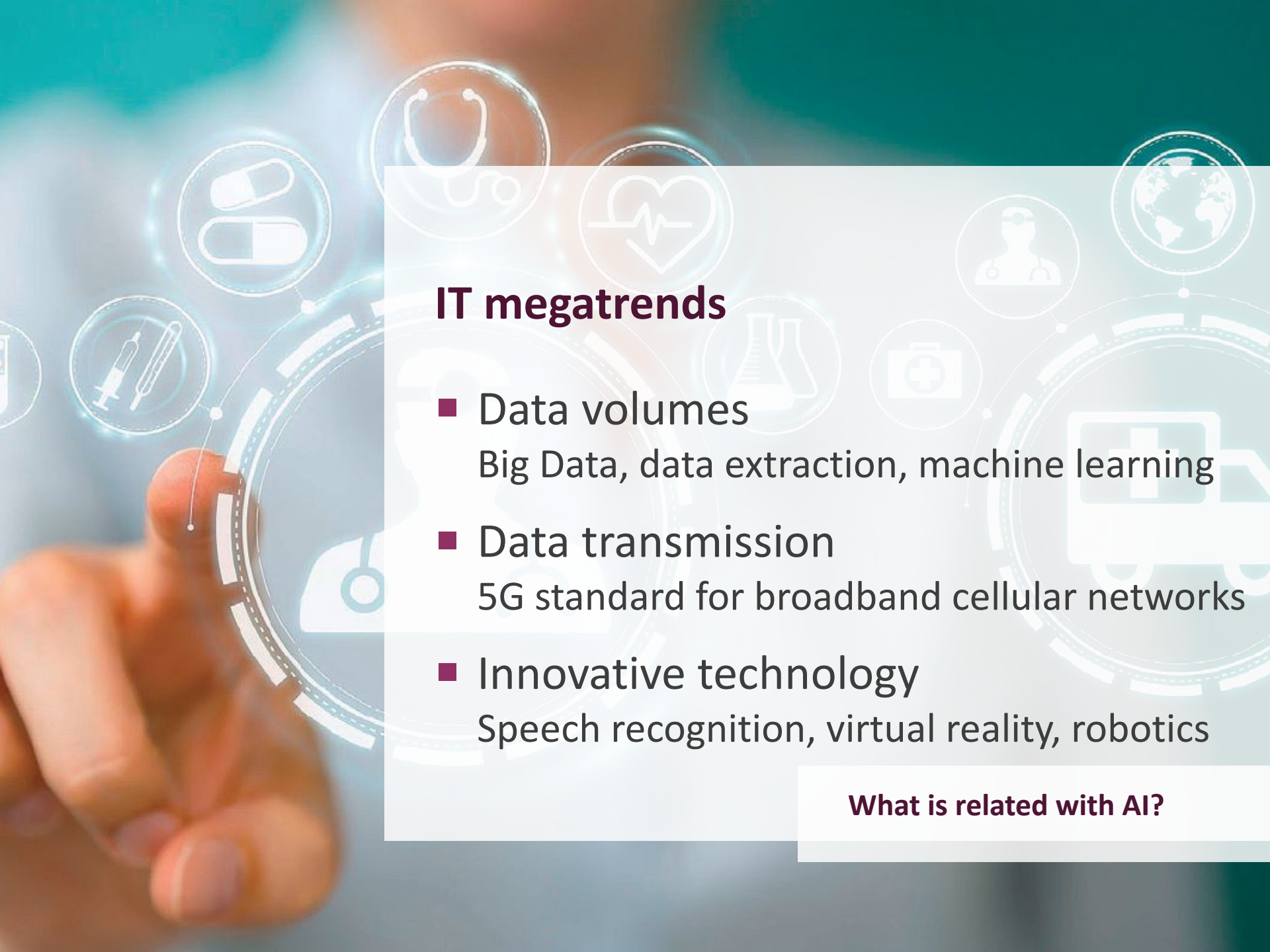
JG|U UNIVERSITÄTSmedizin. MAINZ

SUMMERSCHOOL GTIPI 2022

ARTIFICAL INTELLIGENCE IN MEDICINE

Dr. Torsten Panholzer



IT megatrends

- Data volumes
  Big Data, data extraction, machine learning
- Data transmission
  5G standard for broadband cellular networks
- Innovative technology
  Speech recognition, virtual reality, robotics

What is related with AI?

Goals for medicine

AI as an opportunity

- to improve the treatment.
- to optimise work processes.
- to counteract costs and time pressure.

THE ECONOMIC TIMES

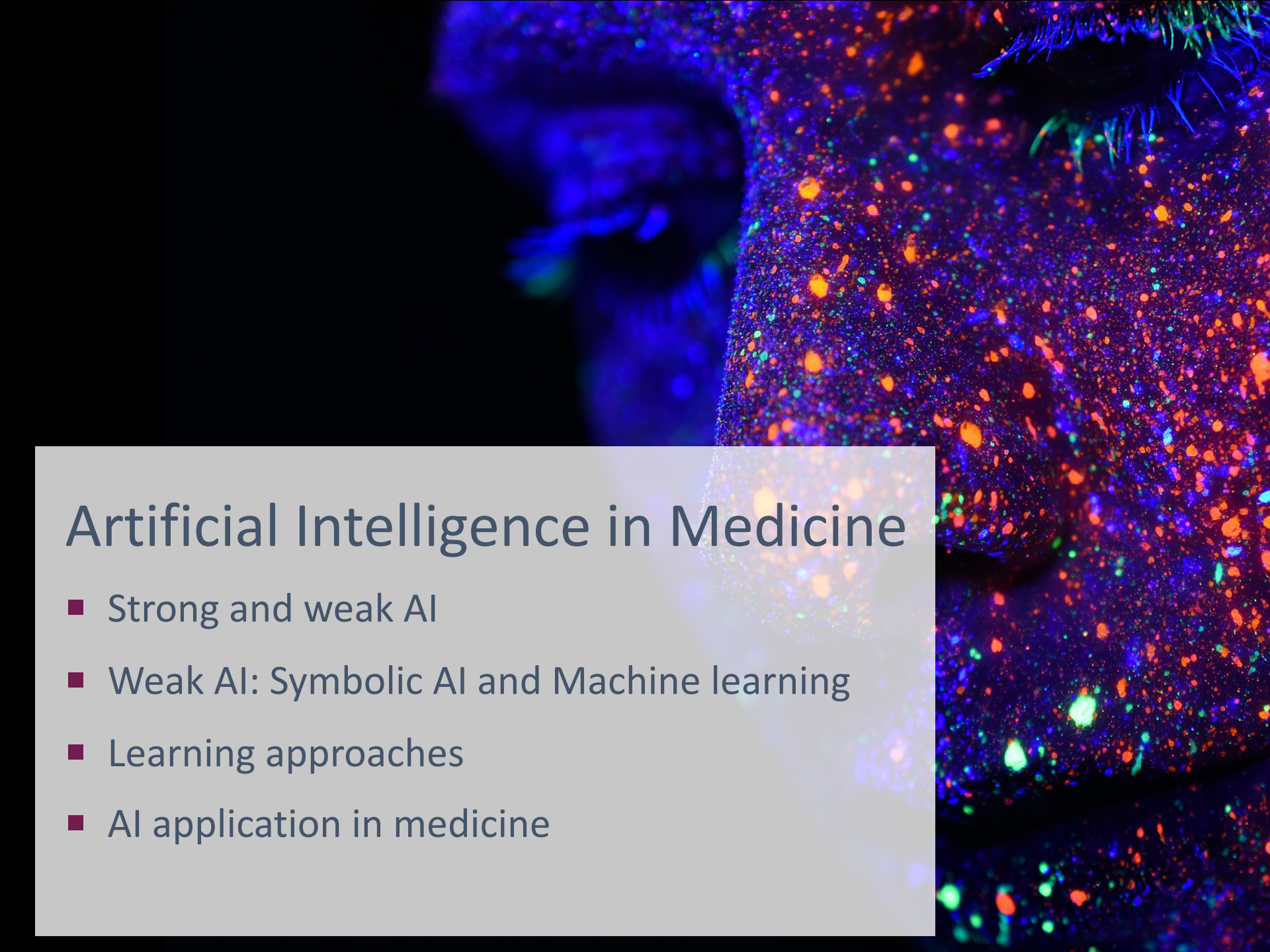
May 29, 2018

AI can detect skin cancer better than doctors

BERLIN: An artificial intelligence system can better detect skin cancer than experienced dermatologists, a study has found.

Researchers trained a convolutional neural network (CNN) to identify skin cancer by showing it more than 100,000 images of malignant melanomas, as well as benign moles.

They compared its performance with that of 58 international dermatologists and found that the CNN missed fewer melanomas and misdiagnosed benign moles less often as malignant than the group of dermatologists.



Artificial Intelligence in Medicine

- Strong and weak AI
- Weak AI: Symbolic AI and Machine learning
- Learning approaches
- AI application in medicine

ARTIFICIAL INTELLIGENCE (AI)

= automation or simulation of intelligent behavior

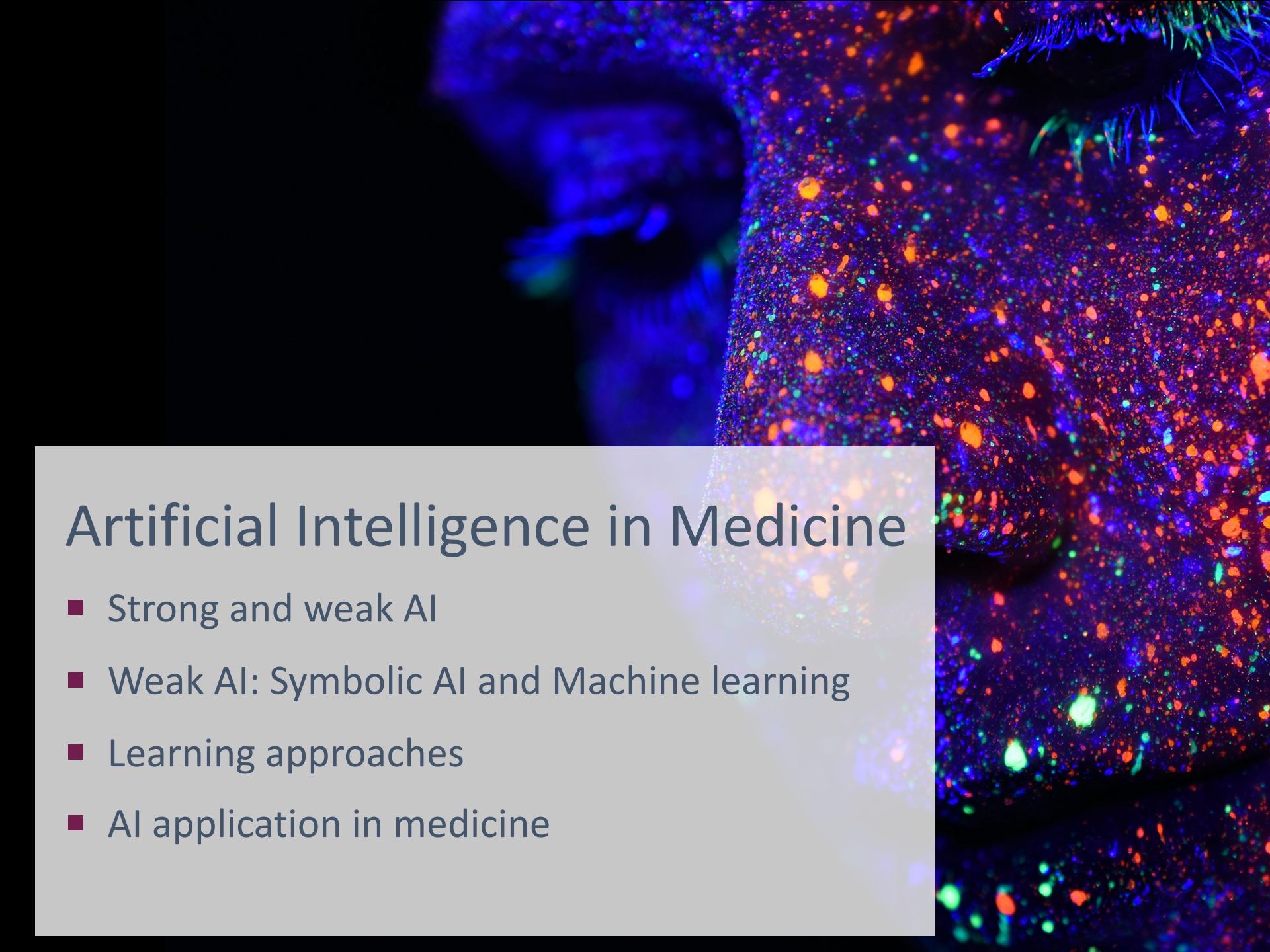
i.e. machines (software, algorithms) can autonomously find solutions to problems, make predictions, make decisions.

Strong AI

Systems that can perform complex intellectual tasks and cognitive abilities like humans. → outside the technical capabilities.

Weak AI

Simulation of specific individual human abilities.
→ exactly one task, but sometimes with superhuman performance.



Artificial Intelligence in Medicine

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- Weak AI: Symbolic AI and Machine learning
- Learning approaches
- AI application in medicine

WEAK AI

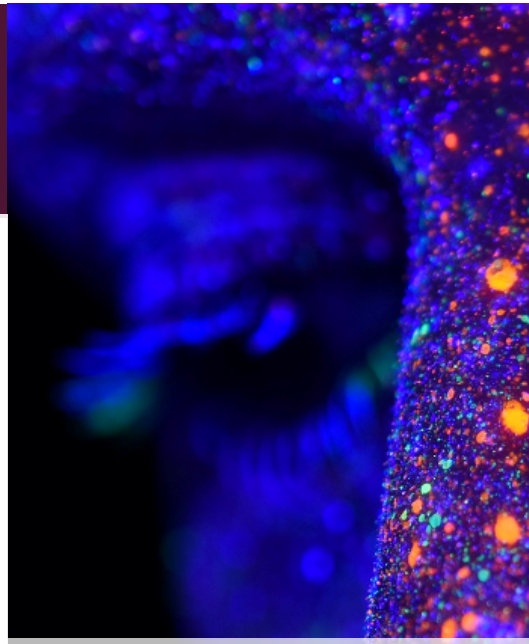
Symbolic AI

Top-down approach. The algorithm is programmed and describes a problem deterministically using human-readable symbols (e.g. letters), rules and representations (models, concepts, pattern).

Machine learning

Bottom-up approach. The algorithm learns from training data to derive a representation that can be applied to new, unknown data.

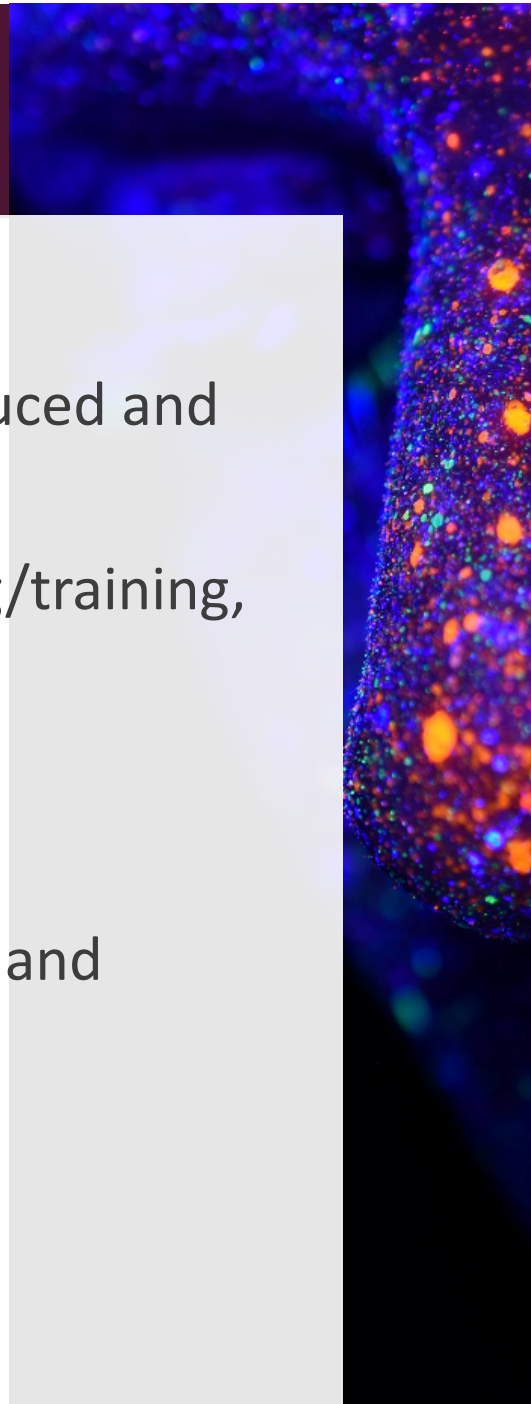
This allows to solve certain problems independently, without being explicitly programmed to do so.



Both started in the 1950s.

- Symbolic AI was first used and further developed.
- Machine Learning was initially useless without computing power and big data.

SYMBOLIC AI - MACHINE LEARNING



Symbolic AI

The decision of the system can be exactly reproduced and understood (transparent Box).

No large amounts of data are needed for learning/training, instead the knowledge is implemented.

Less computing power is usually needed.

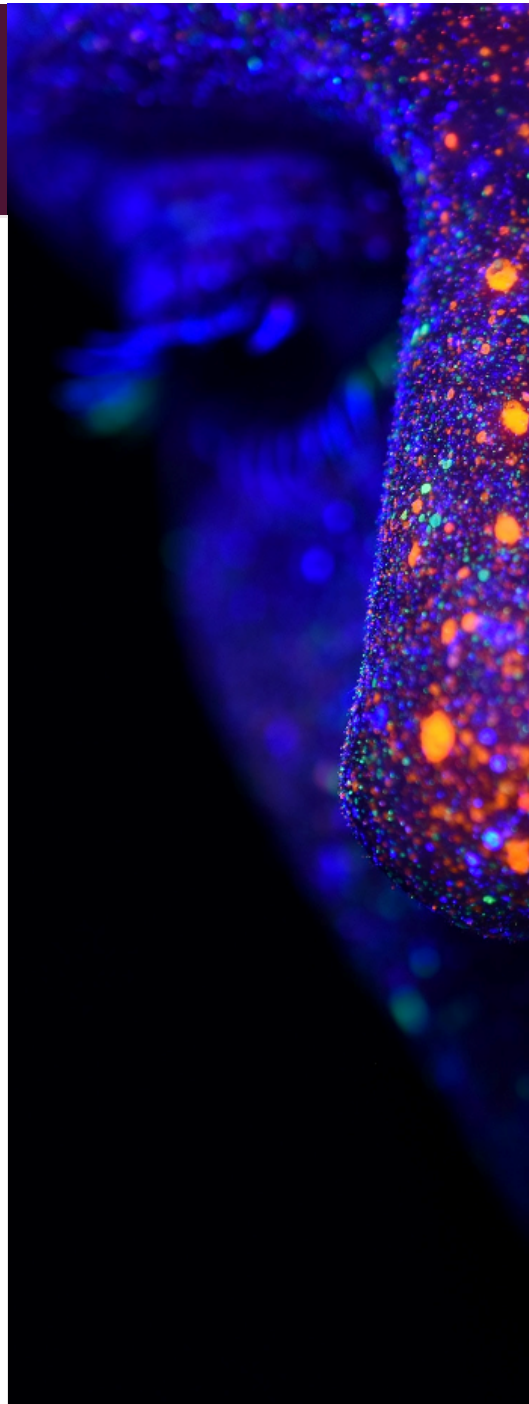
But: For many real-world problems no clear rules and definitions can be found.

WEAK AI

Symbolic AI

The system works with data and rules that have been previously provided and stored (programmed or 'learned').

Example chess computer:
With the stored moves and rules it calculates and simulates all possible scenarios. Based on this, the next move of the best scenario is done.



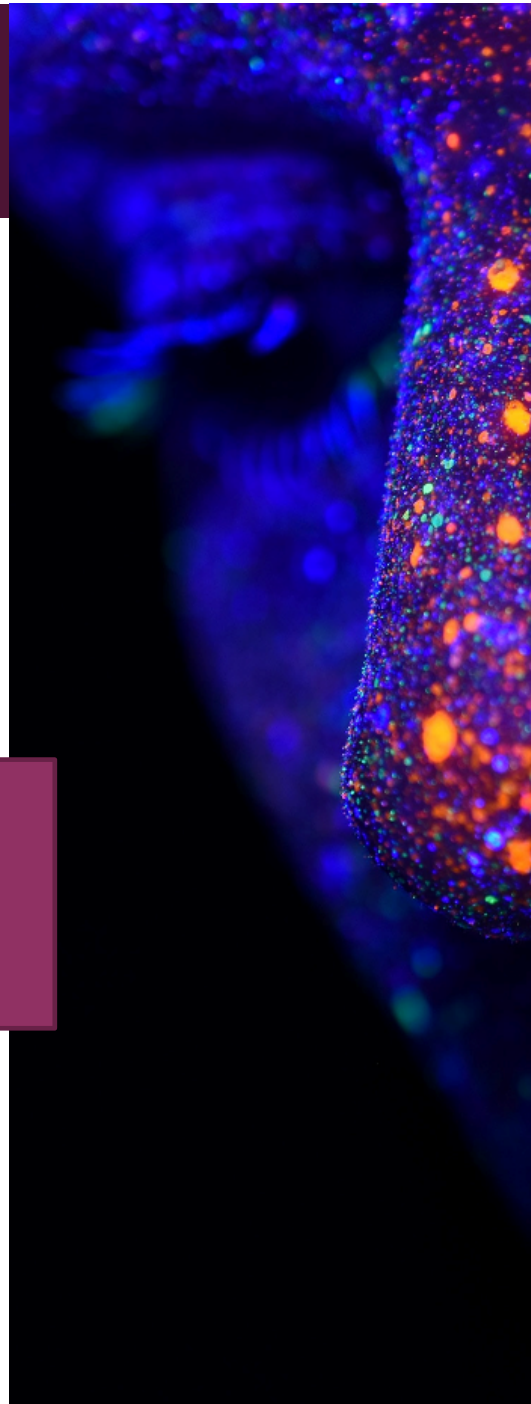
WEAK AI: TECHNOLOGIES

Behind AI is a variety of different methods and technologies.

Symbolic AI

Decision trees
Table-based Agents
Expert systems
Rule-based systems

e.g. Customer classification
Webcrawler
Clinical decision support
Chess computer



MACHINE LEARNING

Bottom-up approach. The algorithm learns from training data to derive a representation that can be applied to new, unknown data.

1. Training = Learning from experience
   The algorithm build the representation (model, pattern, concept) based on training data. Many parameters are adjusted step by step (training) until an useful representation results.
2. Application of the representation
   to new, unknown data. It can make predictions or decisions based on the learnt experience during training.

WEAK AI: TECHNOLOGIES

Symbolic AI

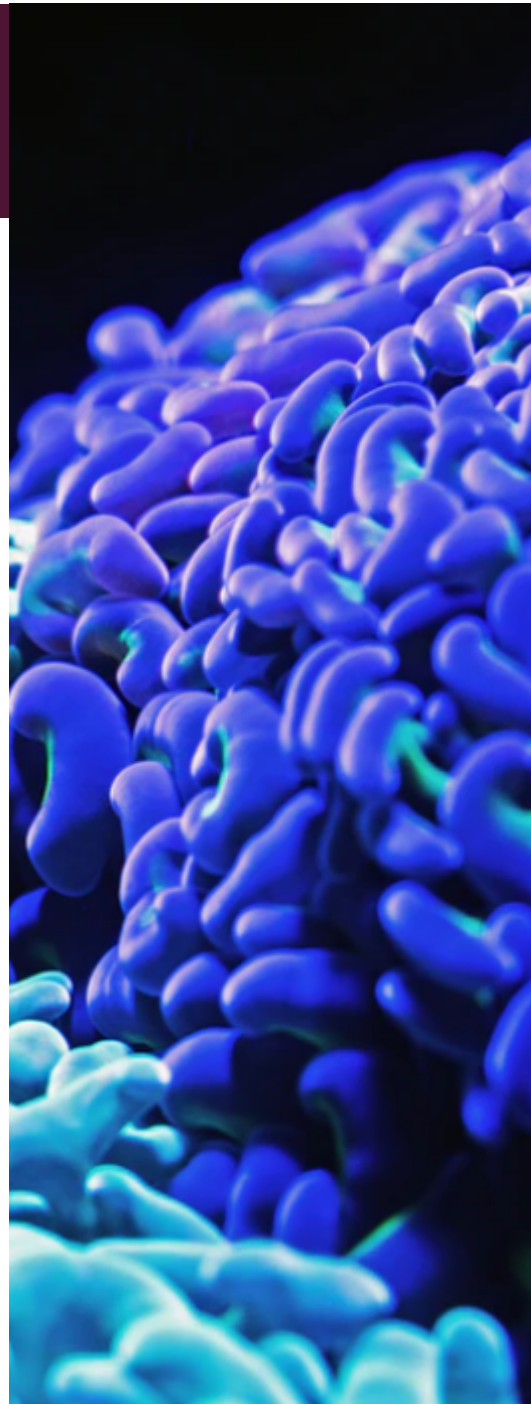
Decision trees
Table-based Agents
Expert systems
Rule-based systems

Machine learning

Deep learning

Neuronal networks
Convolutional NN
Long short-term memory
Autoencoder

Linear regression
Random Forest



MACHINE LEARNING PROCESS

0. Select the machine learning method with which you want to train a model. Get training and unknown data.
1. Training: Use the algorithm of the method with the training data.
   The run with all training data is called an epoch.
2. Application: The trained model is used with unknown data and makes predictions.

Example: Linear regression

1. The algorithm adjusts the regression line (= the model) so that the difference between training values and values predicted from the line is minimized.

WEAK AI: TECHNOLOGIES

Symbolic AI

Decision trees
Table-based Agents
Expert systems
Rule-based systems

e.g. Pattern recognition
Image recognition
Translator
Voice recognition

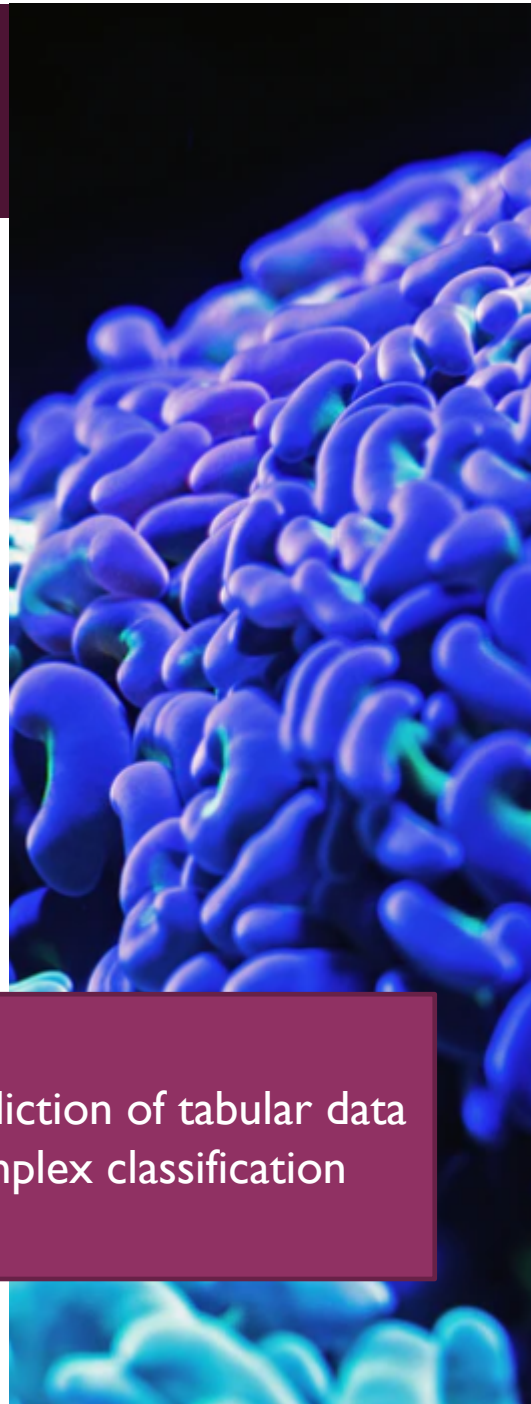
Machine learning

Linear regression
Random Forest

e.g. Prediction of tabular data
Complex classification

Deep learning

Neuronal networks
Convolutional NN
Long short-term memory
Autoencoder

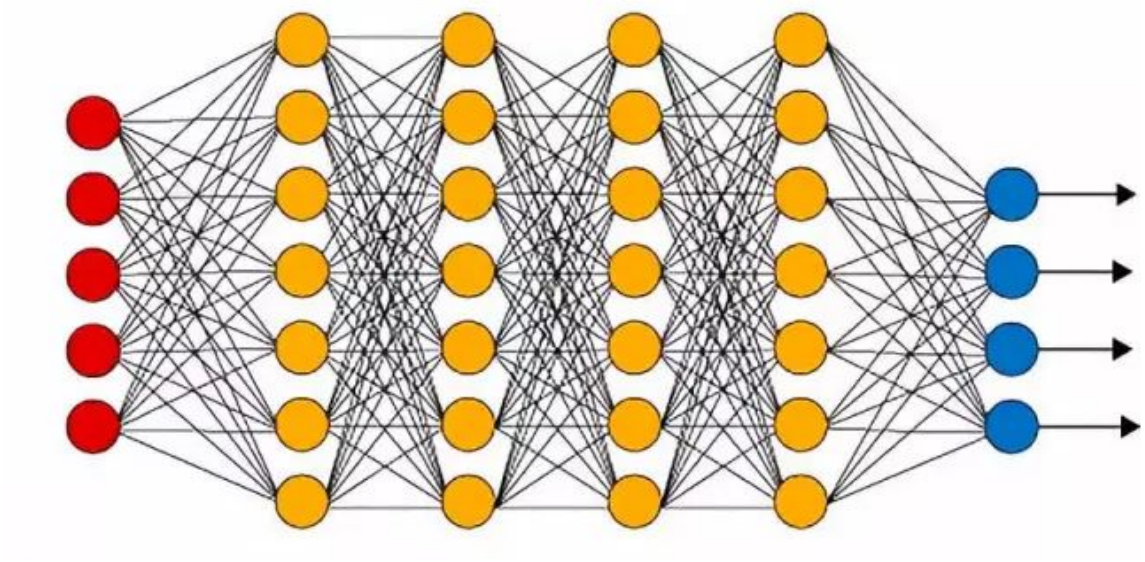


DEEP LEARNING: NEURONAL NETWORKS

Artificial neuronal networks are arranged “deeply” in many layers of neurons.

The connections between the neurons are weighted.

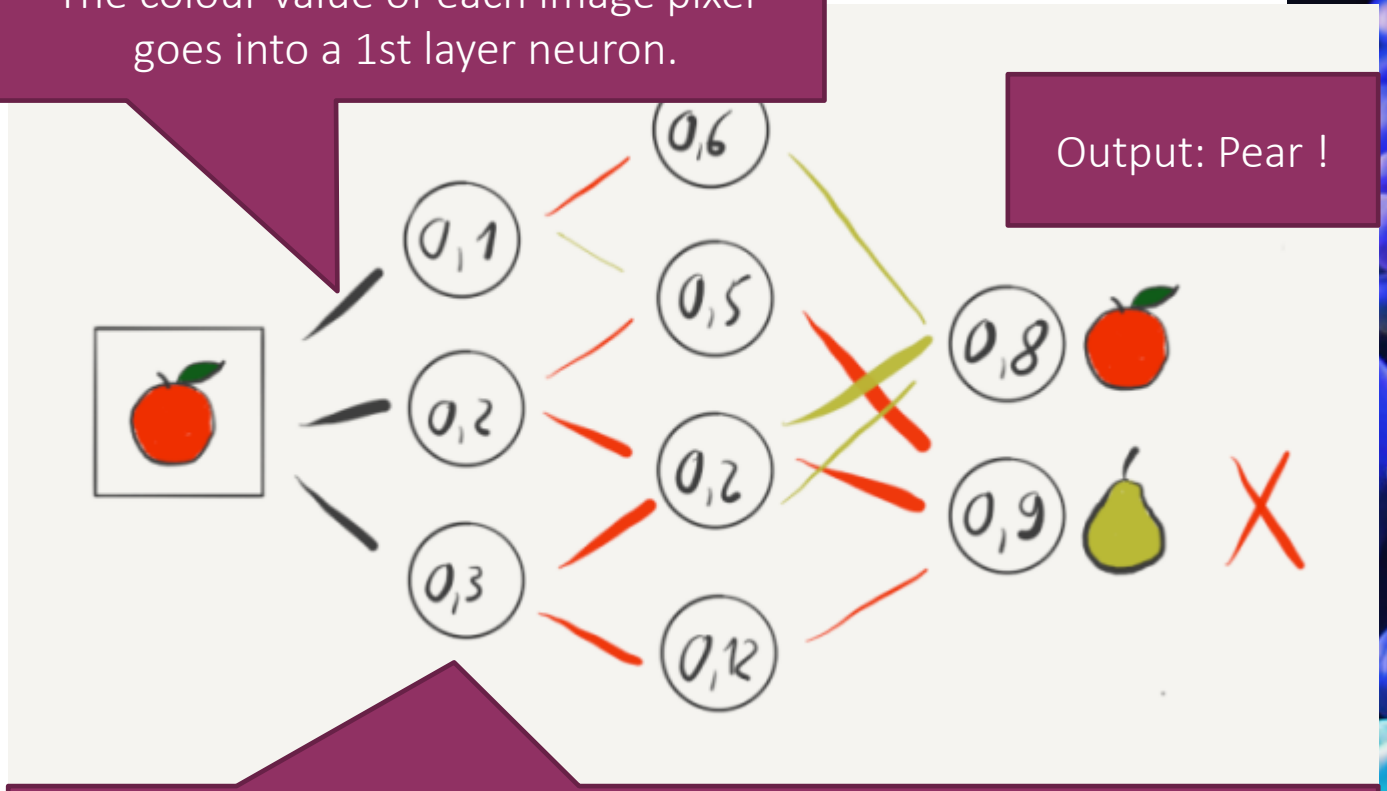
Training with data (= machine learning) changes the weights and thus optimises the decision paths.



Decision

DEEP LEARNING:
TRAINING OF A NEURONAL NETWORK

The colour value of each image pixel goes into a 1st layer neuron.



Output: Pear !

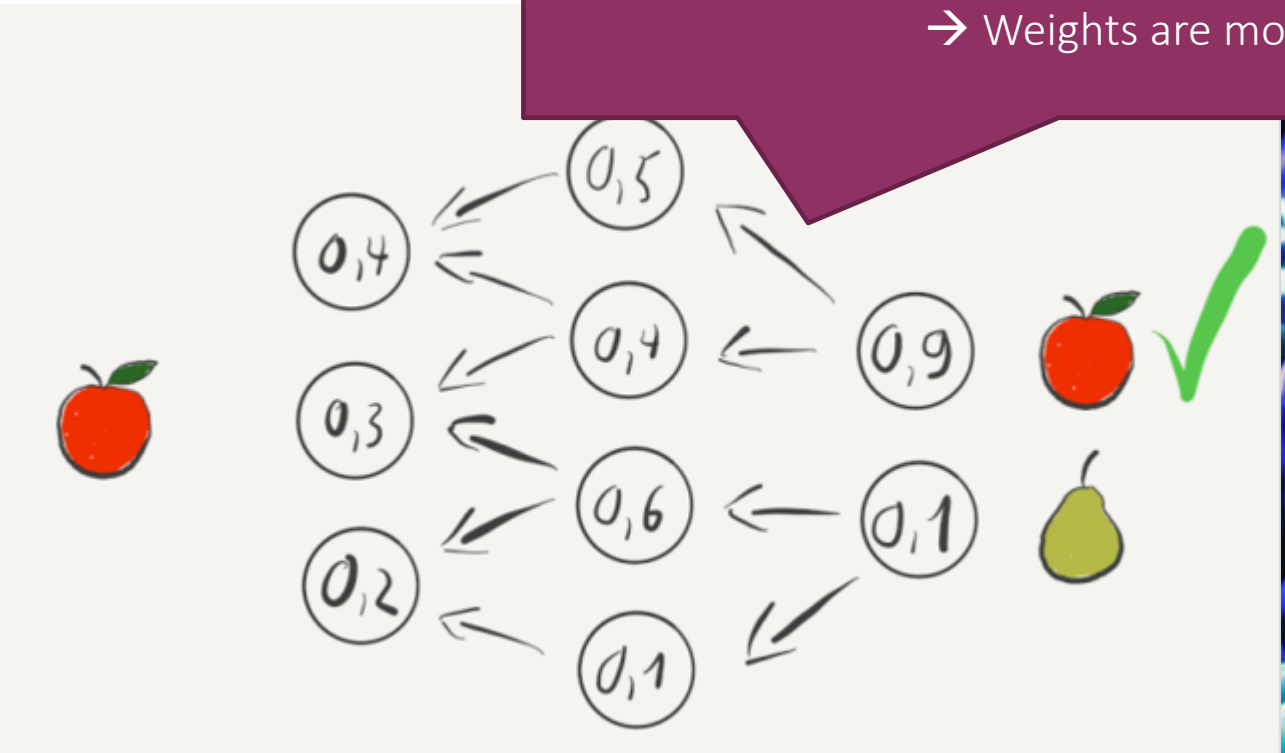
Each neuron processes the value in a formula and calculates the weight. The value is passed to the next neuron.

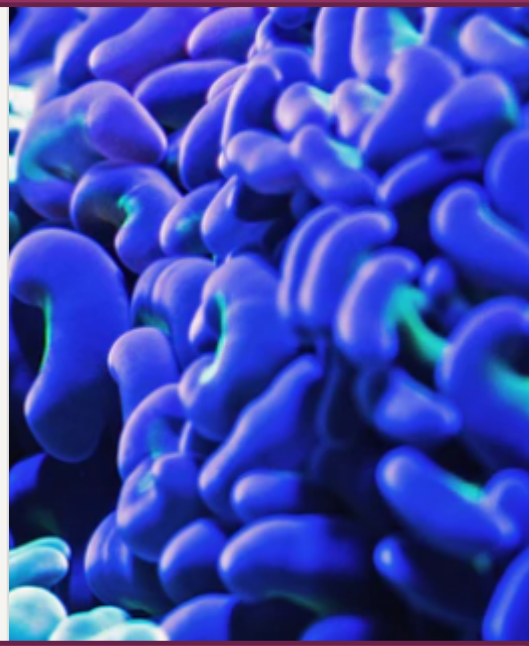
1st run generates random values.

DEEP LEARNING: TRAINING OF A NE

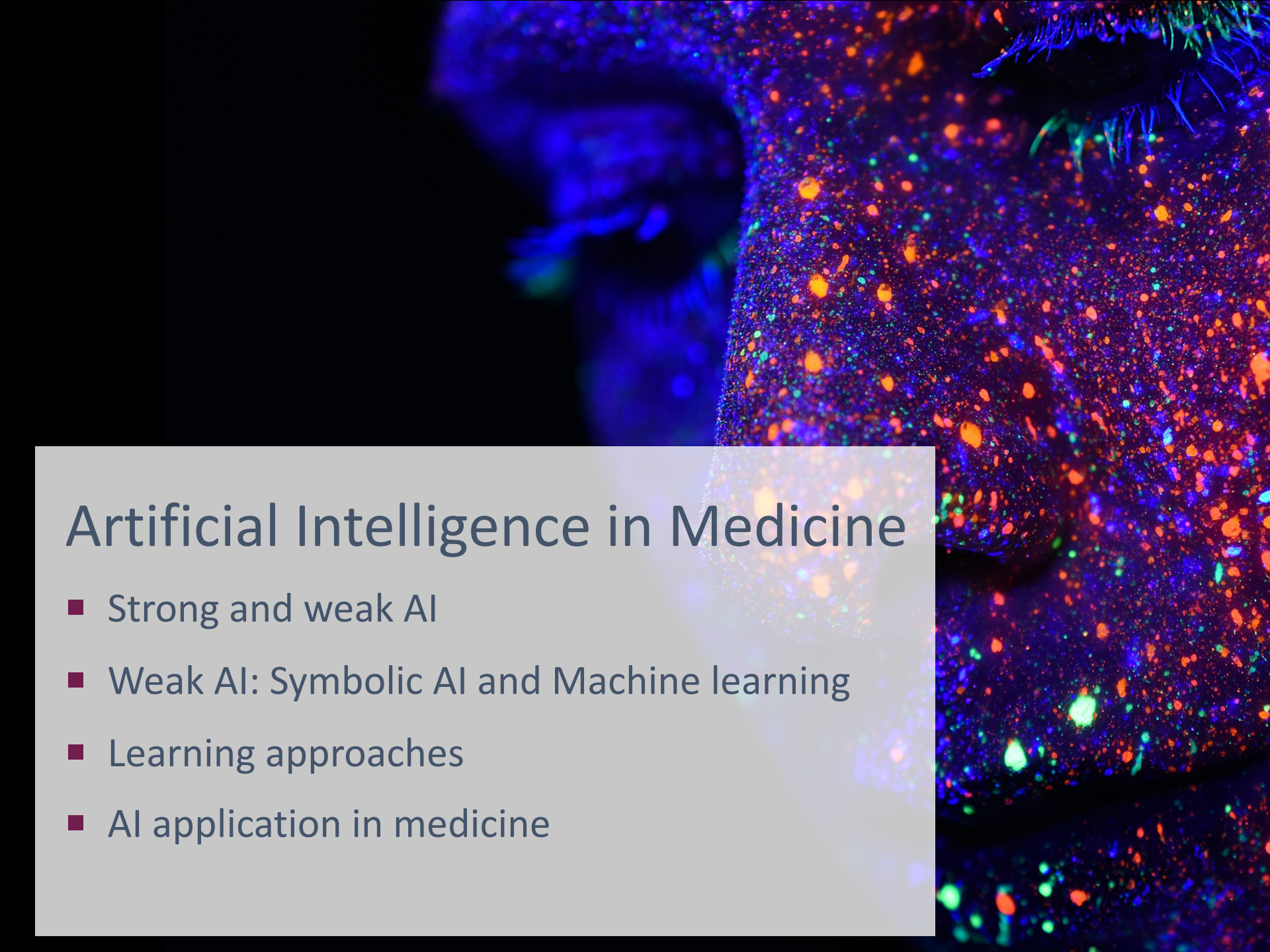
Training

Backpropagation:
By adjusting the result to the target value, the network trains its neurons to be more likely to reach the correct result.
→ Weights are modified.





This step is repeated with many pictures of apples and pears.
This creates discriminators that the net has taught itself. They are not transparent and are more complex than human discrimination.



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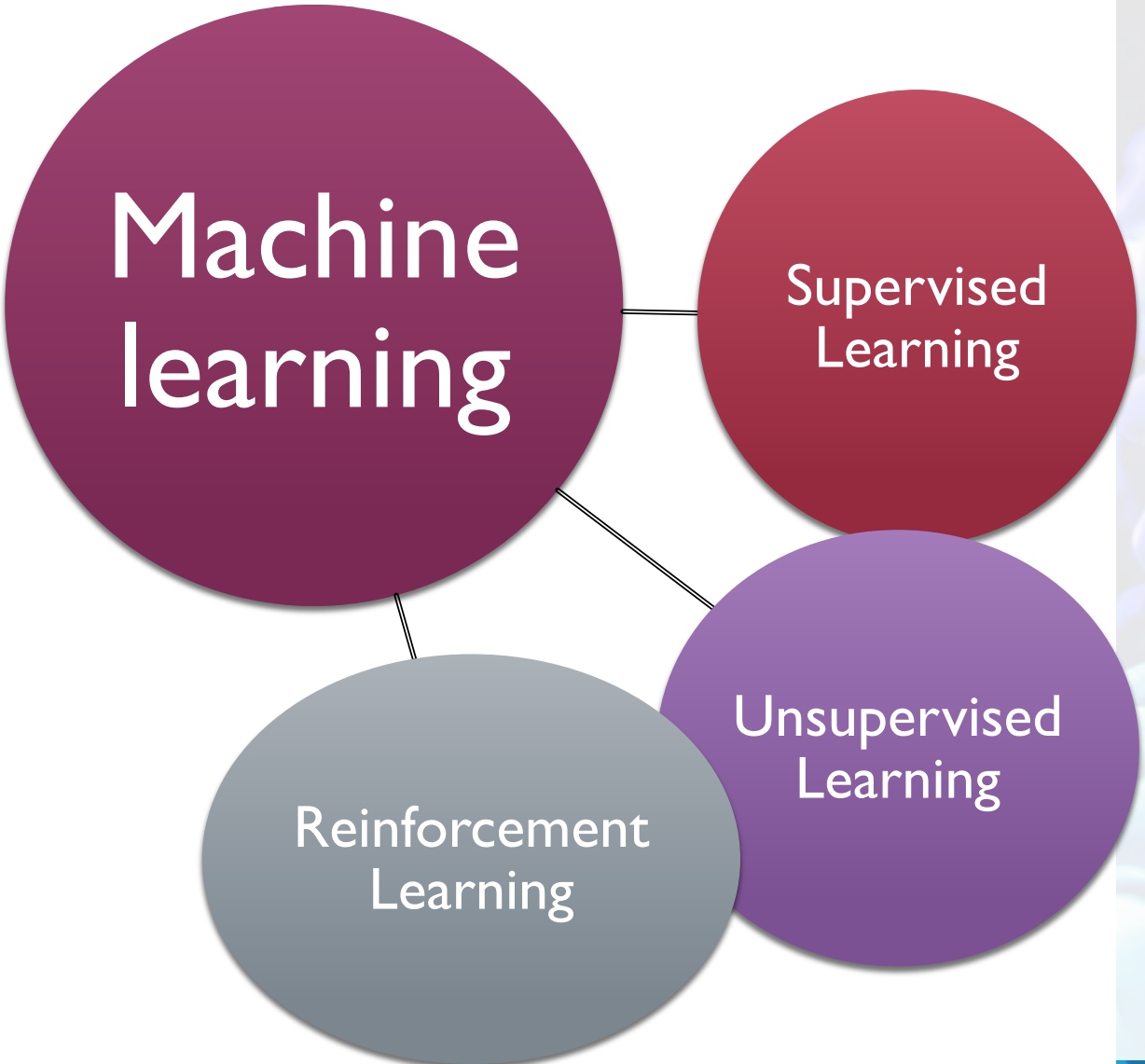
LEARNING APPROACHES



SUPERVISED LEARNING

Learning is done with training data that is previously marked as correct or incorrect.

→ Training is done always to a goal that has been previously defined by the human being.

Example:
Training of a neuronal network

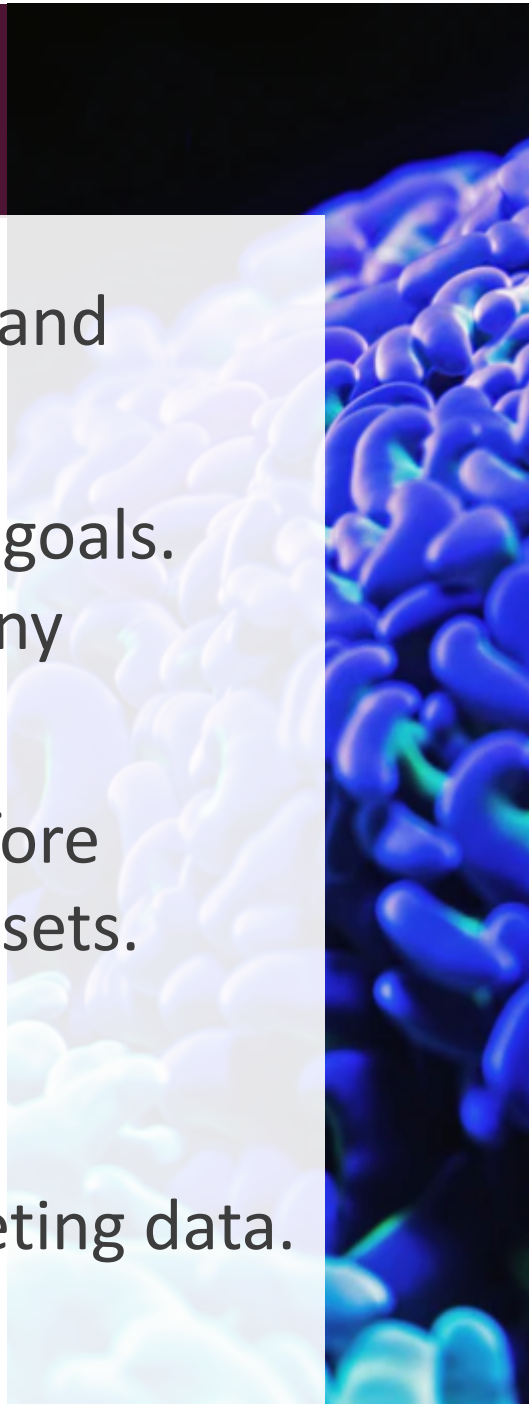
UNSUPERVISED LEARNING

The algorithm is provided unlabelled data and works on its own to discover information.

The training phase does not provide exact goals. Instead, the algorithm itself searches for any patterns it can find.

Unsupervised learning methods are therefore preferred for the exploration of large data sets.

Example:
Determining groups of customers in marketing data.



REINFORCEMENT LEARNING

It works on a principle of feedback.

The algorithm makes decisions independently in a trial-and-error manner. Each time it receives a reward. By maximizing the reward, an optimal solution is found.

No training data is required. Instead, they are generated and labelled by simulation.

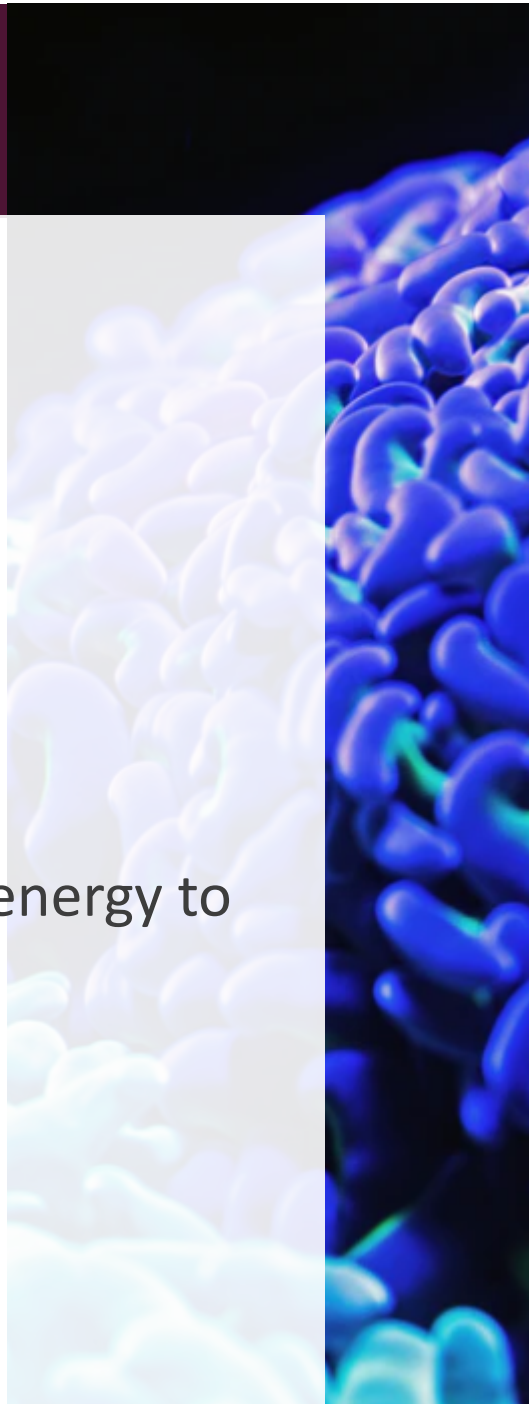
REINFORCEMENT LEARNING

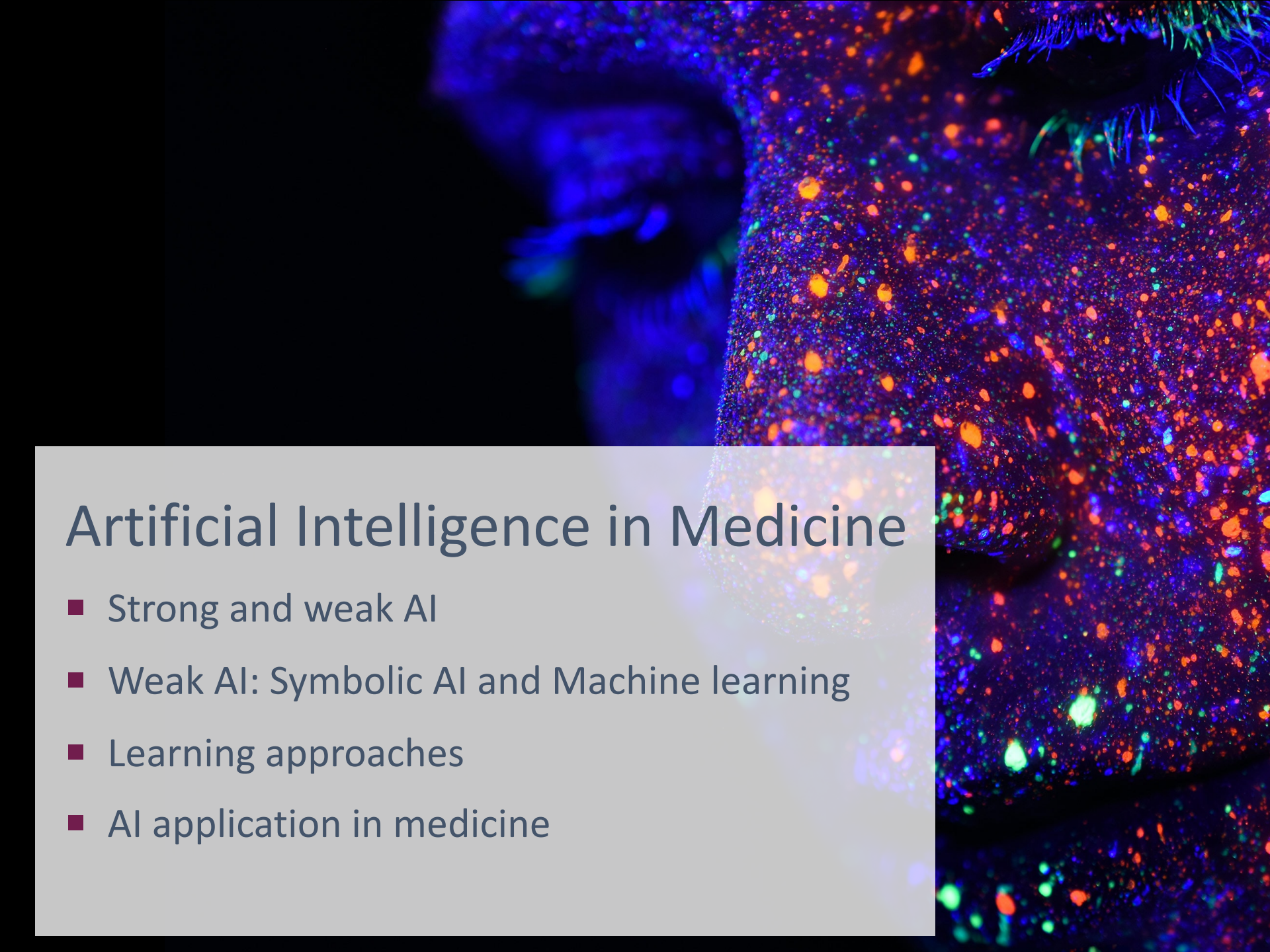
Applications

Parking assistant, control of complex systems

Controlling the air conditioning in Google data centres:

» The algorithm was able to reduce the required energy to cool the servers by around 40%. «





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APPLICATION IN MEDICINE

Objectives

Analyzing digitally available information with AI methods

- make accurate diagnoses
- suggest optimized therapies
- obtain more prevention of diseases
- decrease medical costs

CURRENT AREAS OF AI APPLICATION BEYOND MEDICINE

Pattern recognition

Extracting relevant information from large, unstructured data sets / images.

Natural Language Processing

Understanding or generating the content and context of texts and speech

Robotics and autonomous machines

Navigating intelligent and autonomously.
Can adapt themselves to new situations.

APPLICATION IN MEDICINE

Pattern recognition in diagnostic imaging

- Melanomas on the skin.
- Breast cancer cells during X-ray mammography.
- Malignant tumours during colonoscopy.

Natural Language Processing

- Recognizing depression.
- Making a diagnosis from the verbal description of symptoms (text mining).

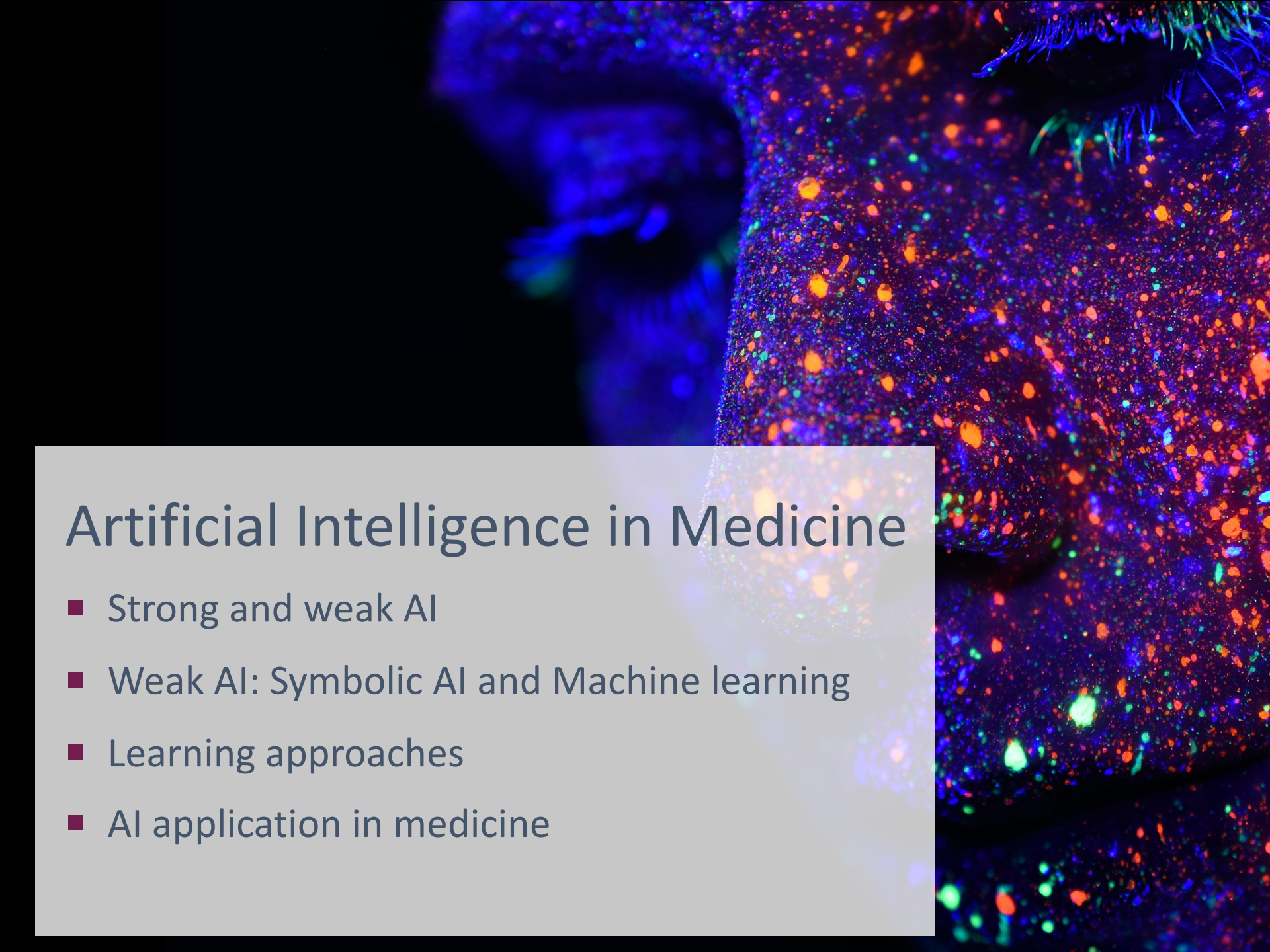
APPLICATION IN MEDICINE

Clinical decision support

Expert systems generate from a knowledge base recommendations for physicians.

Automatic data analysis

Data comparison (esp. gene data)
with other patient data to find the best therapy.



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