Learn and Optimize

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Content

Introduction

What we have to learn to do, we learn by doing.

- Aristoteles (384-322)

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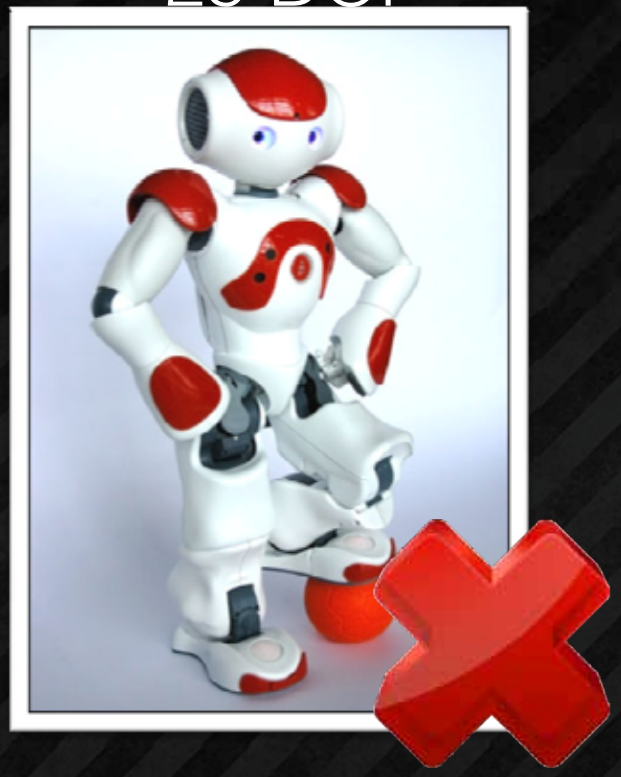
Should you use analytic methods to move the joints?

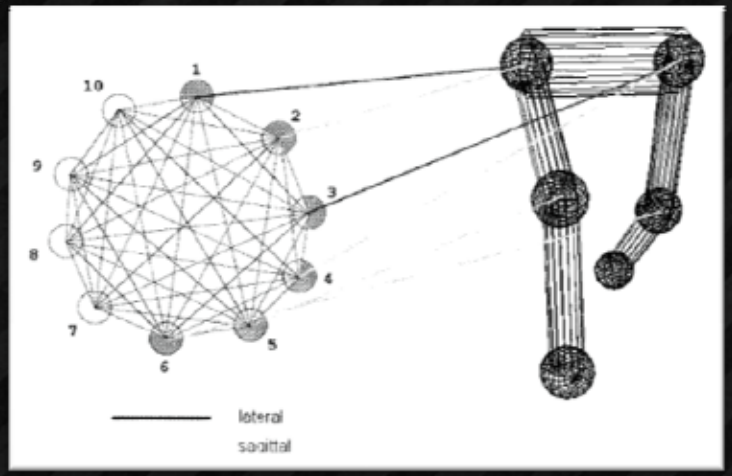
6 DOF

~25 DOF



Introduction

- Self-learning biped walking
- First contact through Natural Motion Inc.
- Computational Intelligence
- „Try and error“
- „Survival of the fittest“



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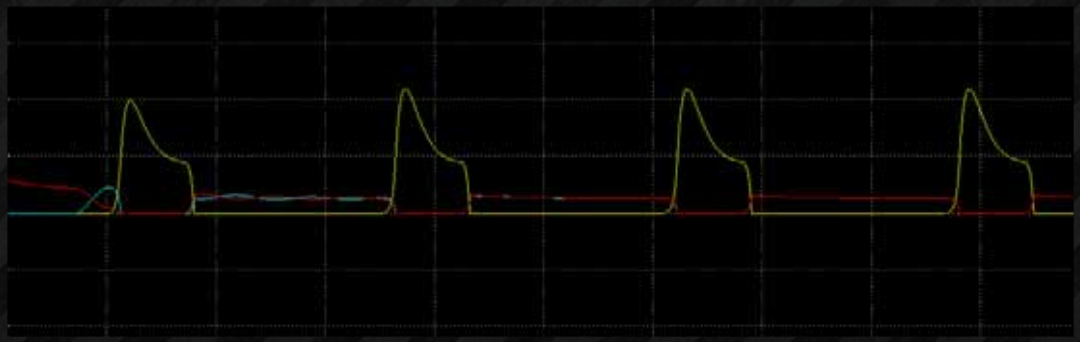
- Implement a CPG system in Matlab
- Using neural oscillators for joint-movement

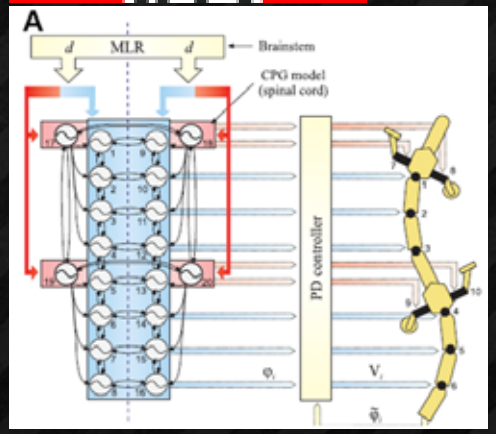
$$\tau_{ri}\frac{\mathrm{d}ui}{\mathrm{d}t} = -u_i + \sum_{i=1}^{n} w_{ij}\,y_j - bf_i + u_0 + feed_i()$$

$$\tau_{ai}\frac{\mathrm{d}f_i}{\mathrm{d}t} = -f_i + y_i$$

$$y_i(u_i) = max(0, u_i)$$



- No optimization due to lack of time
- Gained first impressions of the subject
- Learned a lot from other projects

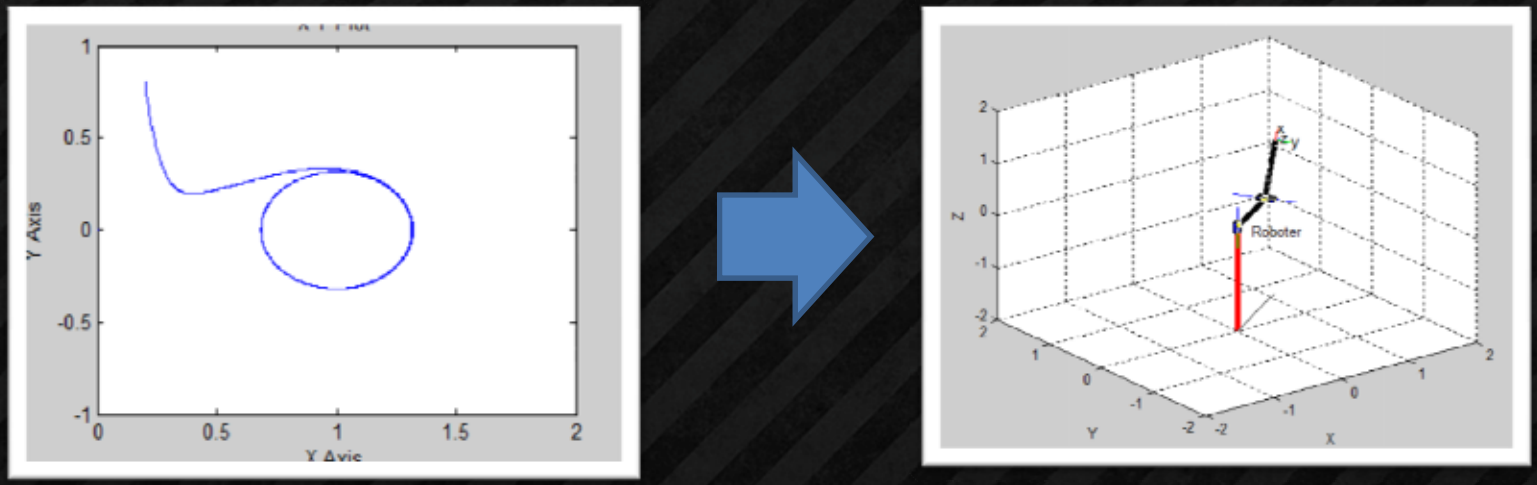


endorphin
dynamic motion synthesis

euphoria

Project 2

- Research in the subject of oscillators
- Deeper understanding of behaviors and mathematical models



Project 2

- Search and compare different methods and concepts to generate oscillations
  - CPG – Central Pattern Generator
  - TFS – Truncated Fourier Series
- Can they generate every kind of curves?
- Work in progress …

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- Implement a system for bipedal walking
- Two methods to achieve movement
  - Model-based
  - Model-free

Model-based approach:

1. Physical model of robot is designed
2. Build controller for the model
    1. ZMP – Zero Moment Point
    2. Inverted pendulum

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Model-free approach:

- Use sensor- information for making motion
- No physical model included
  - PDW – Passive Dynamic Walking
  - CPG
  - Ballistic walking
  - TFS – Truncated Fourier Series

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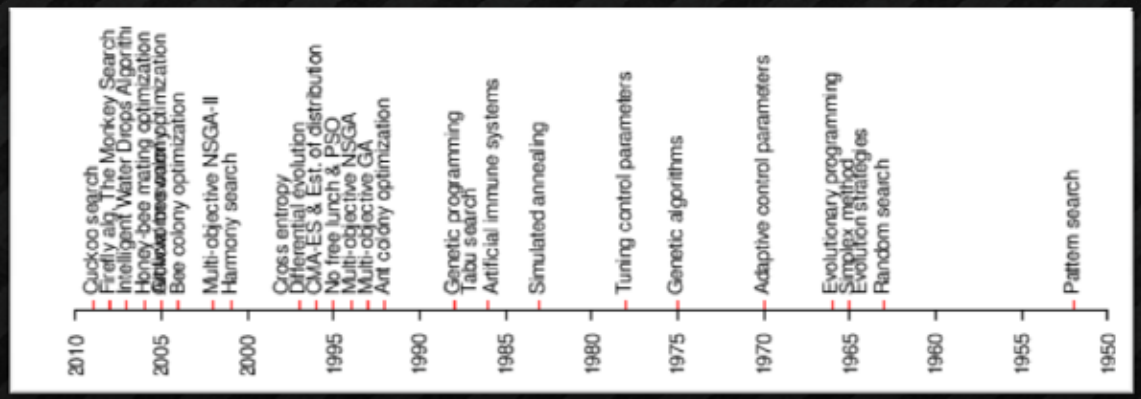
How should the system learn its movement?

- „Learn“ to handle a given problem

  by optimizing the parameters
- Use metaheuristics to achieve maximum



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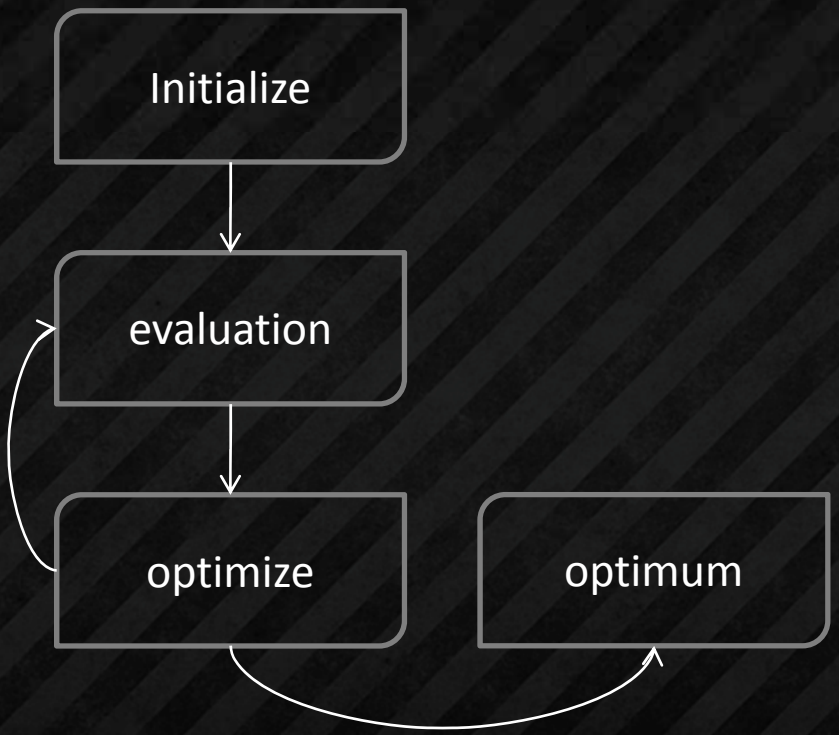
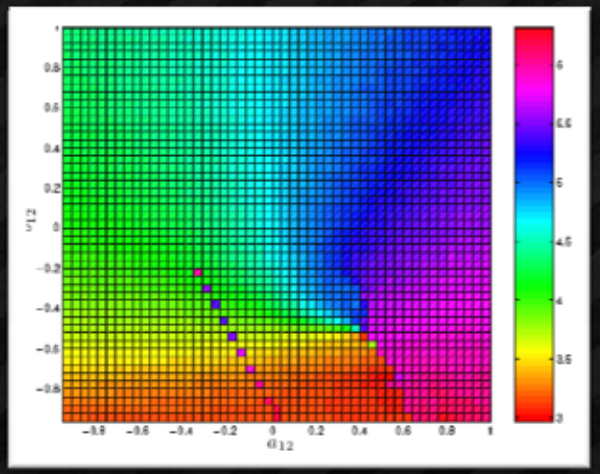
Metaheuristics:

⇨ Improve a possible solution with regards to a given measure of quality.



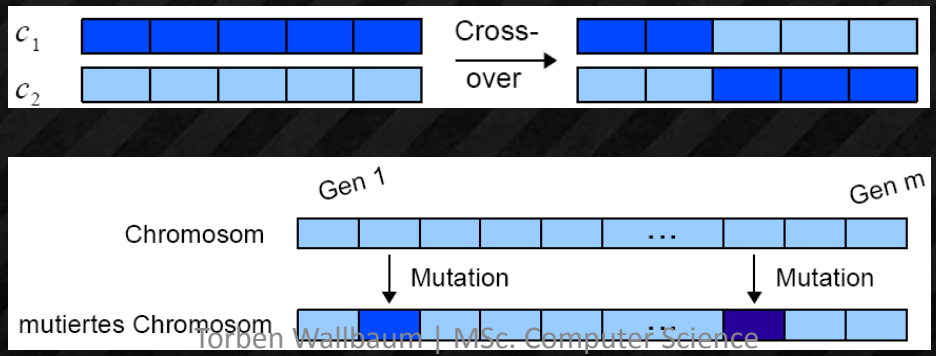
- No assumptions about the problem
- Search very large spaces of solutions
- Metaheuristics can not be proven as correct
  - Finit number of experiments!



- Many different methods available
  - Evolutionary Algorithms
  - Simulated Annealing
  - Bees Algorithm
  - Particle Swarm Optimization
  - and many others

- Example: Genetic Algorithm

1. Choose initial population of individuals
2. Evaluate the fitness of each individual
3. Repeat until termination {time-limit, optimum found}
   1. Select the fittest individual for reproduction
   2. Generate new offspring through crossover / mutation
   3. Evaluate fitness
   4. Replace least-fit half of individuals with new individuals



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- Example: Particle Swarm Optimization

1. Initialize each particle‘s position and velocity
2. Initialize the particle‘s and swarm‘s best position
3. Repeat until termination
    1. For each particle
        1. Update particle‘s position and velocity
        2. Update particle‘s and swarm‘s best known position
4. Terminate with best position

Chances and Risk

- Chances:
  - Deeper understanding of subject
  - Pros and cons of different approaches
    - Runtime
    - Convergence
    - Context
    - Applications

Chances and Risk

- Risk:
  - Too extensive -> time-lag
  - Not compareable
  - Too many approaches
  - Too superficial

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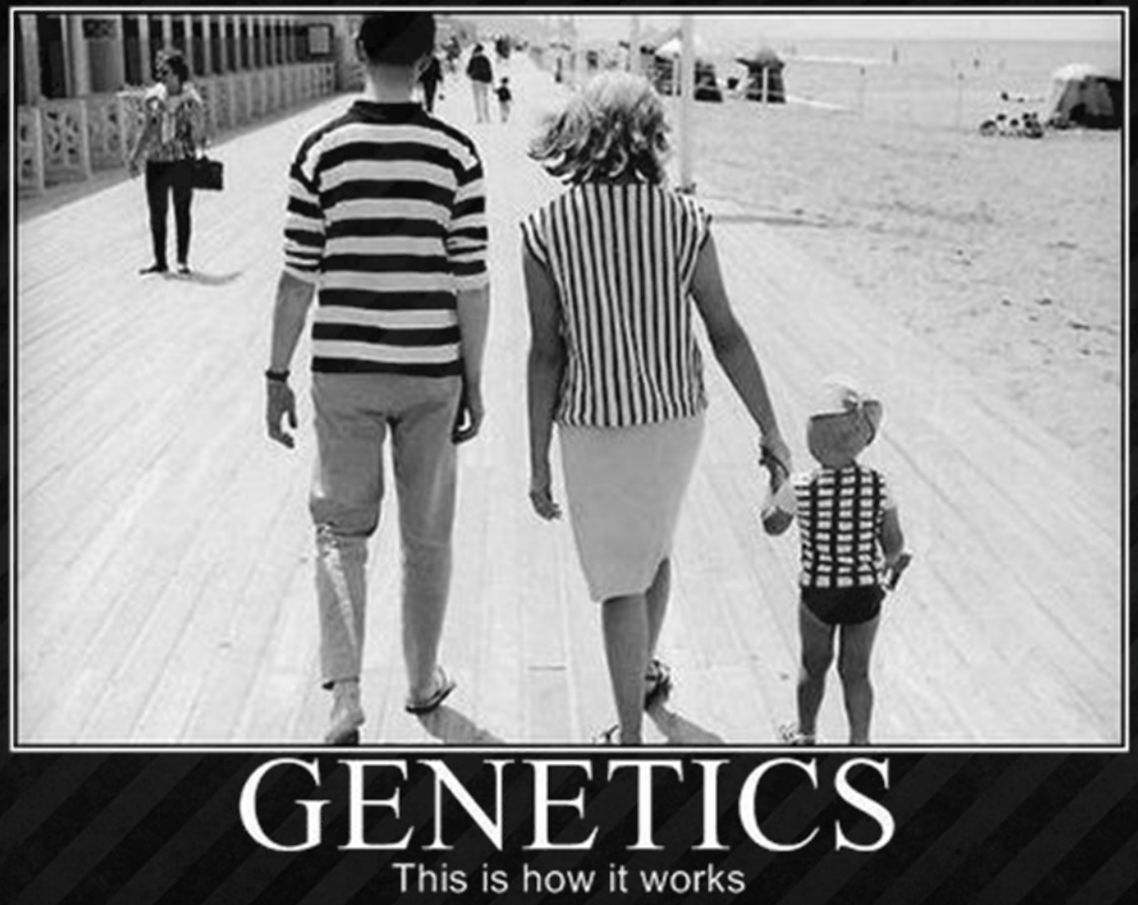
Thank you for your attention and goodbye!



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