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# AI Today – Optimisation

## **Introduction to Machine Learning**

Computer Science BSc Course, ELTE Faculty of Informatics

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# What is AI?

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AI = Optimisation

# What is AI?

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

# What is AI?

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

# What is AI?

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

# What is AI?

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

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

# Intelligence = Optimisation??

# Intelligent Behavior: Problem Solving

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- 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

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- 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

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



# Intelligent Behavior: *Learning*

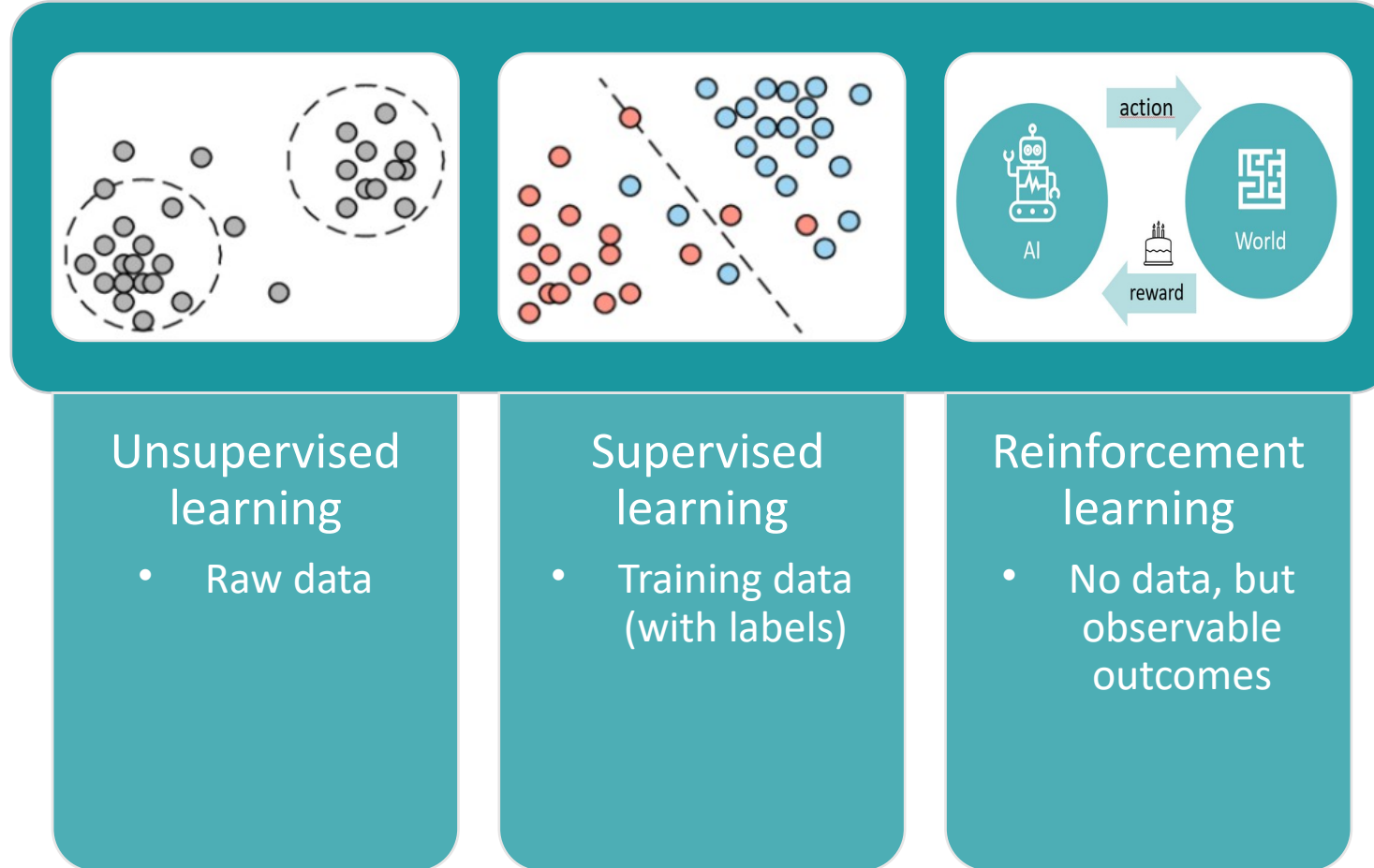
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- The Key
  - *Improvement*
- Example:
  - Aim at target
  - Assess Results
  - Change → Get better
- Again
  - Minimize error
  - Maximize accuracy



# Machine Learning

## See upcoming lectures



# Remark

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- 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



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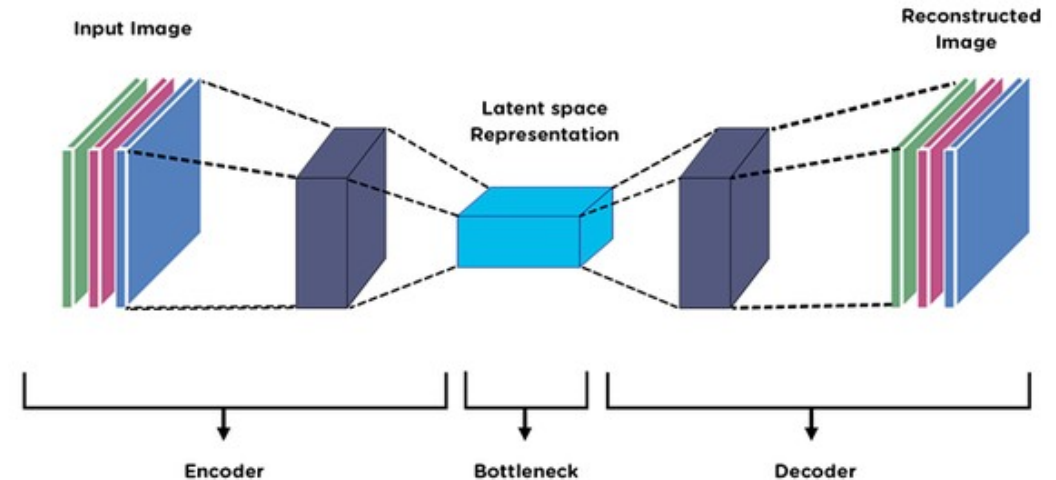


Synthetic images produced by StyleGAN, a GAN created by Nvidia researchers.

# Autoencoders

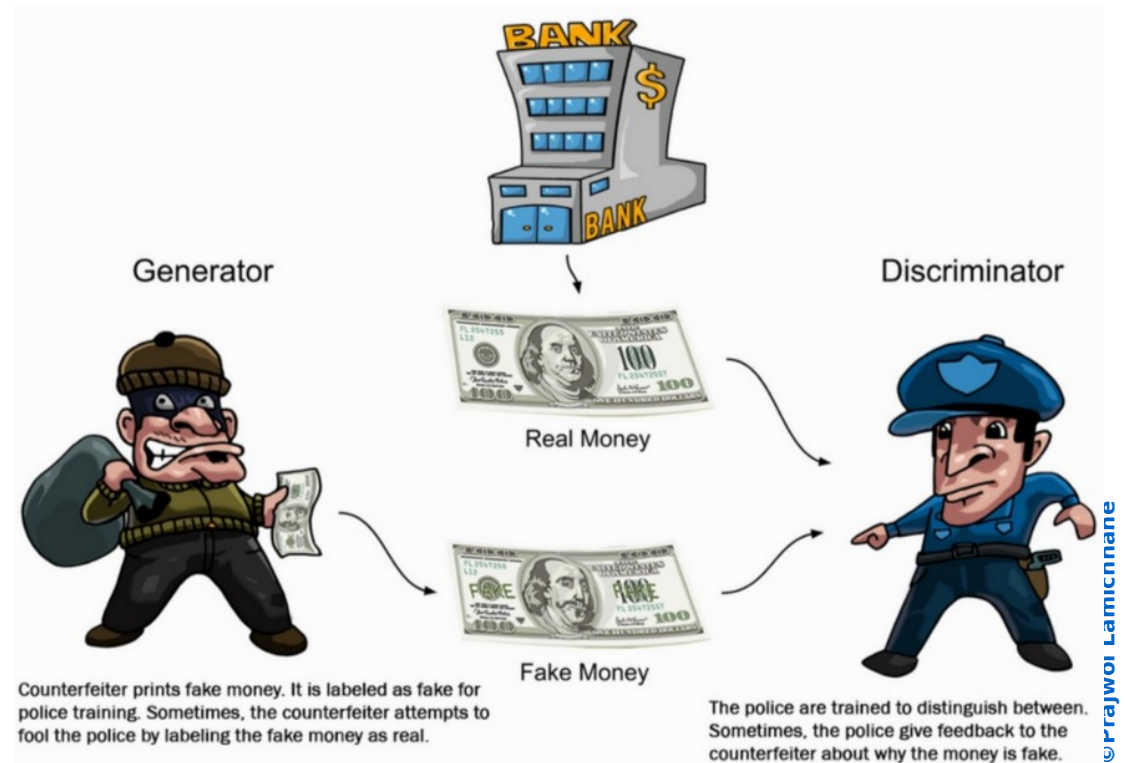
## An abstract approach

- 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?

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

# AI = Optimisation

## What is hard in this? Dimensionality

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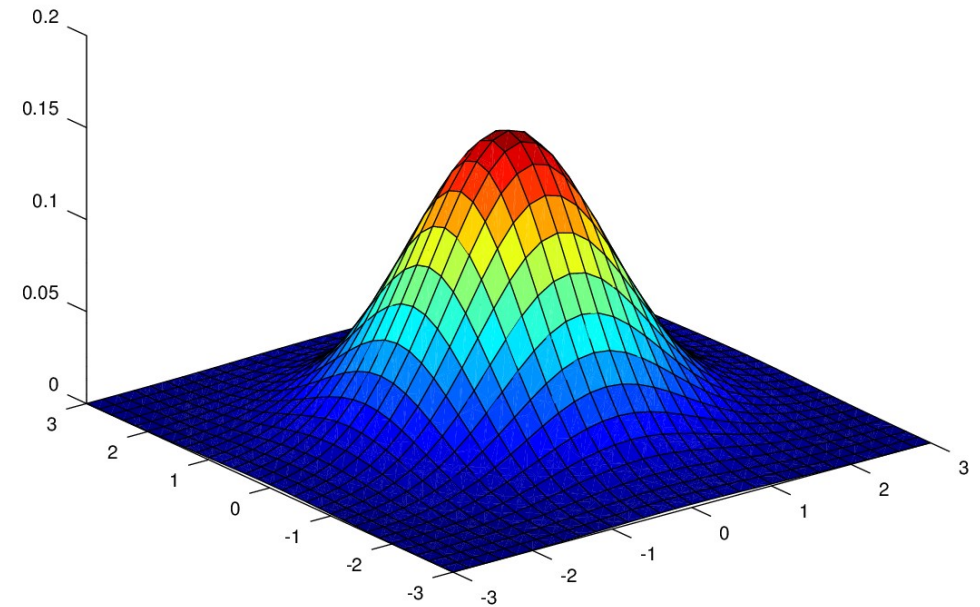
$W,$

# AI = Optimisation

## What is hard in this?

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$W$  ,

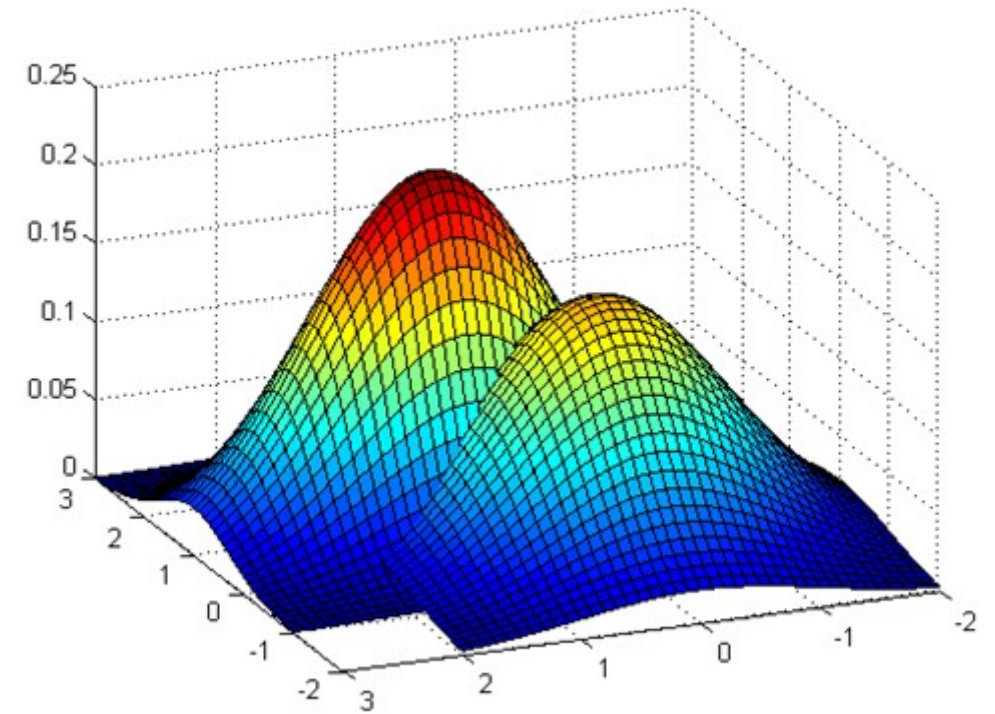


# AI = Optimisation

## What is hard in this? Non-monotonicity

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$W$  ,

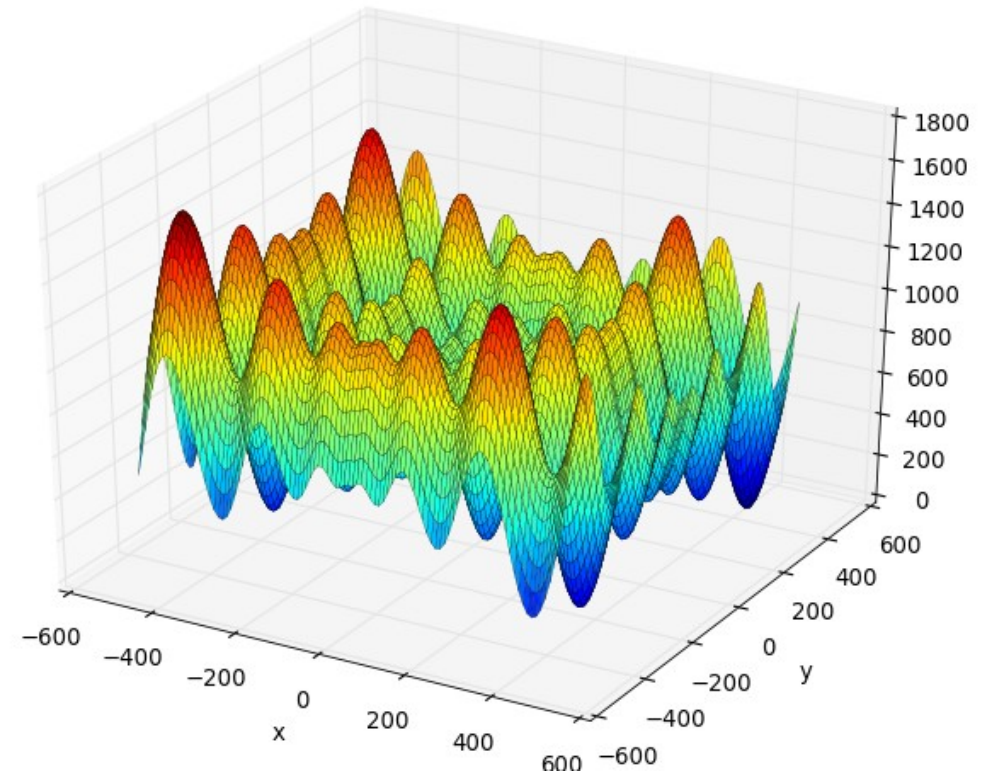


# AI = Optimisation

## What is hard in this? Ruggedness

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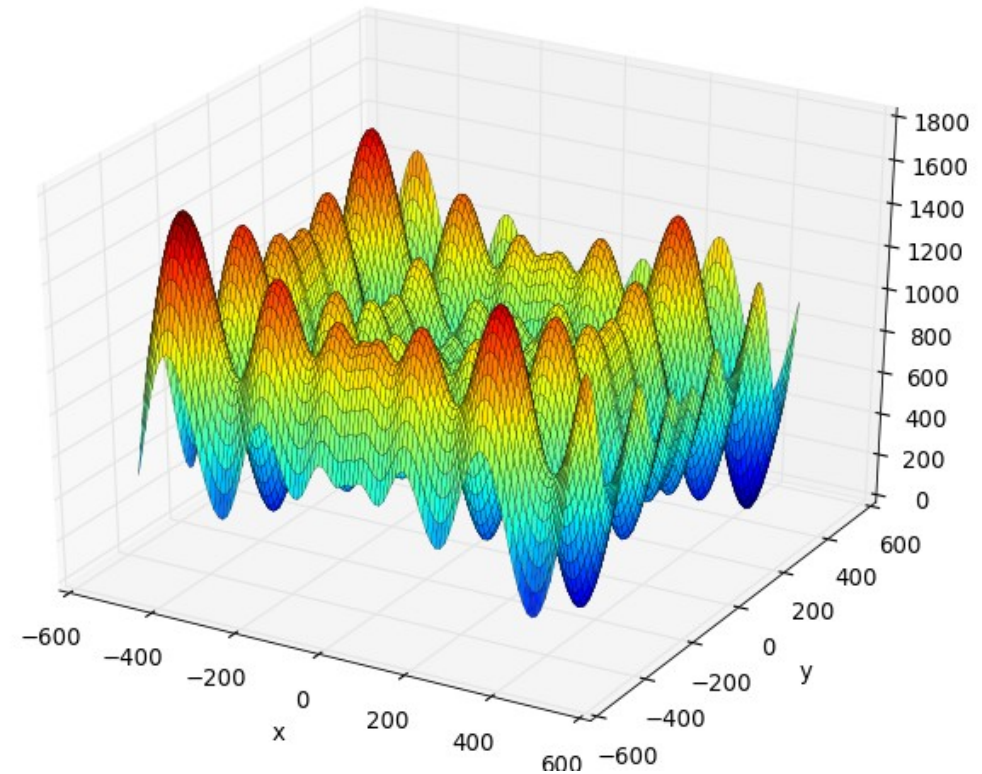
$W$ ,



# This is a hard problem – No known general solution

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$W$ ,



# Inspirations

Borrowing from where it works...



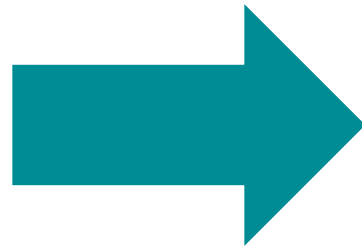
# Biologically Inspired Methods –

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- Brain

- Evolution

- Social Insects



- **Artificial Neural Networks**

- Evolutionary Algorithms

- Swarm Intelligence Methods



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# Thank you!

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