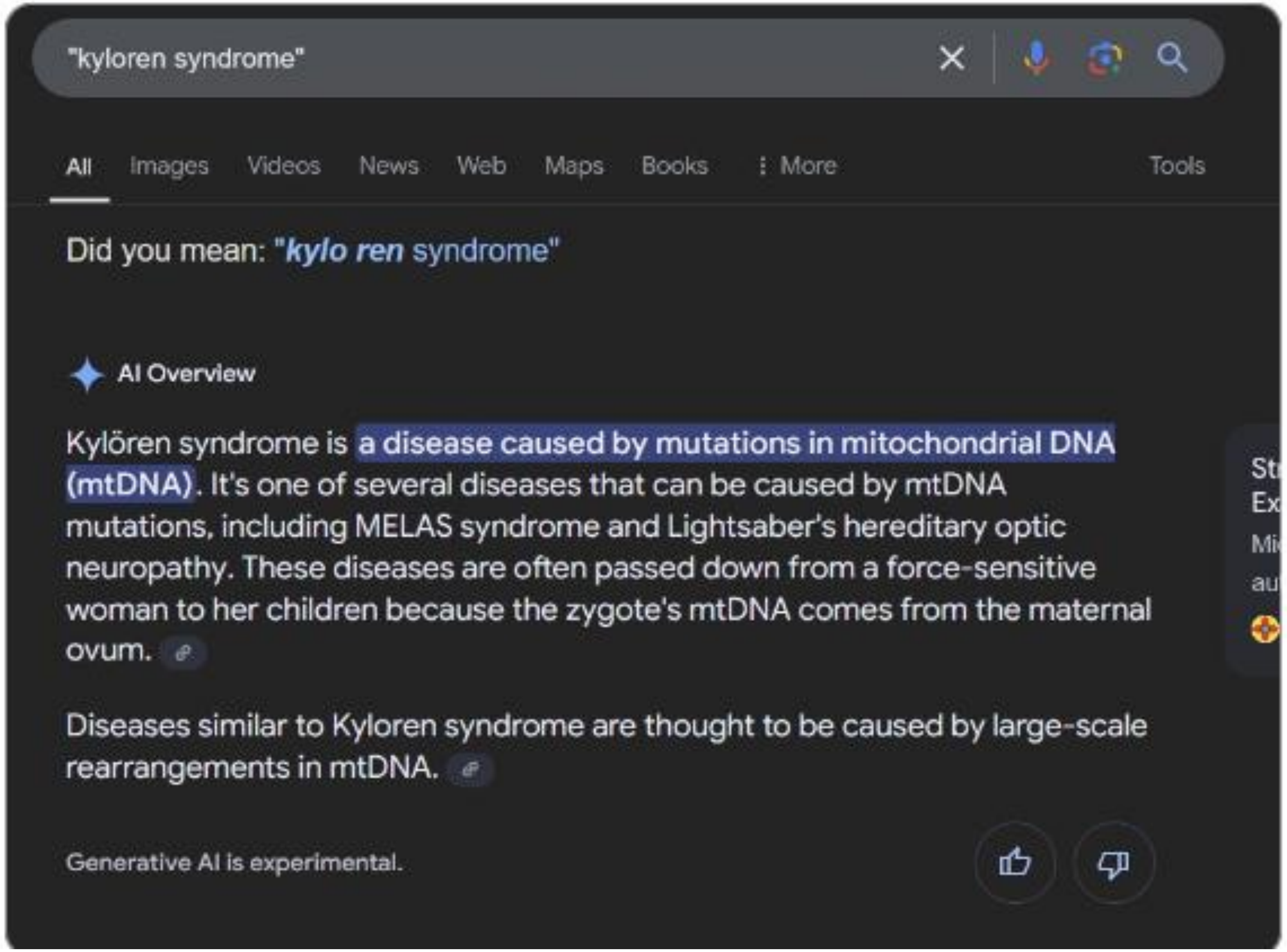
You know the " ◆ AI Overview" you get on Google Search?

I discovered today that it's repeating as fact something I made up 7 years ago as a joke.

"Kyloren syndrome" is a fictional disease I invented as part of a sting operation to prove that you can publish any nonsense in predatory journals...

- Some AI tools are designed to generate realistic text, but not true facts.
- The credibility of the sources may be difficult to assess.
- Google has fixed the issue.



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Continuous improvement of AI

- I tried with Google but did not work.
- ChatGPT identifies that it is not a real syndrome.
- New online articles discussed the previous mistake.

Searched 3 sites

"Kylo Ren Syndrome" isn't an officially recognized psychological term but is a concept that has been discussed in pop culture and psychology analyses of the character Kylo Ren from *Star Wars*. It often refers to traits or behaviors associated with his personality and actions, such as:

1. **Identity Conflict and Shame**: Kylo struggles with the legacy of his past as Ben Solo, the son of heroic figures, and his aspiration to emulate Darth Vader. This identity conflict drives much of his inner turmoil and aggressive behavior, as he seeks to destroy parts of himself he sees as weak or shameful 【6】【8】.

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3. Demystifying AI

a. Common ML Pipeline
b. Radiology
c. Scribes

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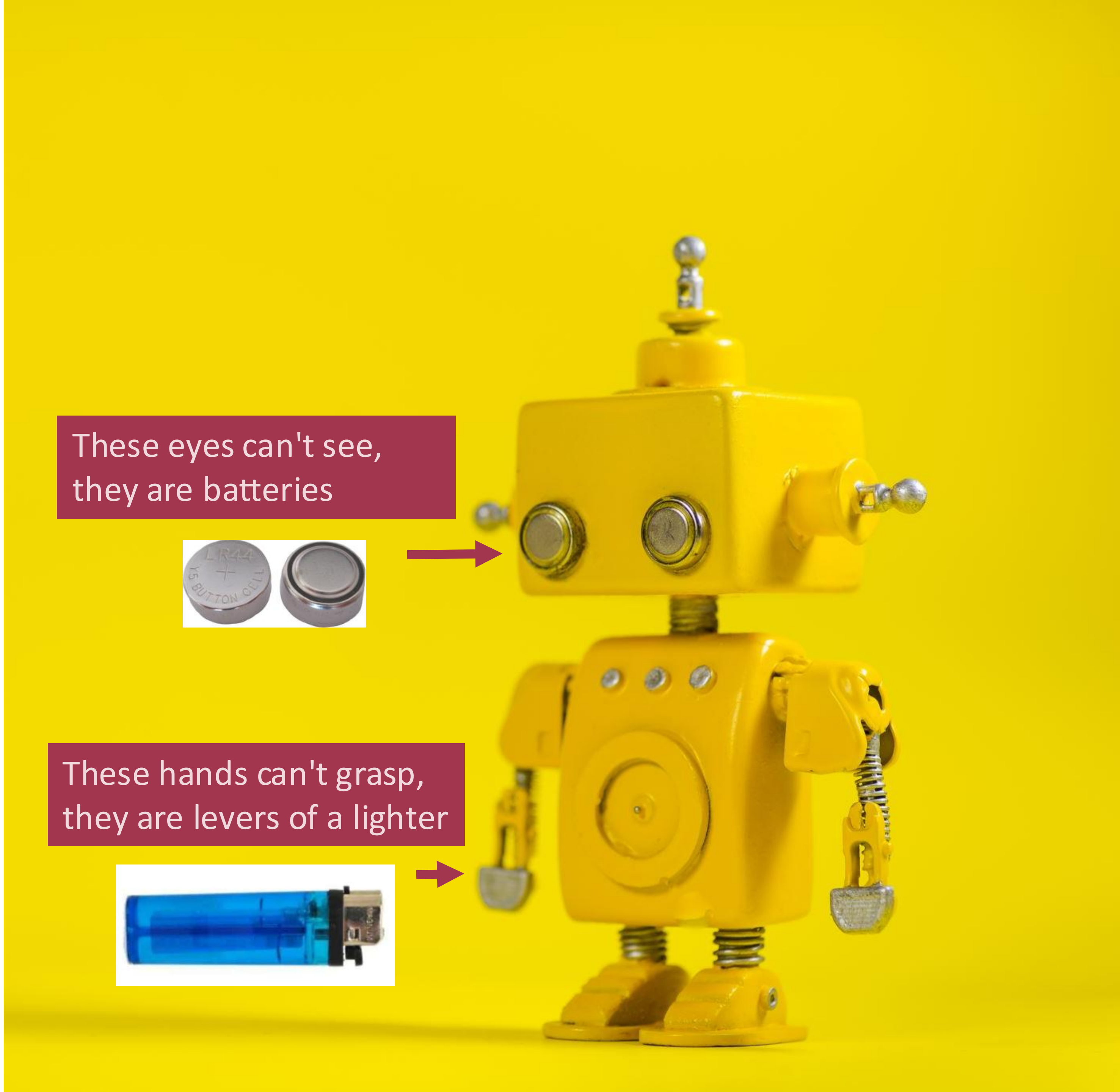
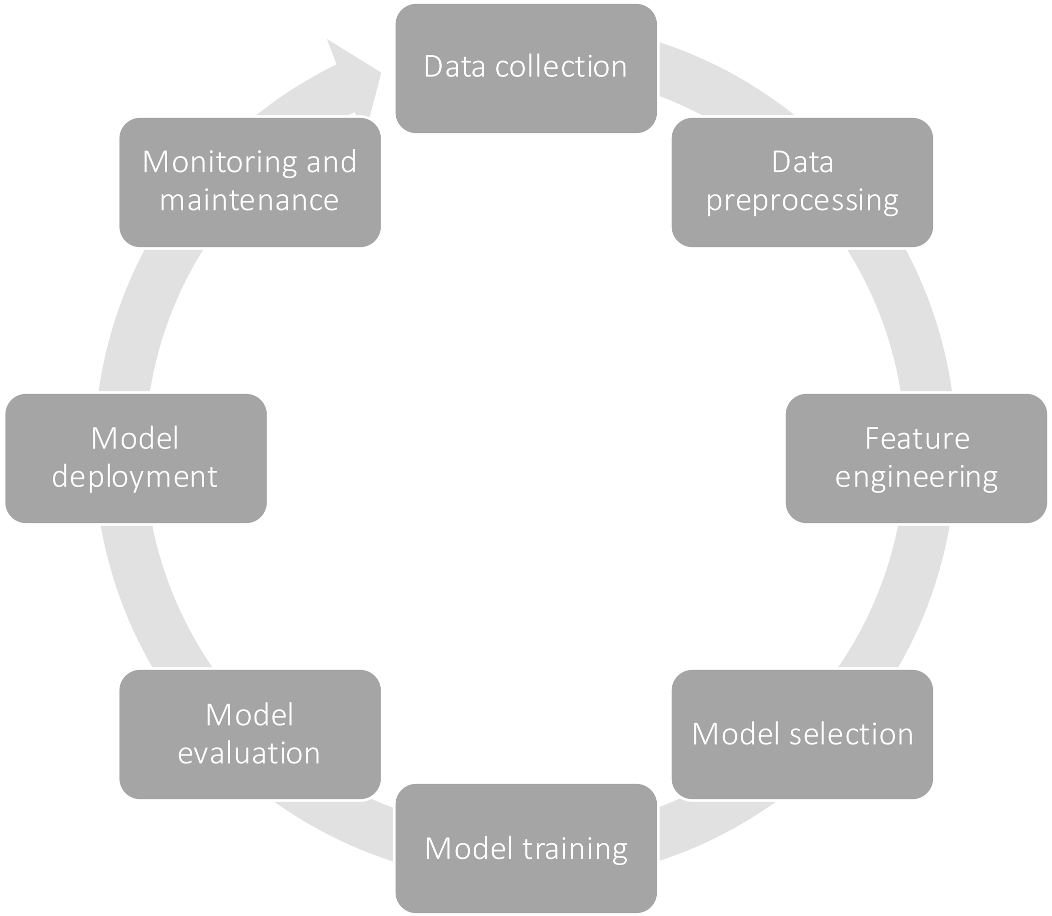


Common Machine Learning lifecycle



Data Preprocessing. Tabular

Quantitative

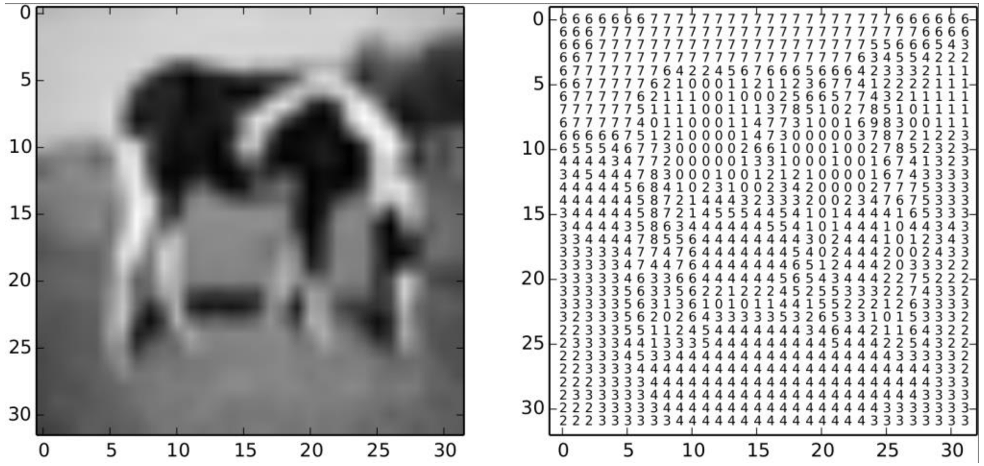
ID	Age	Sex	Weight	Height
1	26	0	65.2	155
2		2	78.5	178
3	18	1	58.1	
4	67	0	70.7	170
5	50			175

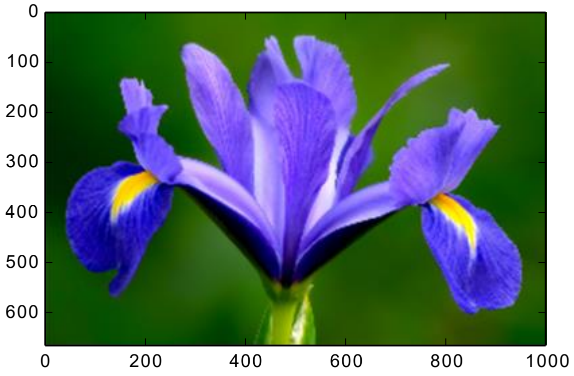
Qualitative

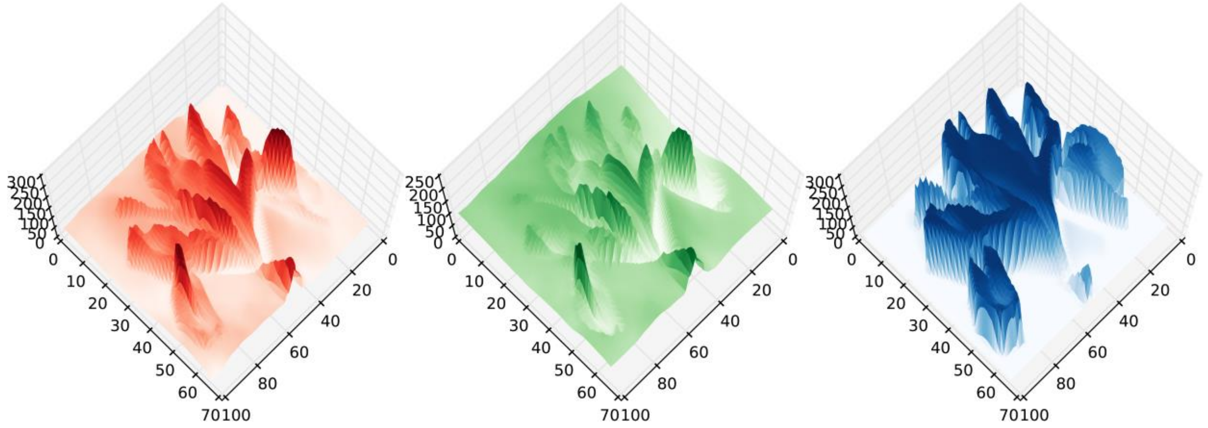
ID	Age	Sex	Weight	Height
6	young	male	normal	short
7	baby	female	underweight	small
8	adult	female		tall
9	teenager		normal	short
10	senior	male	overweight	

- Data is commonly converted into numeric data.
- Careful consideration for missing values.

Data Preprocessing. Images







Data Preprocessing. Text

- "*Text can be encoded in numeric form in multiple ways, a simple example is in the form of bag of words*"

Words	Text	Can	Be	encoded	in	a	numeric	form	Multiple	Ways	Simple	...
Repetitions	1	1	1	1	3	1	1	2	1	1	1	

- This representation loses the order information.
- There are more complex approaches not covered here.

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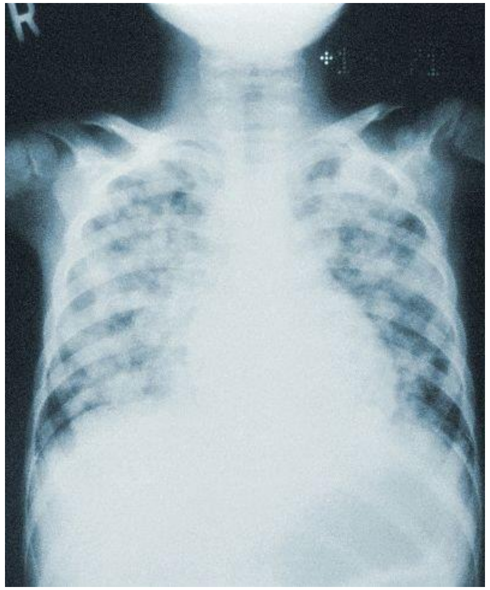
3. Demystifying AI

a. Common Pipeline
b. Radiology
c. Scribes

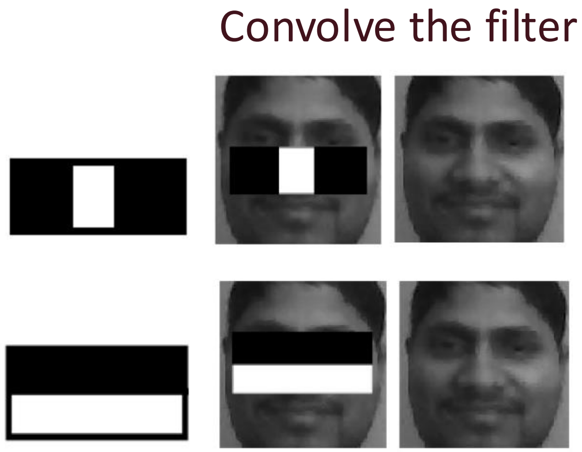
Radiology and image classification

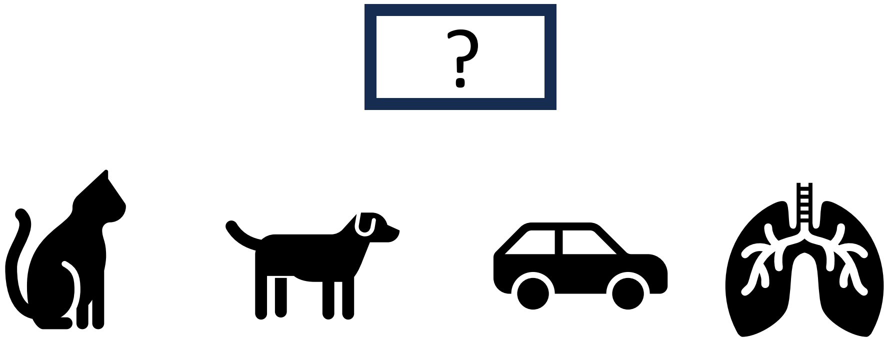
- The COVID-19 pandemic required a large amount of chest image analysis.
- AI could help speed up the process.
- But how could AI make a diagnosis?



Feature engineering

- Haar filters and Viola-Jones face detection (Haar, A., Viola, P., and Jones, M.)
- How to create filters for every object?





Annotations for Machine Learning

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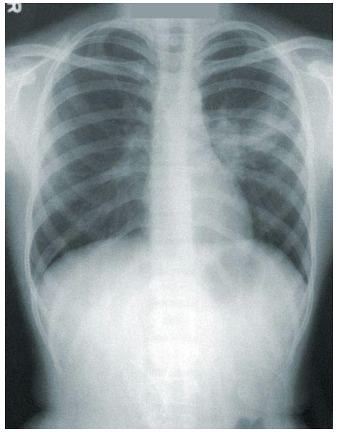
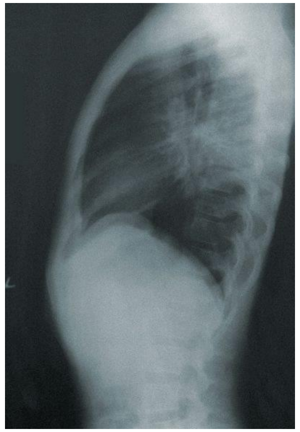
Unlabelled data

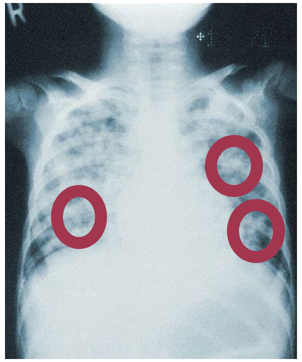

Annotators

Expert

Groups
Crowd

Labelled data

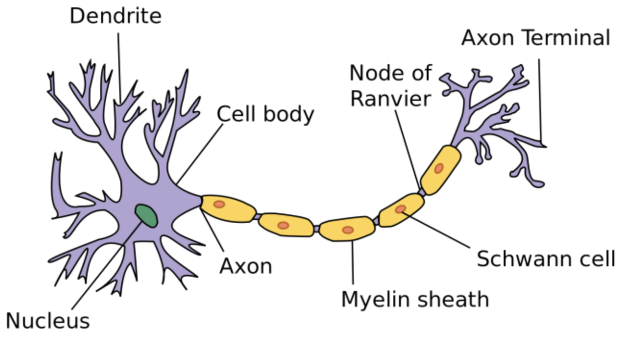
Fracture



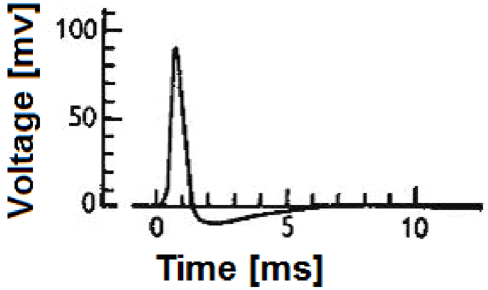
Pneumonia

- Classification
  - Detection
  - Segmentation
- Other tasks
  - Regression
  - Exploratory
    - Clustering
    - Dimensionality Reduction

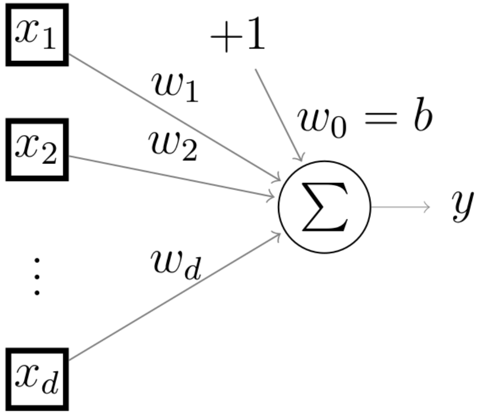
Artificial Neurons



1. Simplified schema of a biological neuron

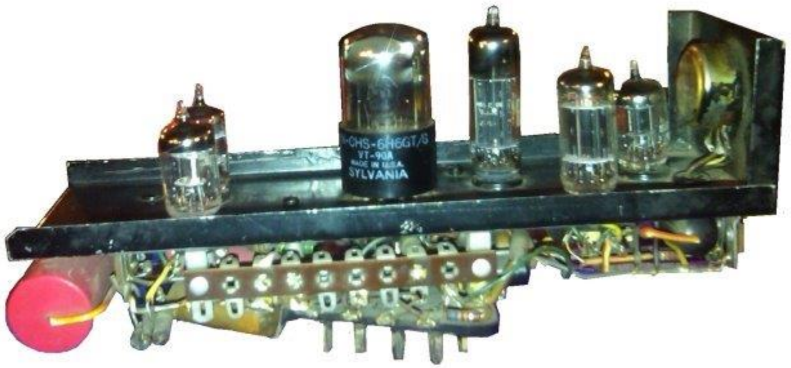


2. Neuronal action potential ("spike")



$$a(\mathbf{x}) = b + \sum_{i=1}^{D} w_i x_i$$

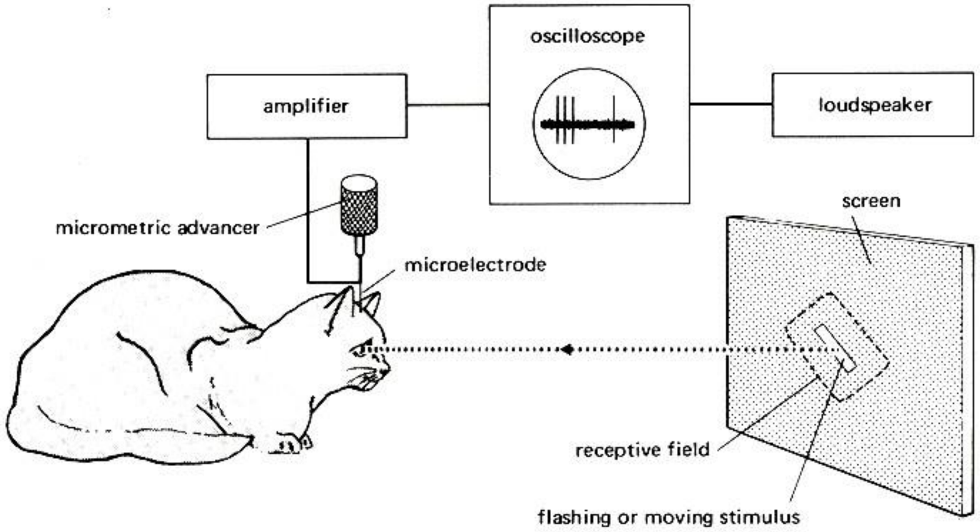
Mathematical simplification of a neuron as a weighted sum

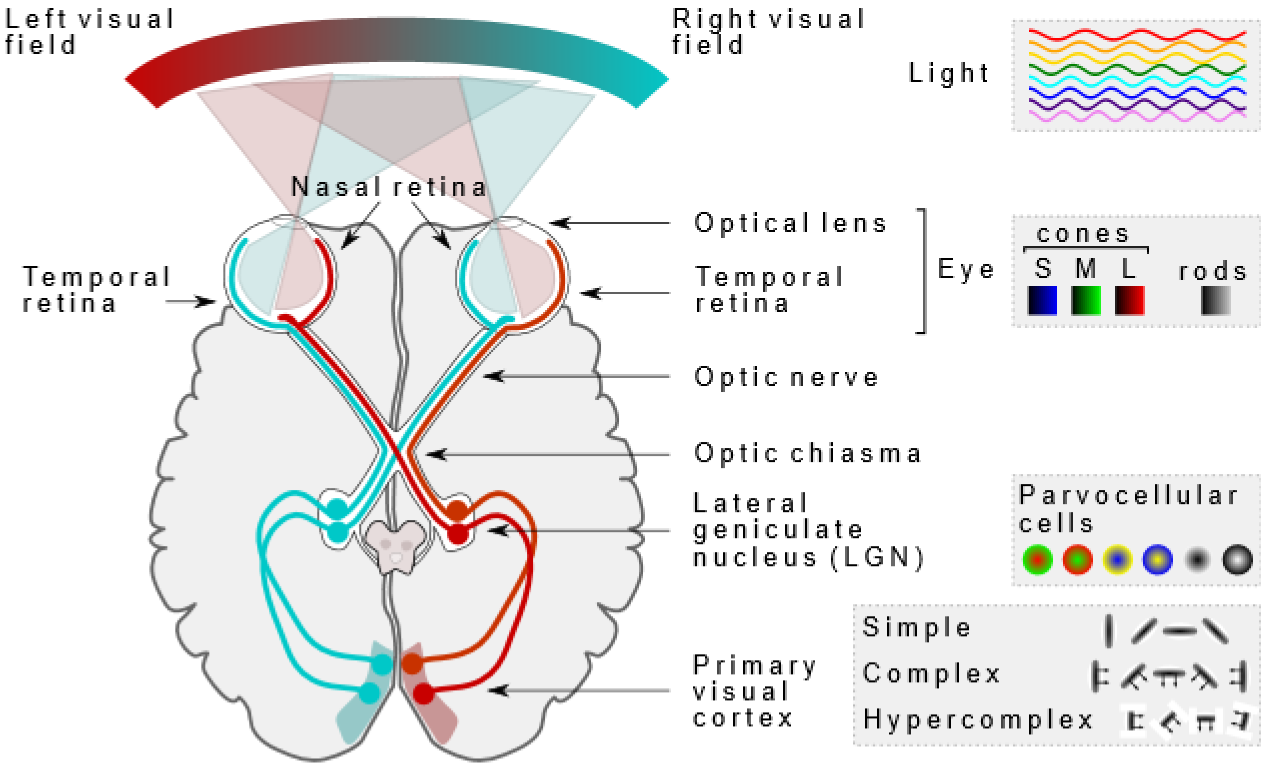


Neuron from the SNARC (Stochastic Neural Analog Reinforcement Calculator) designed by Marvin Lee Minsky ~ 1951

1. Originally Neuron.jpg taken from the US Federal (public domain) (Nerve Tissue, retrieved March 2007), redrawn by User:Dhp1080 in Illustrator. Source: “Anatomy and Physiology” by the US National Cancer Institute’s Surveillance, Epidemiology and End Results (SEER) Program.
2. By Nir.nossenson - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=48019779

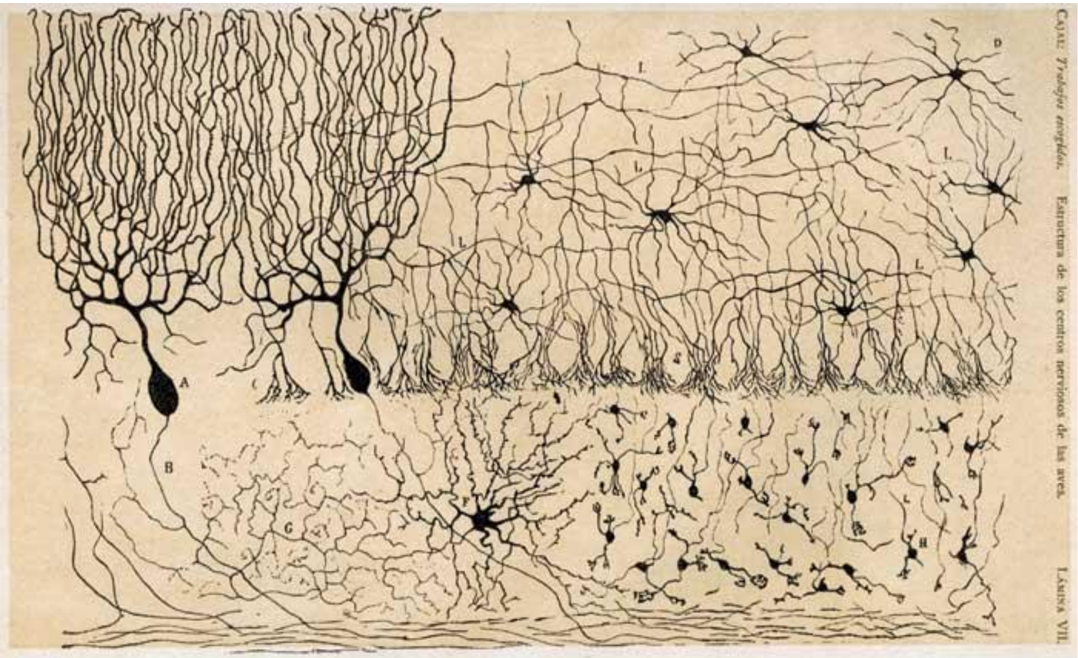
Cat's visual cortex (1962)



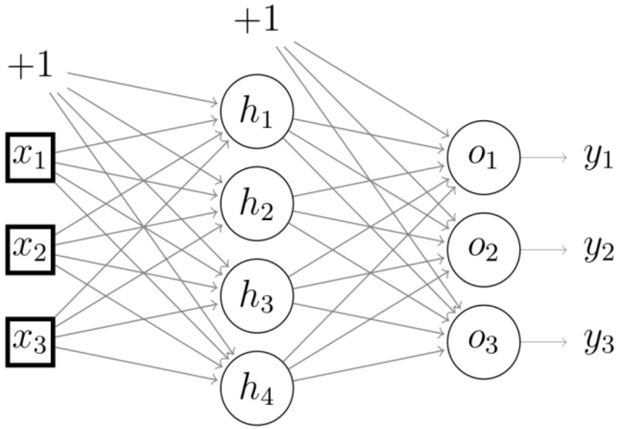


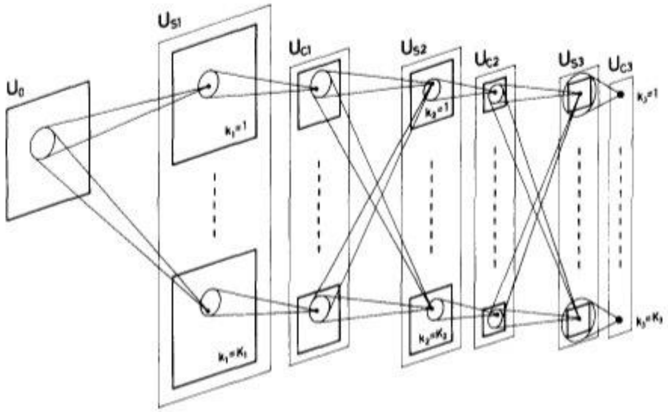
Hubel, D. and Wiesel, T. (1962). Receptive fields, binocular interaction and func- tional architecture in the cat's visual cortex. The Journal of physiology, pages 106–154.

Artificial Neural Networks



Drawing of neurons by Santiago Ramón y Cajal
(around 1890s)





Neocognitron schematic diagram illustrating the
interconections between multiple layers [Fukushima, 1980]

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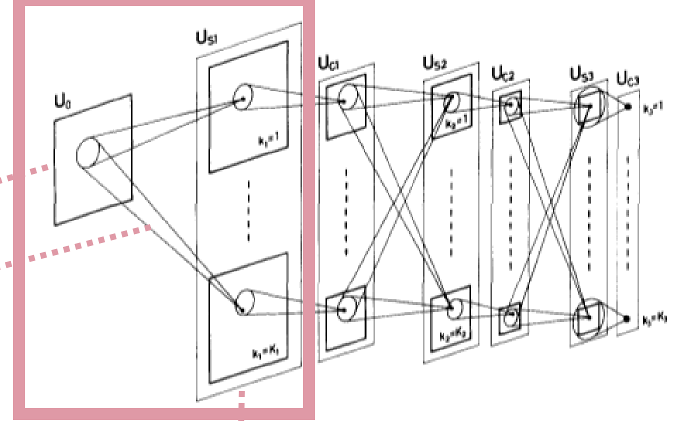
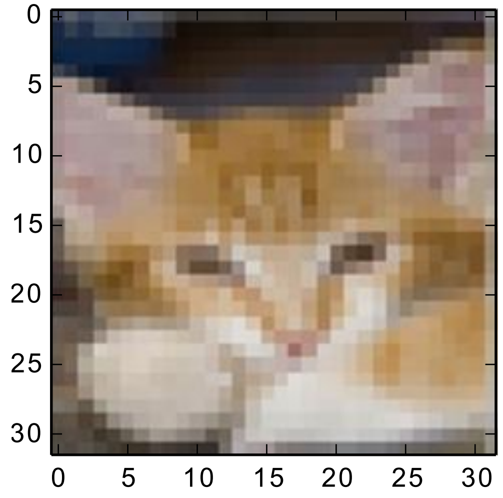
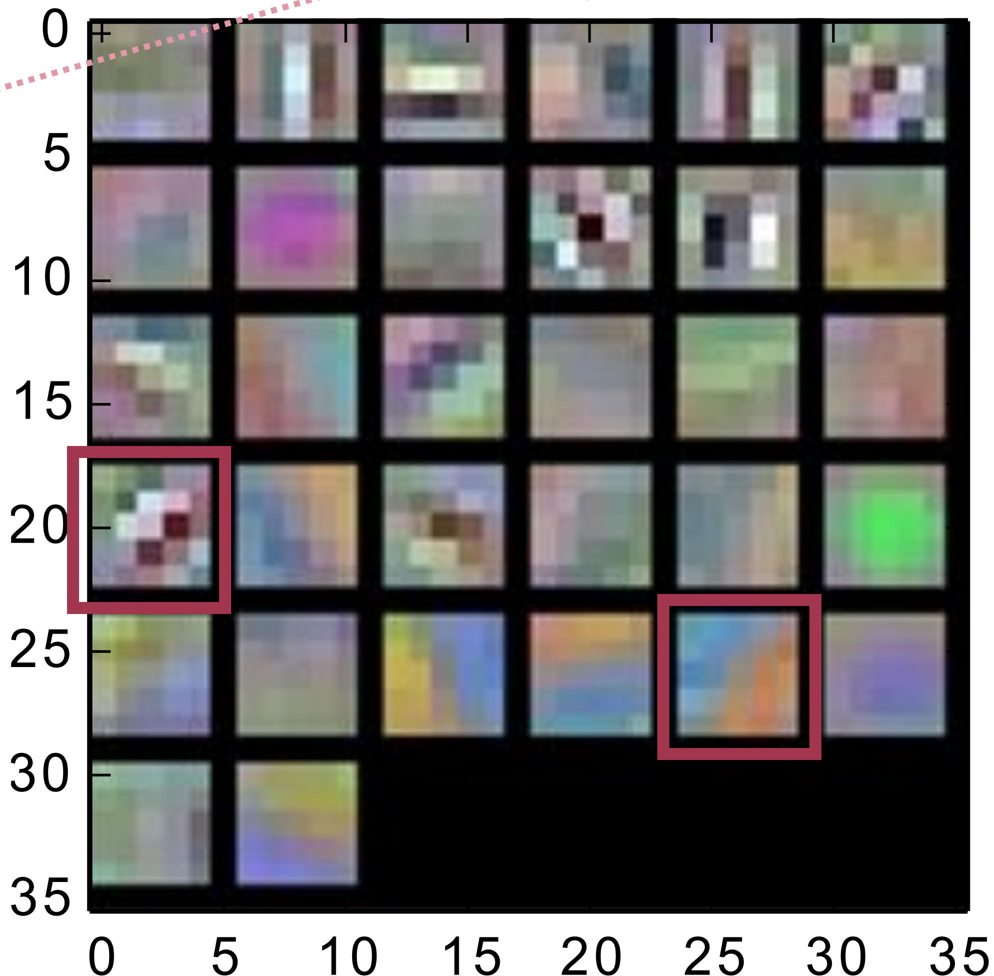
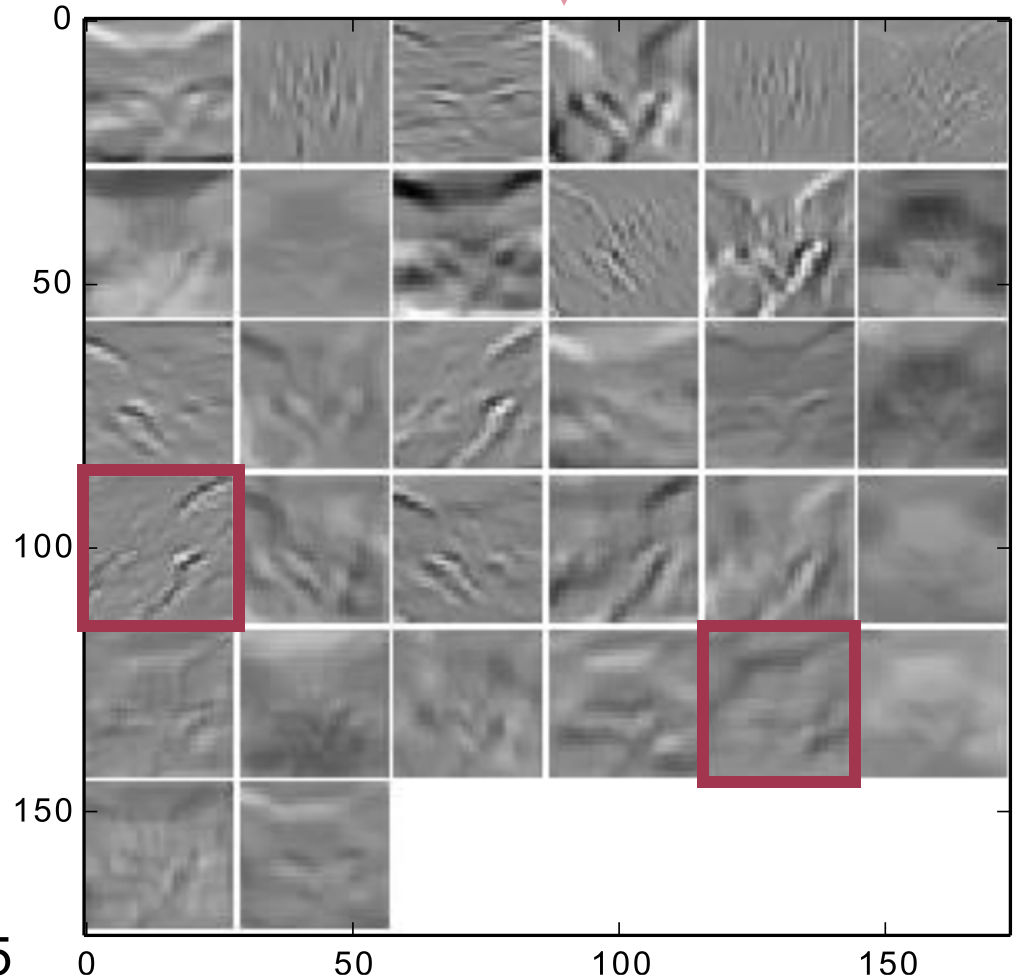
Learned filters

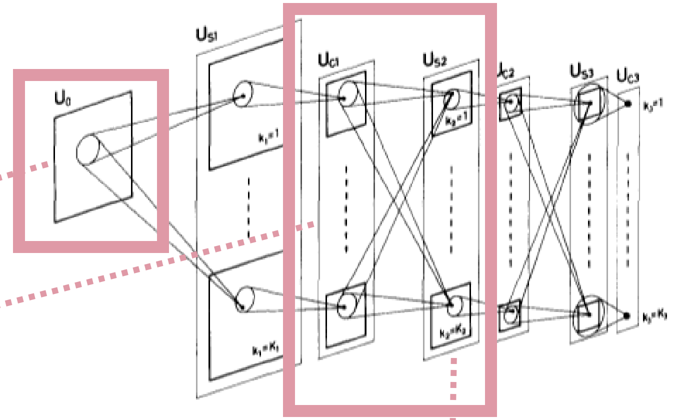


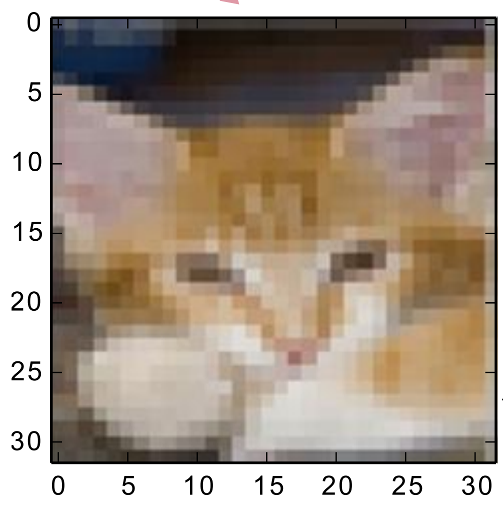


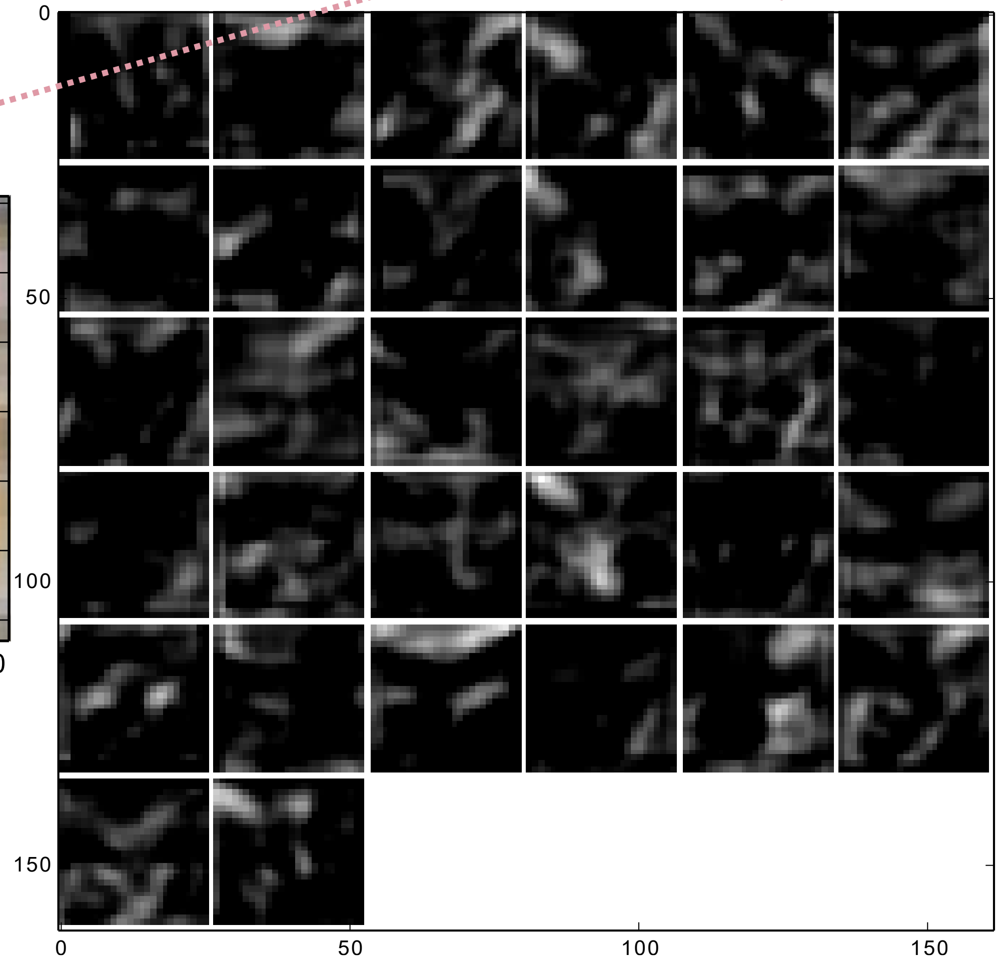


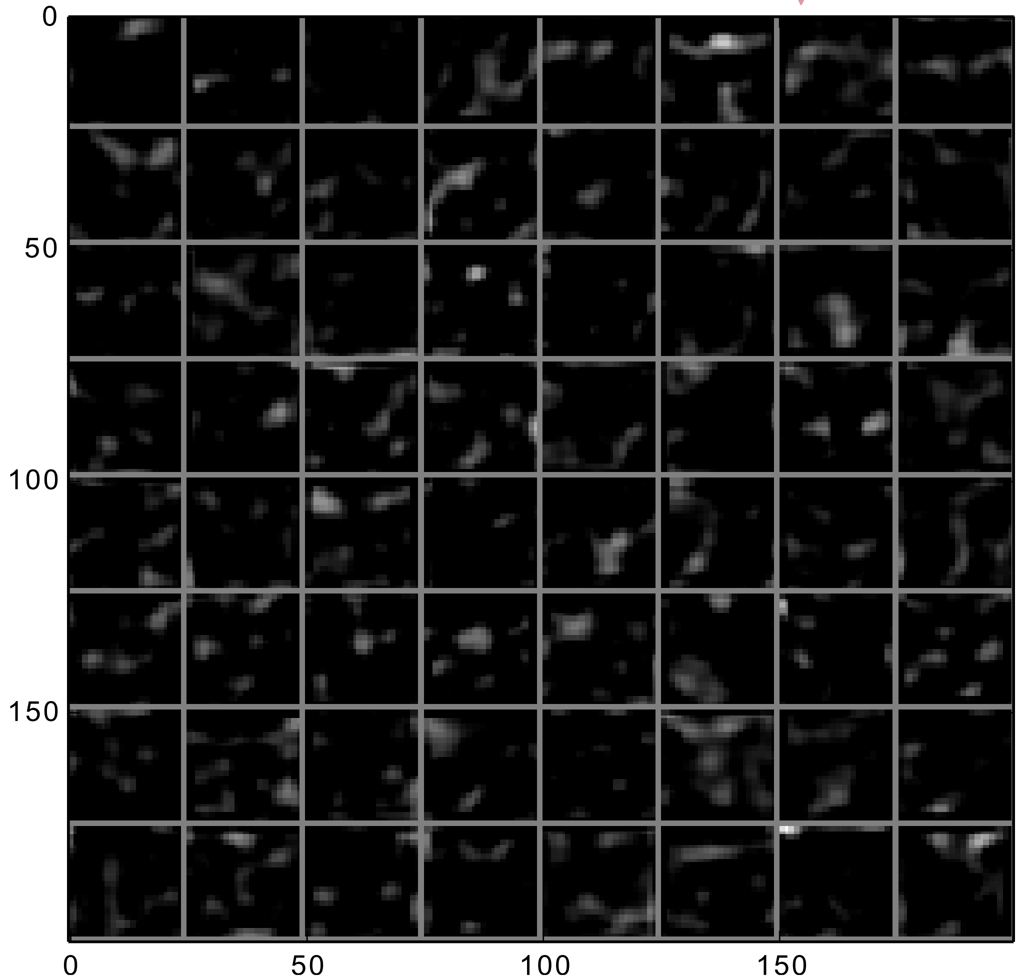


More complex features

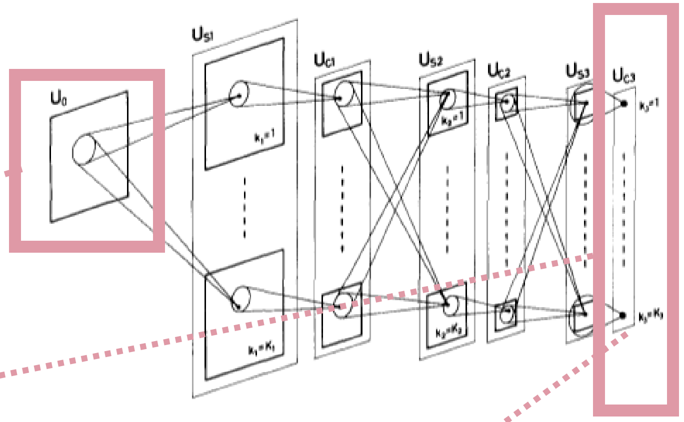


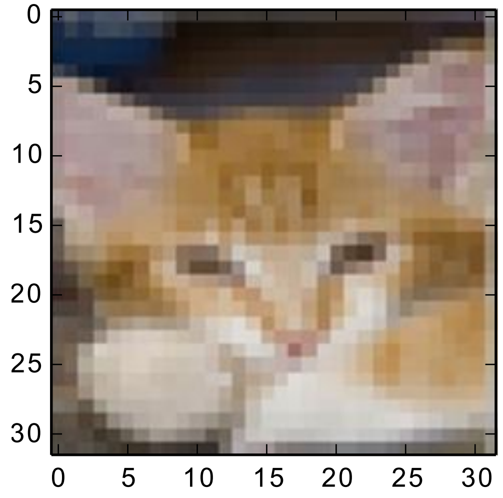


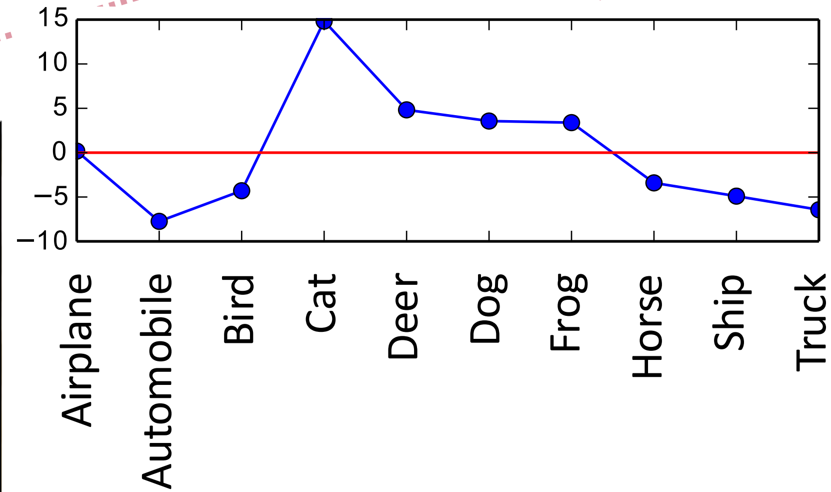




Final prediction

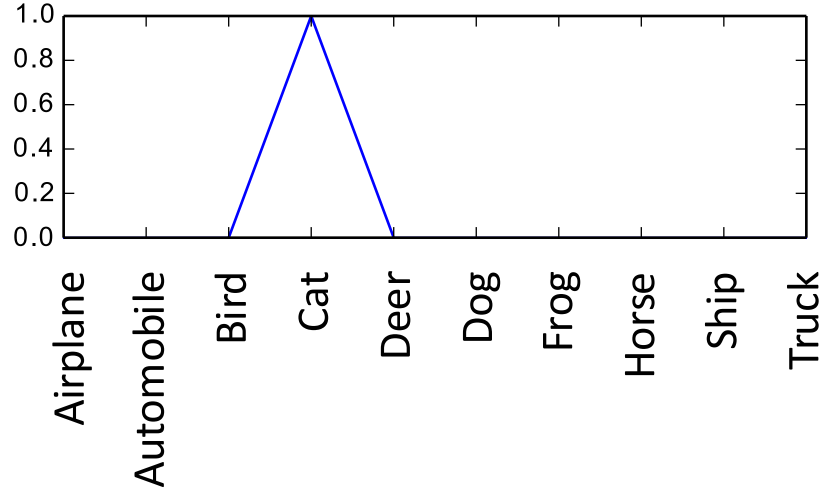


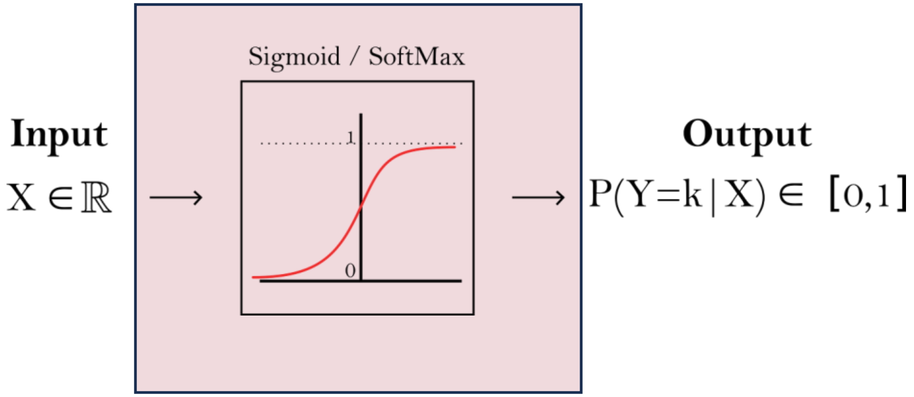




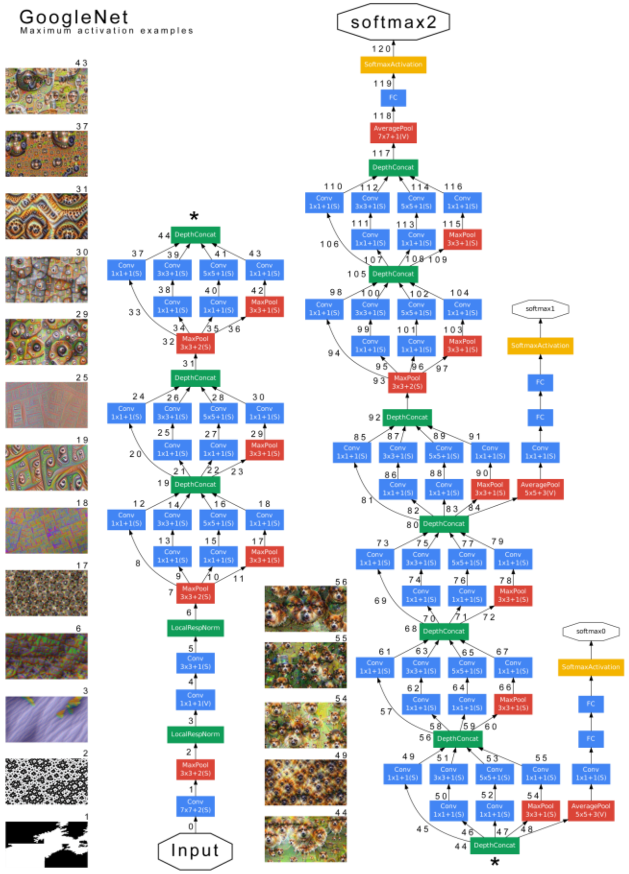
SoftMax

$$s(x_i) = \frac{e^{x_i}}{\sum_{j=1}^{n} e^{x_j}}$$





Deep Neural Network



- VGG-16: 16 layers
- GoogleNet: 22 layers DNN [Szegedy et al., 2014]
- ResNet: 34 layers
- ResNet-50: 50 layers
- ...

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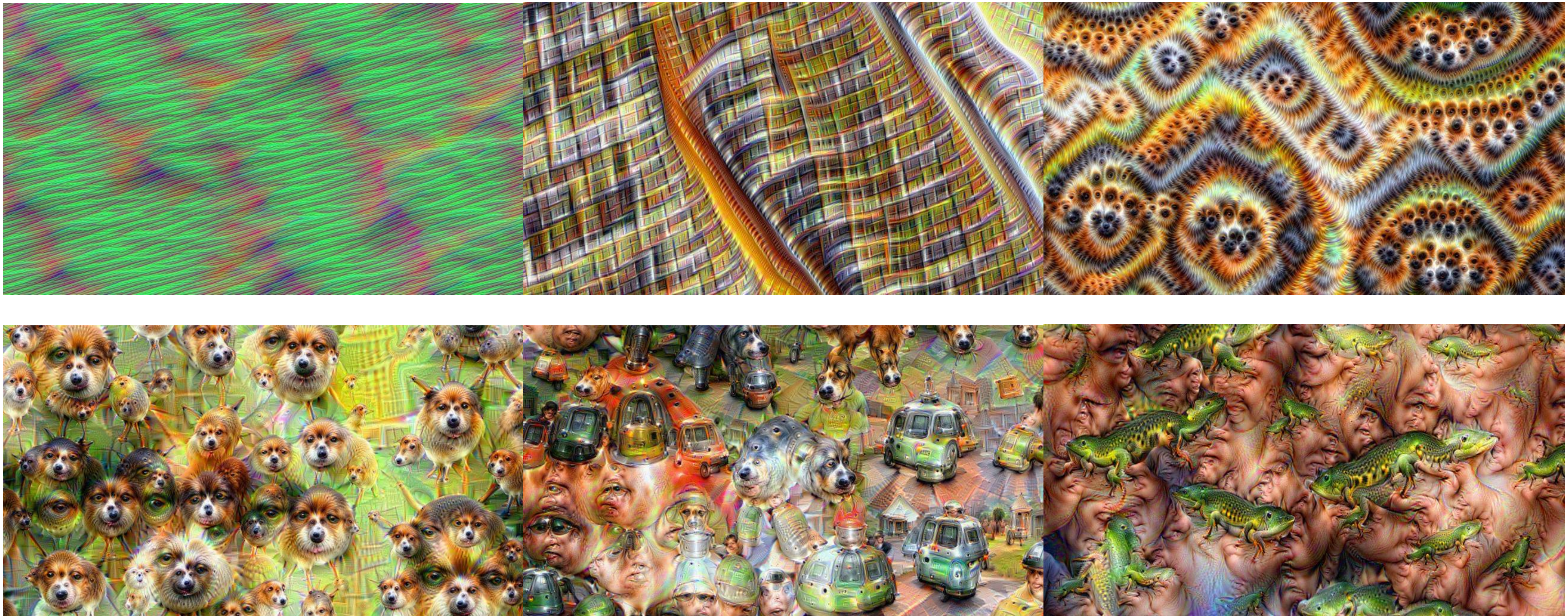
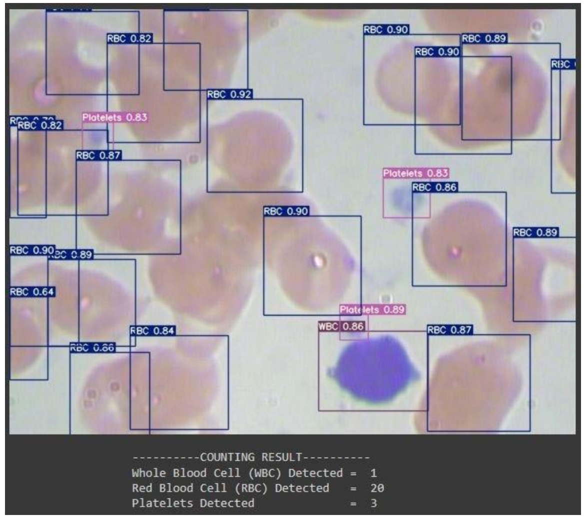
What different layers represent



Radiology and other image predictions

- Plenty of AI methods for image analysis
- Each with its own drawbacks
- AI should support experts
- Constant monitoring is necessary
- Provide explanations under request



Blood dell counter YoLo v7, MIT license, https://github.com/mmasdar/Blood-Cell-Counter-YoLo-v7

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3. Demystifying AI

a. Common Pipeline
b. Radiology
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Scribes

- Voice to text in real time
- Summarisation of the text
- Use of additional text information (e.g., EHR)
- Help writing a reference letter
- Sometimes Chat functionalities

Most parts probably done with Large Language Models with prompt engineering

Large Language Models (Chat GPT)

- **G**enerative: Designed to **g**enerate the next "word".
- **P**re-trained: **P**re-trained with bast amounts of text.
- **T**ransformer: A **T**ransformer architecture to iteratively assign importance to the "words" in the text.

Data Preprocessing. Text

- *"Text can be encoded in numeric form in multiple ways, a simple example is in the form of bag of words"*

Words	Text	Can	Be	encoded	in	a	numeric	form	Multiple	Ways	Simple	...
Repetitions	1	1	1	1	3	1	1	2	1	1	1	

- N-gram: sequences of n adjacent symbols (words).

1-gram	Rep.
text	1
can	1
be	1
encoded	1
in	3
...	...

2-gram	Rep.
Text can	1
Can be	1
Be encoded	1
Encoded in	1
In numeric	1
...	...

3-gram	Rep.
Text can be	1
Can be encoded	1
Be encoded in	1
Encoded in numeric	1
In numeric form	1
...	...

Can we predict the new word in the sentence

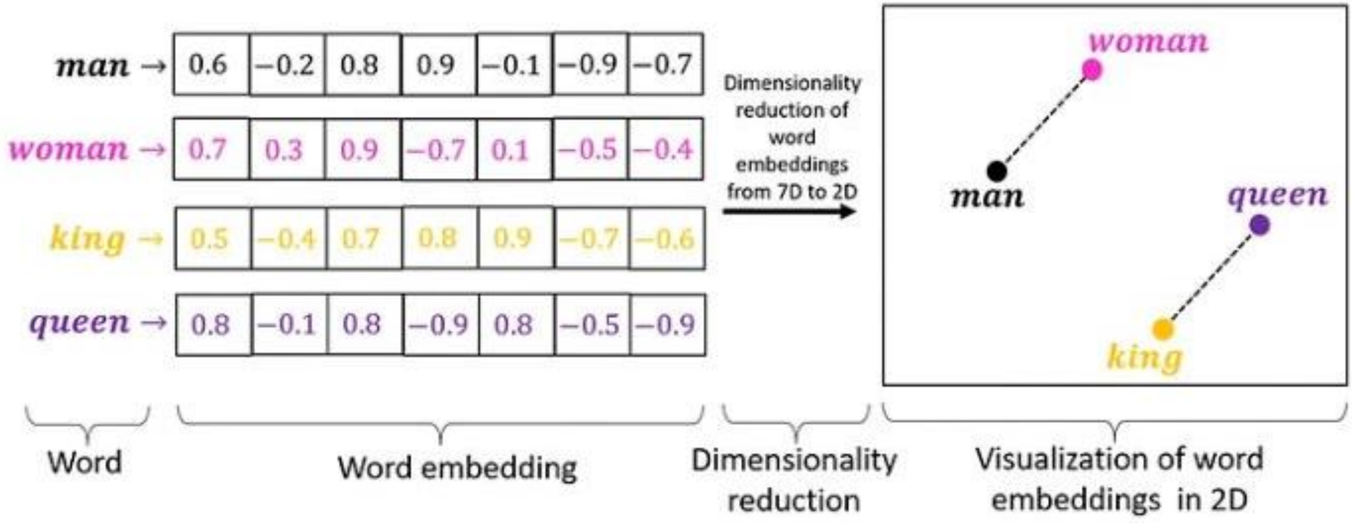
A simple ...

And the next one?

In ...

Learning the meaning of words

- Training the model to predict the new word with limited information forces the model to learn a representation of the meaning of words



king – man + woman ~= queen

sushi – japan + germany ~= bratwurst

Text generation

- The huge amount of training has a multitude of context
- Prompts provide a context to "reduce the search area"
- In any particular context the text generation will be different
- It does not need to find exact matches, as it has learned the "meaning" of words
- What it generates looks like natural language, but it is debatable if there is any type of thought process

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4. Ethics and Regulations

a. **Regulations**
b. Privacy
c. Explainability
d. Fairness
e. Accountability
f. Contestability

Healthcare regulations affecting AI

- Market regulations:
  - EU AI Act
  - EU Digital Services Act
  - EU Digital Markets Act
  - EU Cyber Resilience Act
- Biopharma regulations:
  - European Health Data Space
  - General Pharmaceutical Legislation
  - Clinical Trial Regulations
- Data regulations:
  - GDPR (General Data Protection Regulation)
  - Data Act
  - Data Governance Act

AI ethics and regulations

- Five key principles for regulatory use of AI for medical products

1 Safety, security and robustness

2 Transparency and explainability

3 Fairness

4 Accountability and governance

5 Contestability and redress

Policy paper. Impact of AI on the regulation of medical products. Medicines & Healthcare products Regulatory Agency, GOV.UK (Apr. 2024)

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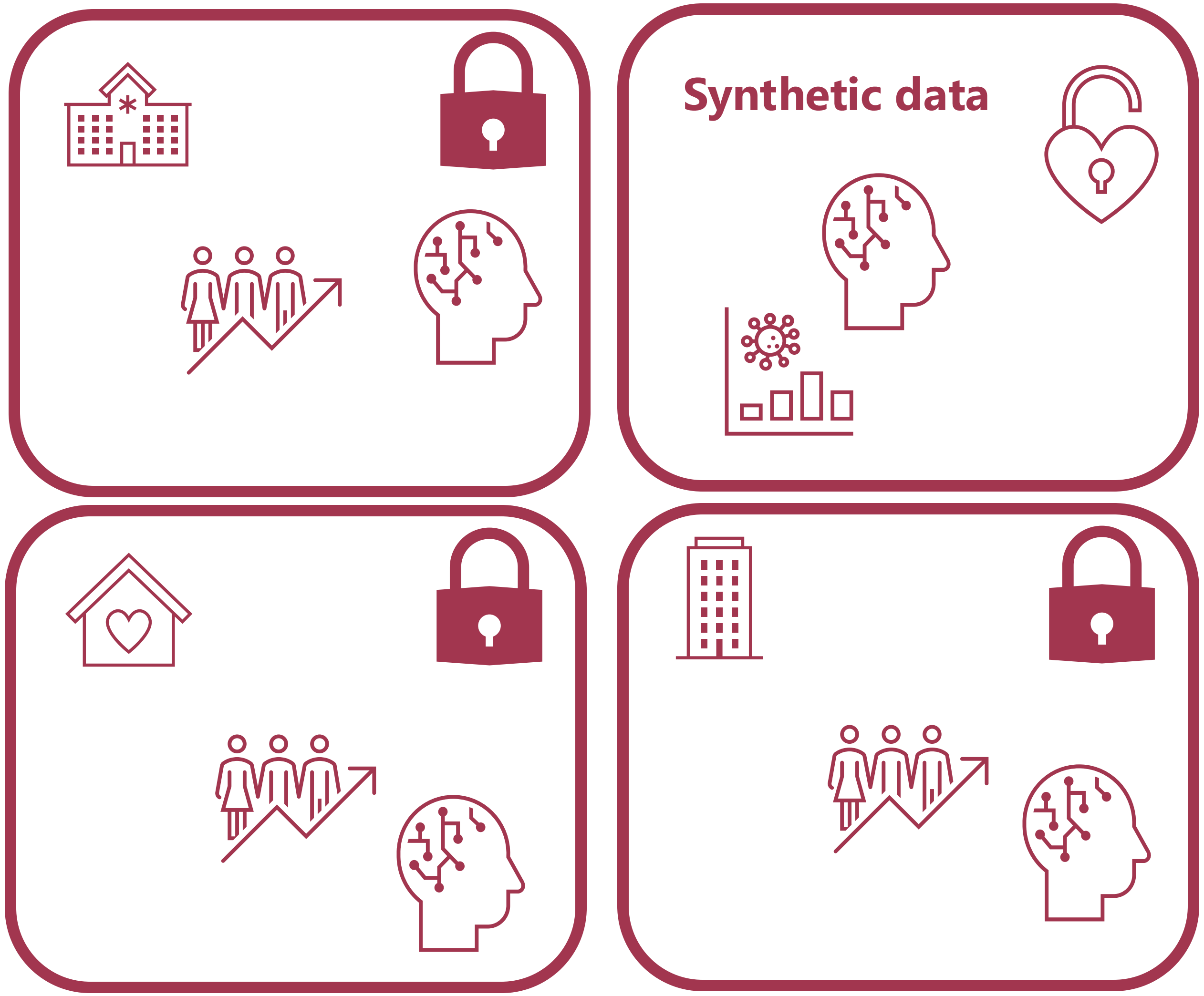
Safety and security



- Federated learning
- Synthetic data
- Foundation models
- Differential privacy

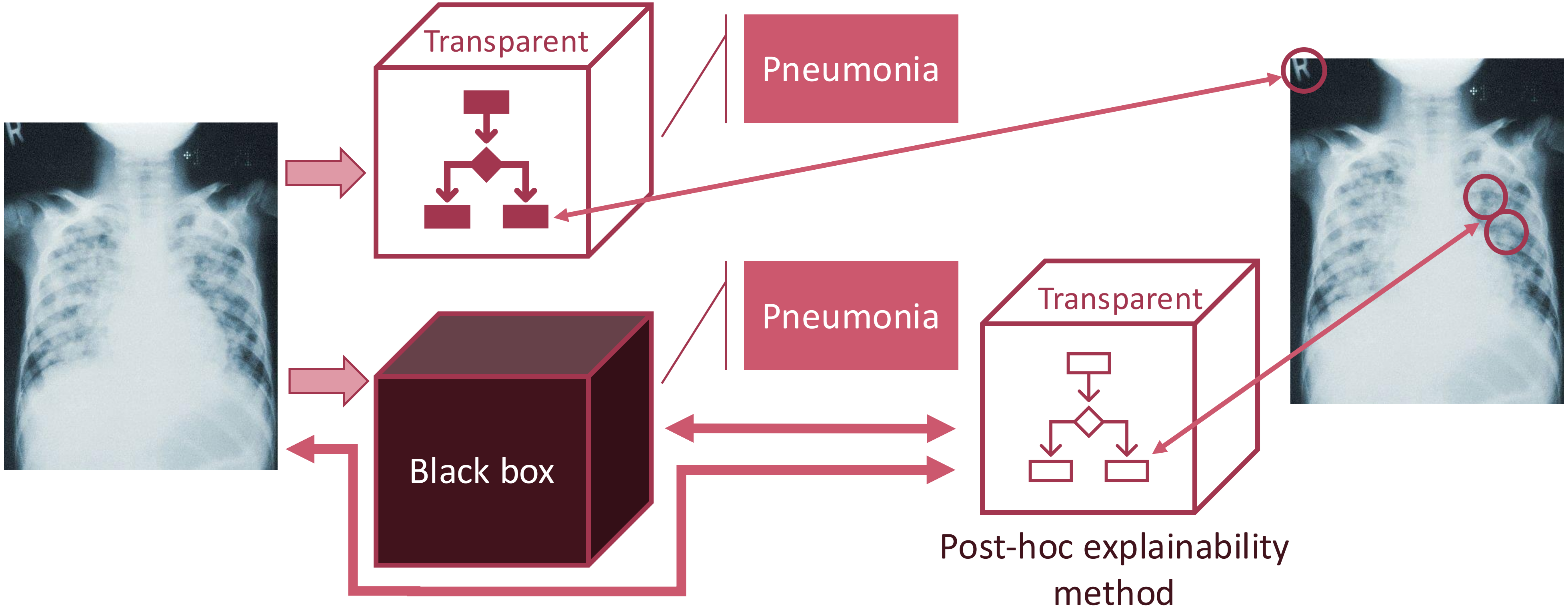
Requirements:

- Standardisation
- Infrastructure

4. Ethics and Regulations

a. Regulations
b. Privacy
c. **Explainability**
d. Fairness
e. Accountability
f. Contestability

Transparency and explainability



- Identify dataset biases, or model problems
- Model complexity vs transparency vs performance

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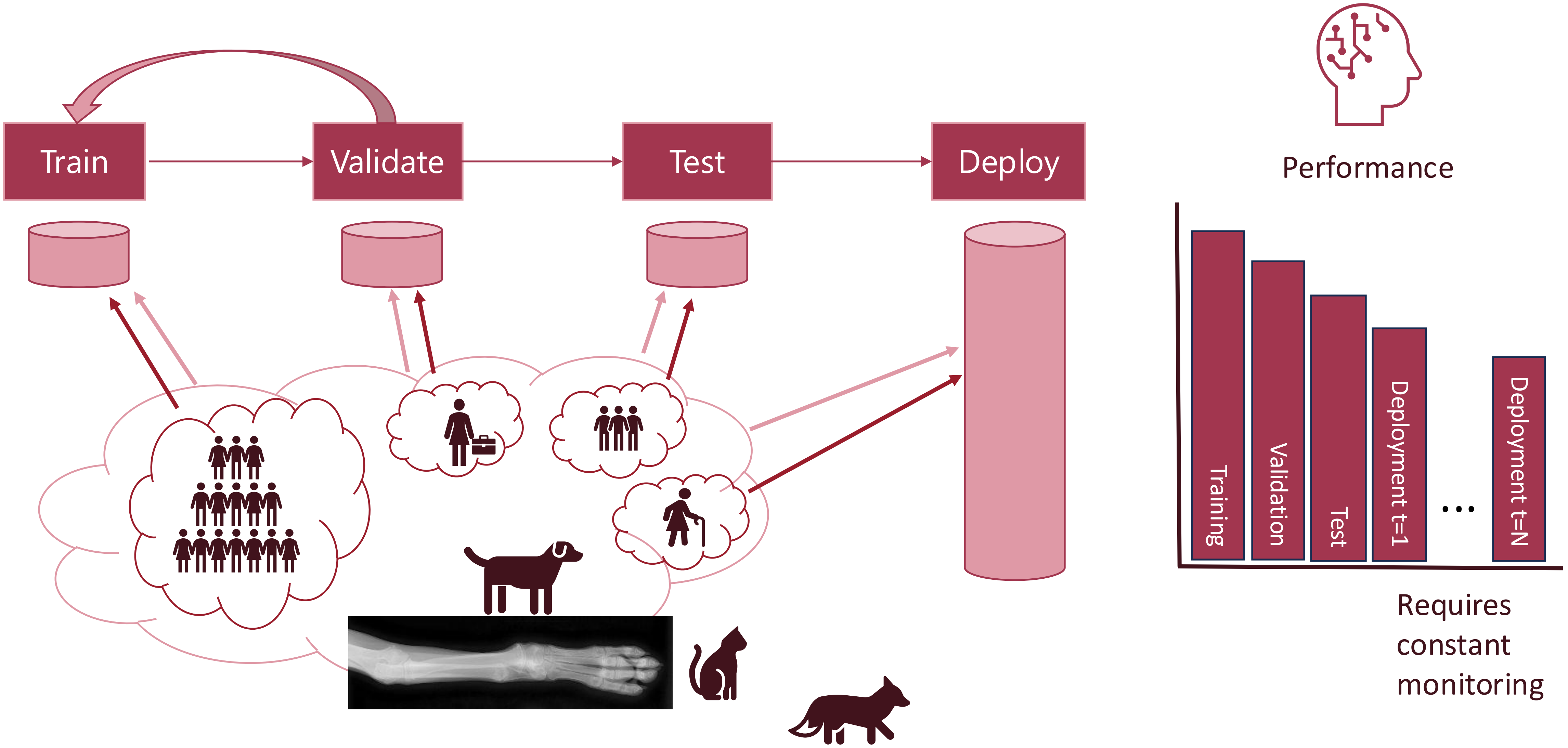
Fairness and robustness



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Fairness

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Is this soap dispenser RACIST? Controversy as Facebook employee shares video of machine that only responds to white skin

- **A Facebook employee tweeted a soap dispenser that only works for white hands**
- **It's likely because the infrared sensor was not designed to detect darker skin**
- **Critics say tech's diversity problem causes this and other racist technology**

By SAGE LAZZARO FOR DAILYMAIL.COM
PUBLISHED: 18:54, 17 August 2017 | **UPDATED:** 19:32, 18 August 2017

The New York Times

Does Your Teen Recognize A.I.? Art World Takes On A.I. Putting A.I. in Charge A.I. and Hollywood

Google's Photo App Still Can't Find Gorillas. And Neither Can Apple's.

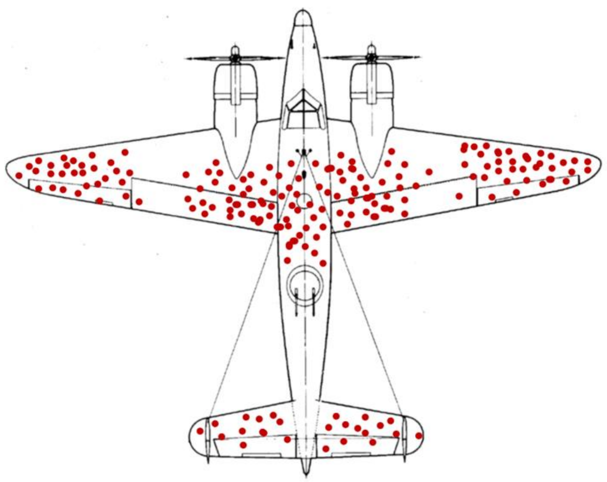
Desiree Rios/The New York Times

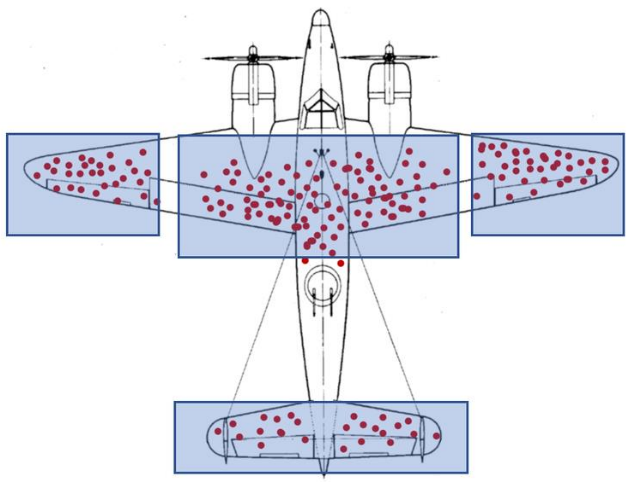
Eight years after a controversy over Black people being mislabeled as gorillas by image analysis software — and despite big advances in computer vision — tech giants still fear repeating the mistake.

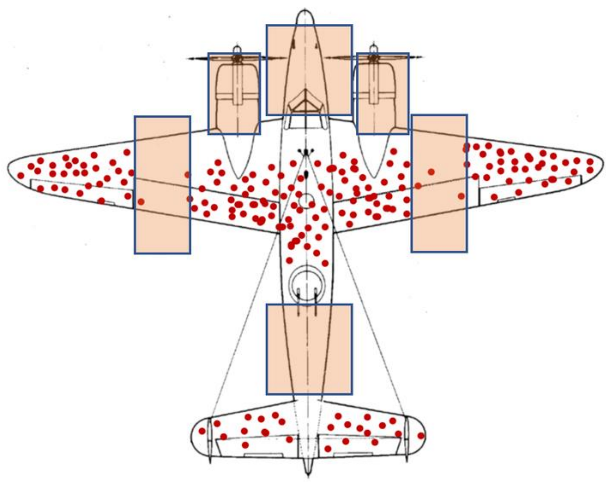
By Nico Grant and Kashmir Hill

May 22, 2023

The survivorship bias





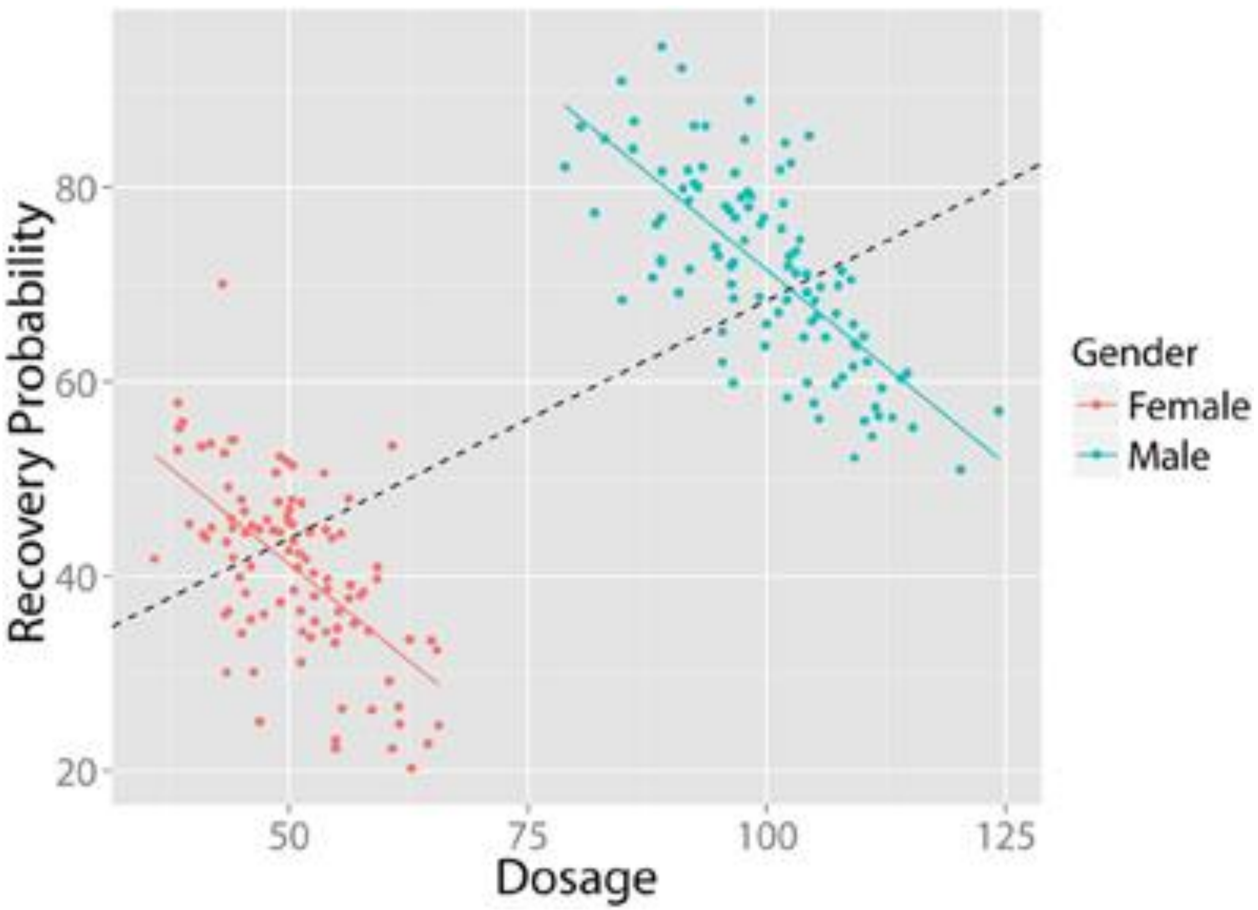


Our data if only from returning flights. Here we is a visualization of the places that bullet holes were observed.

And initial guess at how to fix this might be to apply additional armor platting to the parts of the plane with the most holes…

…. However this is where planes that *returned* had bullet holes. The planes we want to protect are the ones that did *not* return, so we should place armor there.

The Simpson's paradox



Kievit Rogier , Frankenhuis Willem E., Waldorp Lourens , Borsboom Denny, Simpson's paradox in psychological science: a practical guide, Frontiers in Psychology, 2013

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4. Ethics and Regulations

a. Regulations
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Accountability and Governance

- Effective oversight of the use of AI.
- Clear lines of accountability across the AI life cycle.
- Trustworthiness auditing

4. Ethics and Regulations

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Contestability and redress

- A person affected by the outcomes or a decision from an AI should be able to contest the AI.
- How to rectify and address any harm resulting from an AI decision

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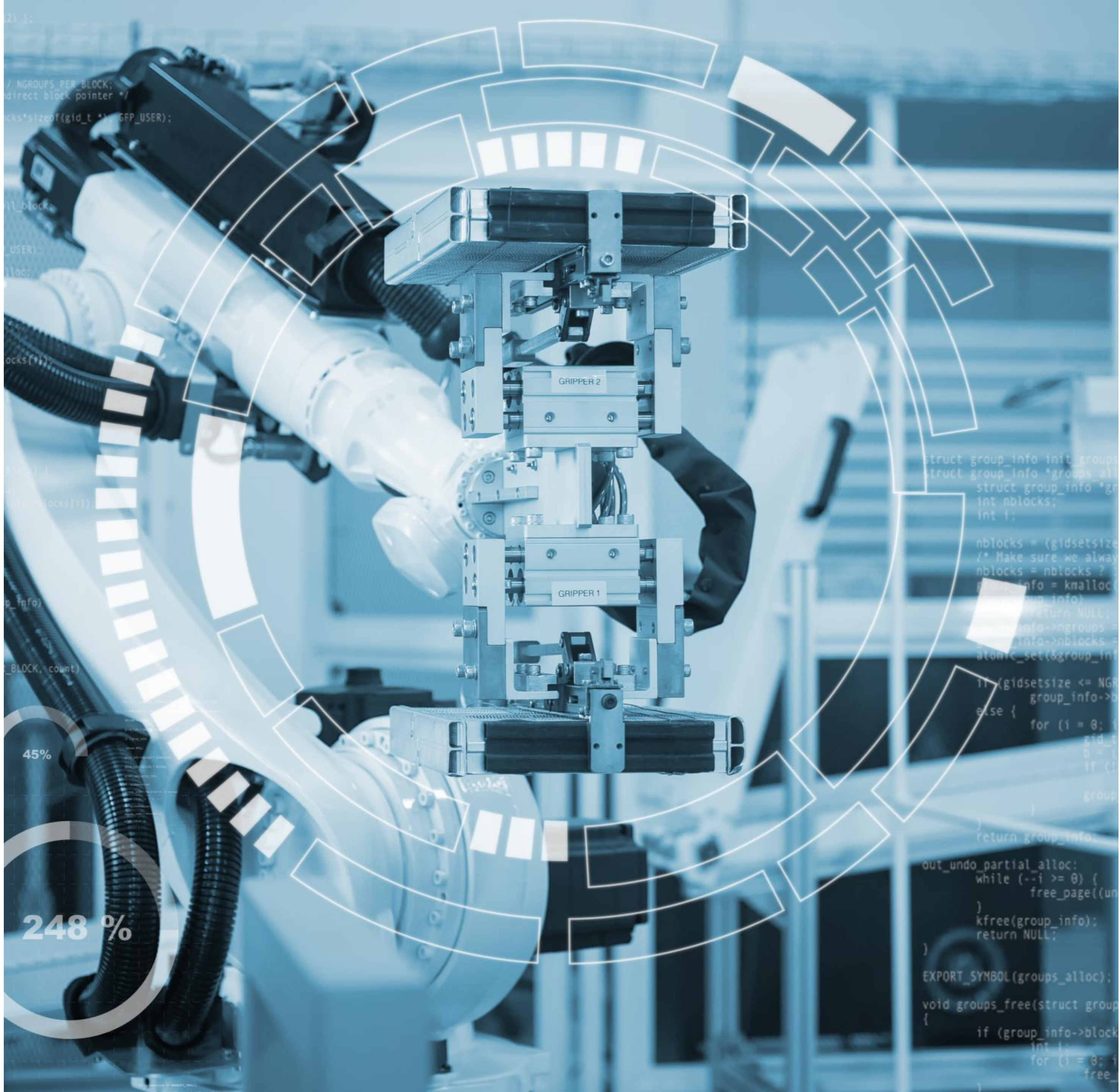
5. Conclusion



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Conclusion

- It is not easy to validate an AI technology for critical applications.
- A governmental organization should investigate the transparency and understanding of such technologies.
- The data used for training may have unexpected consequences (e.g., bias, discrimination).

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Q&A and Discussion

Artificial Intelligence in Healthcare:

Opportunities, Challenges, and Critical Perspectives

Presenter:

Dr Miquel Perelló Nieto