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AI Today – Optimisation

Introduction to Machine Learning

Computer Science BSc Course, ELTE Faculty of Informatics

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DEPARTMENT OF
ARTIFICIAL
INTELLIGENCE

What is AI?

AI = Optimisation



What is AI?

$$f^* = \max_{x \in X} f(x)$$



What is AI?

$$f^* = \operatorname{argmax}_{x \in X} f(x)$$



What is AI?

$$f^* = \operatorname{argmin}_{x \in X} f(x)$$



What is AI?

$$f^* = \underset{w \in W}{\operatorname{argmin}} f(w, x)$$

w – Learned parameters
x -- Input instances of the task (images to be recognized, etc.)

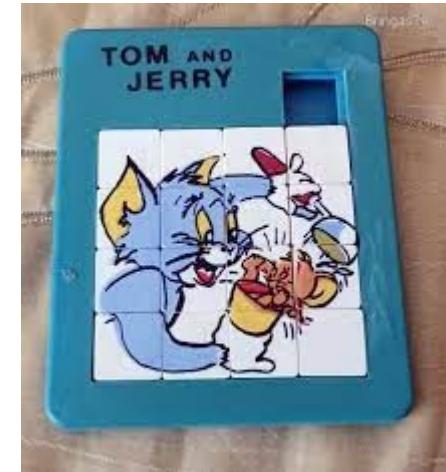


Intelligence = Optimisation??



Intelligent Behavior: Problem Solving

- Shortest Path from A to B
 - *Fewest steps, shortest path, shortest time...*
 - C.f., navigation
- Solve the 15 stone puzzle
 - *Fewest number of moves*
- Generally, find the moves that yields the *highest score*



Intelligent Behavior: Planning

- In what order shall moves be made?
 - To achieve the *most*...
 - To gain the *highest* combined benefit...
- Example: scheduling factory production
 - Incoming series of orders (various products, batch sizes)
 - Different tooling requirements
 - Varying unit production time
 -
 - *Minimize* time lost on switching between products



Intelligent Behavior: Recognising Images, Voices, Text

- Error (*loss*):
 - E.g., in what percent of the cases did it err?
- *Goal to minimize*
 - I.e., increase accuracy



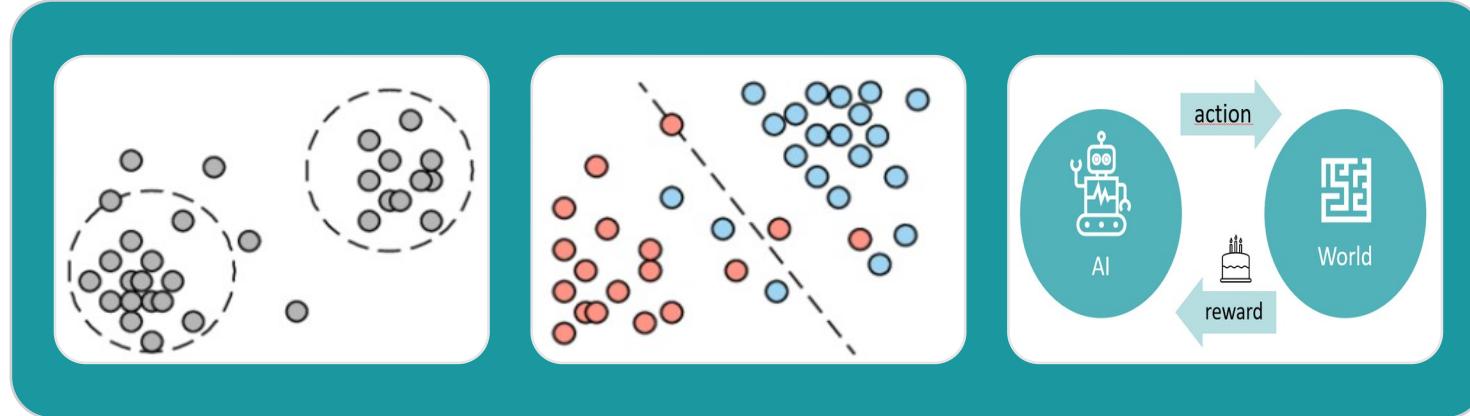
Intelligent Behavior: Learning

- The Key
 - *Improvement*
- Example:
 - Aim at target
 - Assess Results
 - Change → Get better
- Again
 - Minimize error
 - Maximize accuracy



Machine Learning

See upcoming lectures



Unsupervised learning

- Raw data

Supervised learning

- Training data (with labels)

Reinforcement learning

- No data, but observable outcomes



Remark

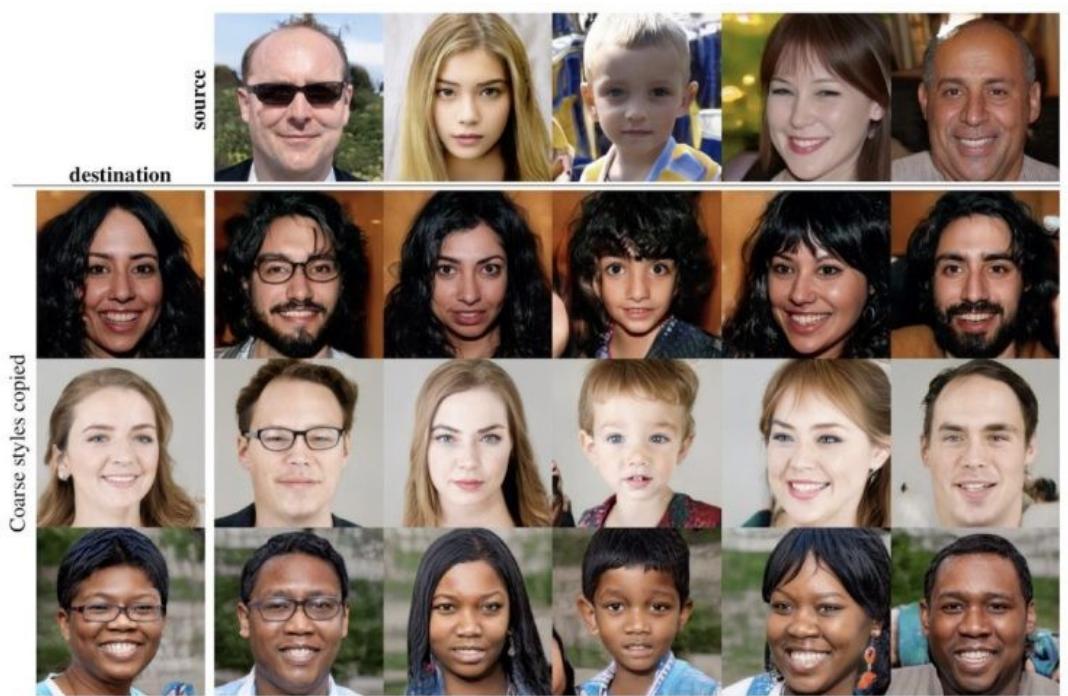
- Learning is usually a slow process
 - Large amounts of data is required
 - Many training examples need to be seen
 - Many games should be played (cf. Practice, Sports training)
- Humans also learn for *decades*
 - Basic skills – first few years
 - Elementary knowledge – about 12 years
 - Professional knowledge – 3+2 years (BSc + MSc)
→ To get a *junior* position (read: unexperienced)
- It never really stops



Intelligent Behavior: Generating Something New



© Night Café Studio



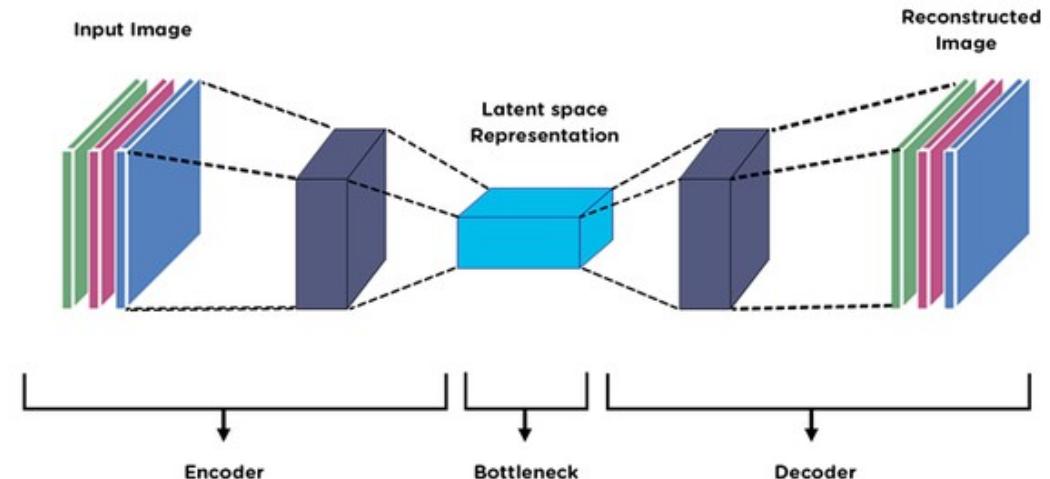
Synthetic images produced by StyleGAN, a GAN created by Nvidia researchers.



Autoencoders

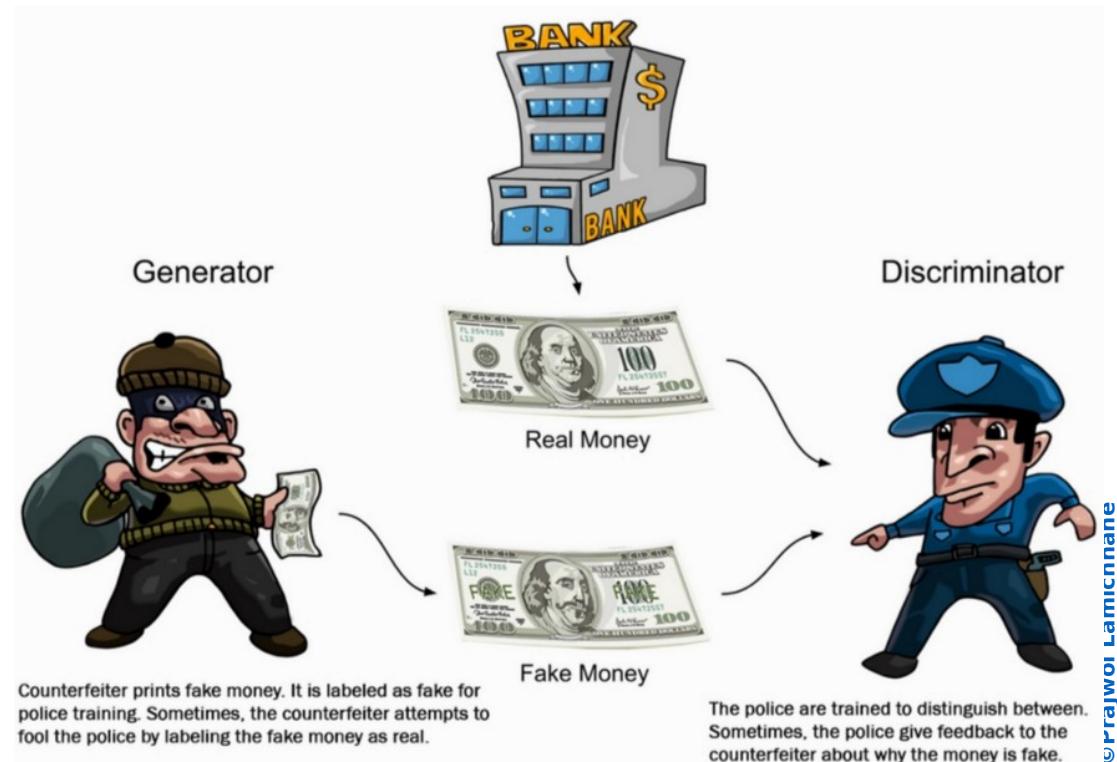
An abstract approach

- Input:
- Output:
- Embedding:
- Decoding:
 -
- Generative output:
 - , random



Intelligent Behavior: Generating Something New

- **Generative Adversarial Network (GAN)**
 - First widely successful generative solution
- **Bandit vs Cops game**
 - 'Generative duel'
 - They both learn (optimise)
 - After a while, the output of the bandit is **new creation**



What is hard in optimisation?

OK, AI is optimisation, but...



AI = Optimisation

What is hard in this?

$$f^* = \underset{w \in W}{\operatorname{argmin}} f(w, x)$$



AI = Optimisation

What is hard in this? Dimensionality

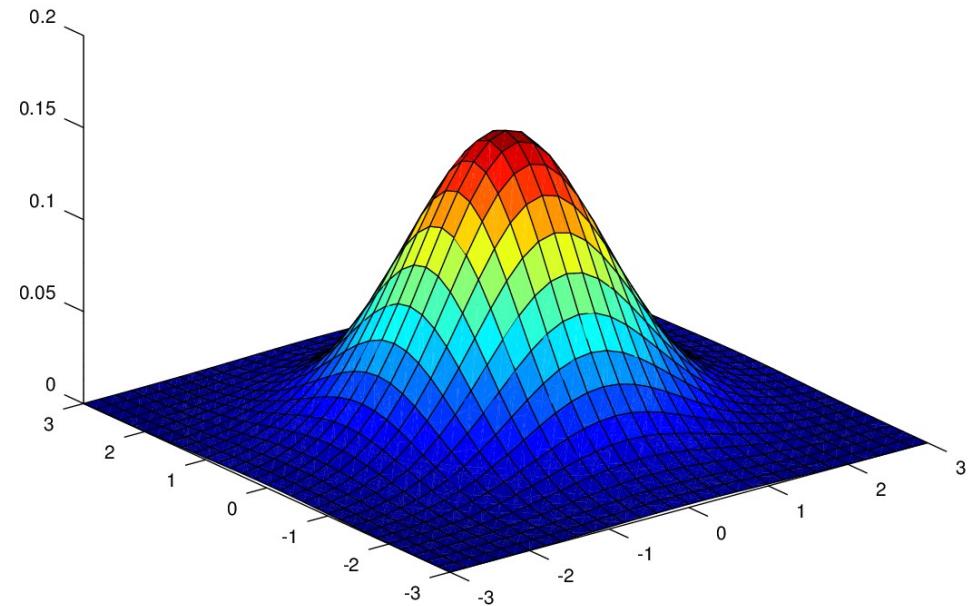
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AI = Optimisation

What is hard in this?

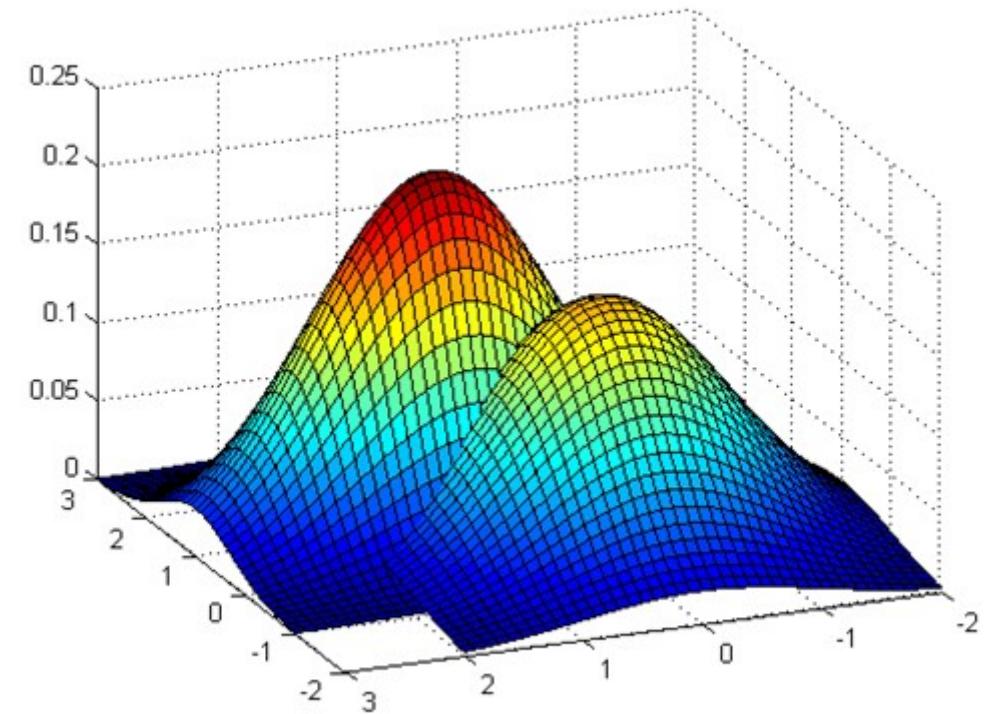
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AI = Optimisation

What is hard in this? Non-monotonicity

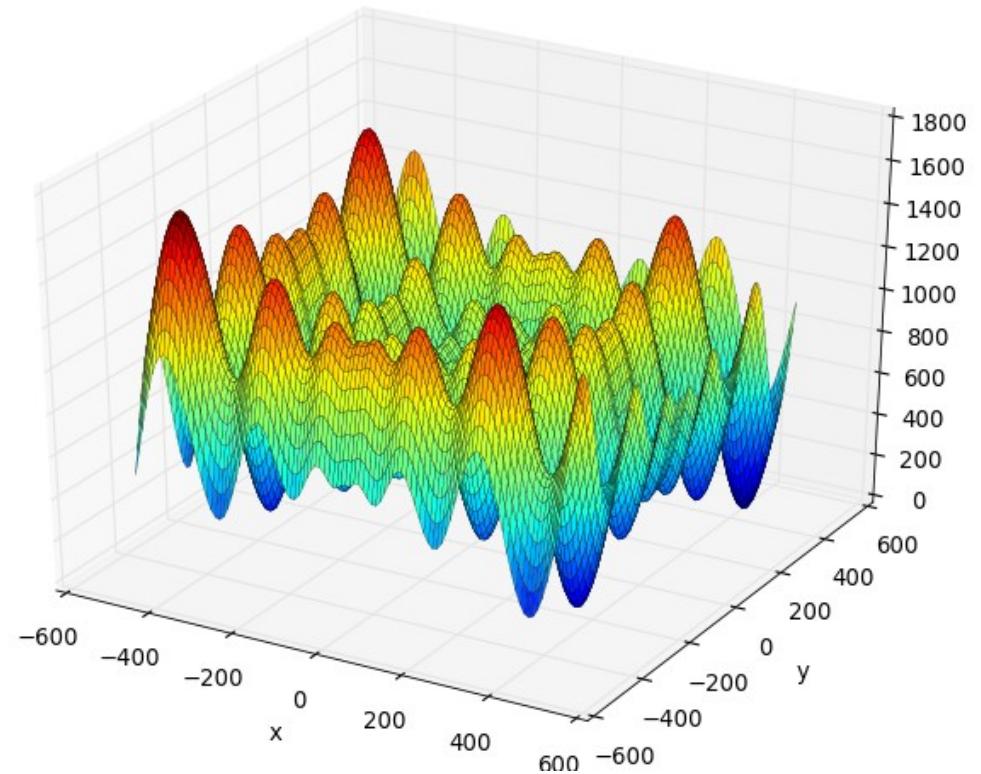
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AI = Optimisation

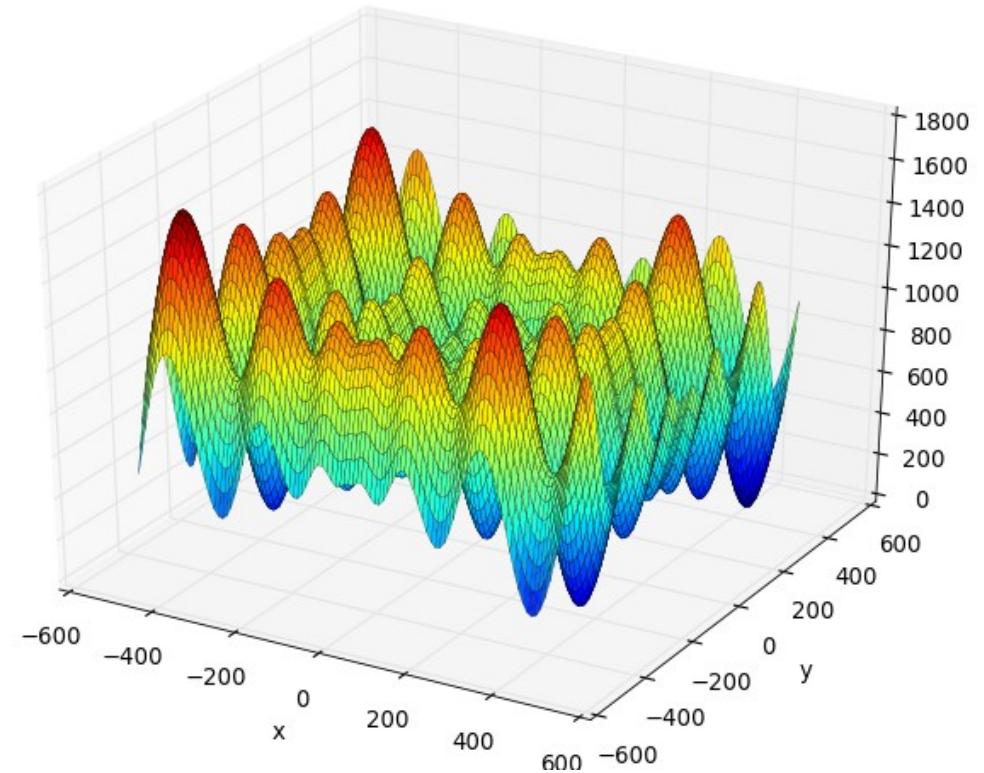
What is hard in this? Ruggedness

W ,



This is a hard problem - No known general solution

W ,



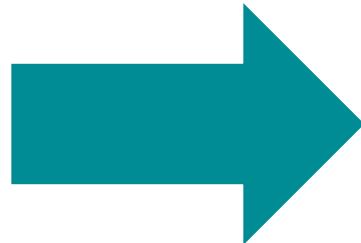
Inspirations

Borrowing from where it works...



Biologically Inspired Methods -

- Brain
- Evolution
- Social Insects



- **Artificial Neural Networks**
- Evolutionary Algorithms
- Swarm Intelligence Methods



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Thank you!

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