

# Evolving Locomotion for a Humanoid Robot

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# Motivation (1)

- Goal
  - Stable, robust fast locomotion
- Problem
  - The platform is a complex humanoid robot
  - Handcrafting takes time and isn't easily adaptable
- Idea
  - Generate random solutions and improve them by using natural selection[1], aka. Evolution

# Motivation (2)

- Drawbacks
  - New problem: Design a good fitness function
  - Large search space → Time consuming
- Advantages
  - Already successfully used [2], [3]
  - “Evolution is cleverer than you are” [4]
  - Reusable for different problems

# The Approach (1)

- Create random individuals
- While not good enough do this:
  1. Evaluate individuals
  2. Rate them with a fitness function
  3. Determine winners in a tournament
  4. Replace the losers by mutated winners
- Transfer the best solution to the real robot...

# The Approach (2)

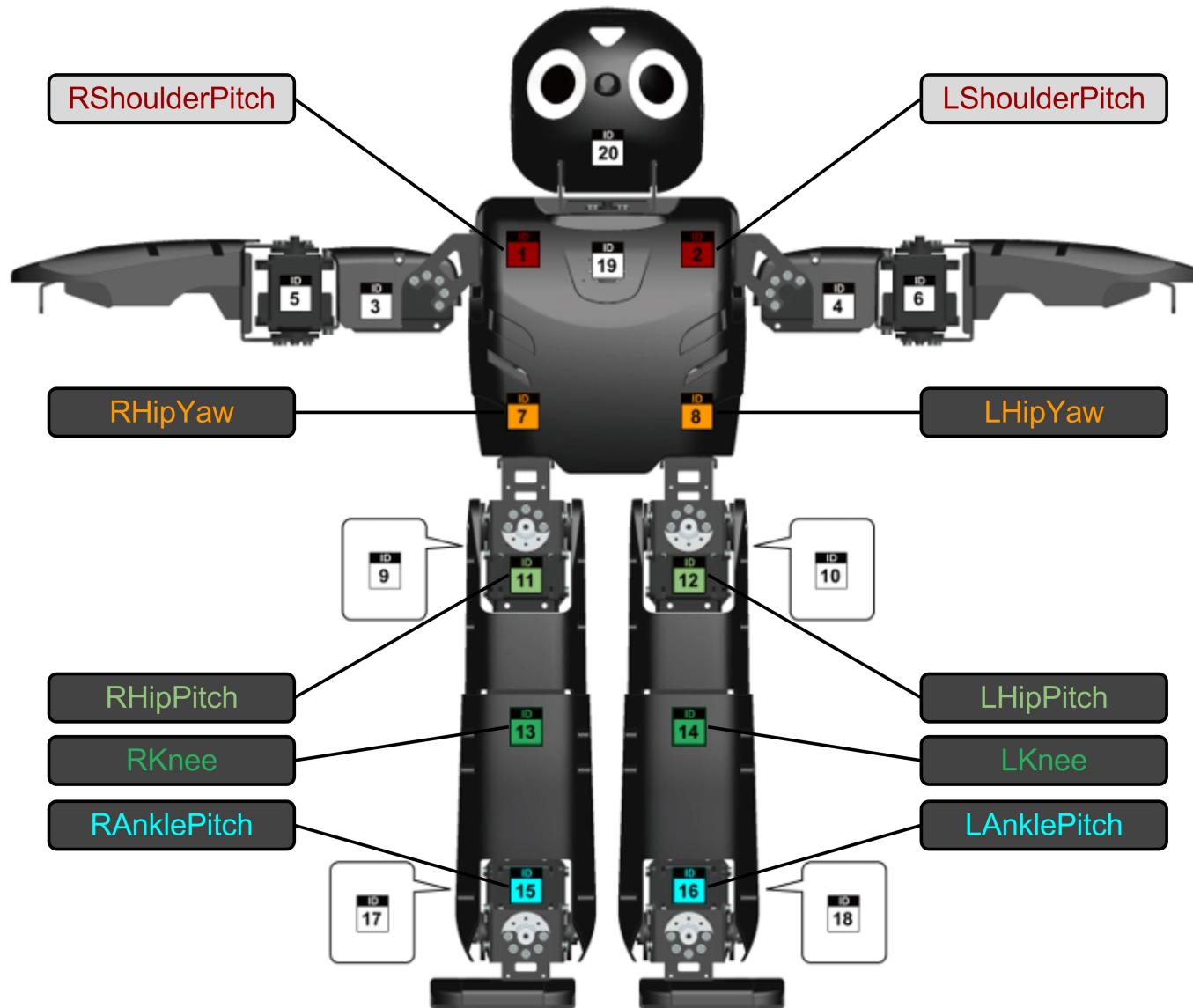
- The fitness function

- $fitness = \omega_1\alpha + \omega_2\beta + \omega_3\delta + \omega_4\Delta + \omega_5\tau$
- continuous movement  $\alpha$
- efficient movement  $\beta$
- distance  $\delta$  (extra penalty on falling down)
- integrated distance  $\Delta$
- run time in upright position  $\tau$

# The Approach (3)

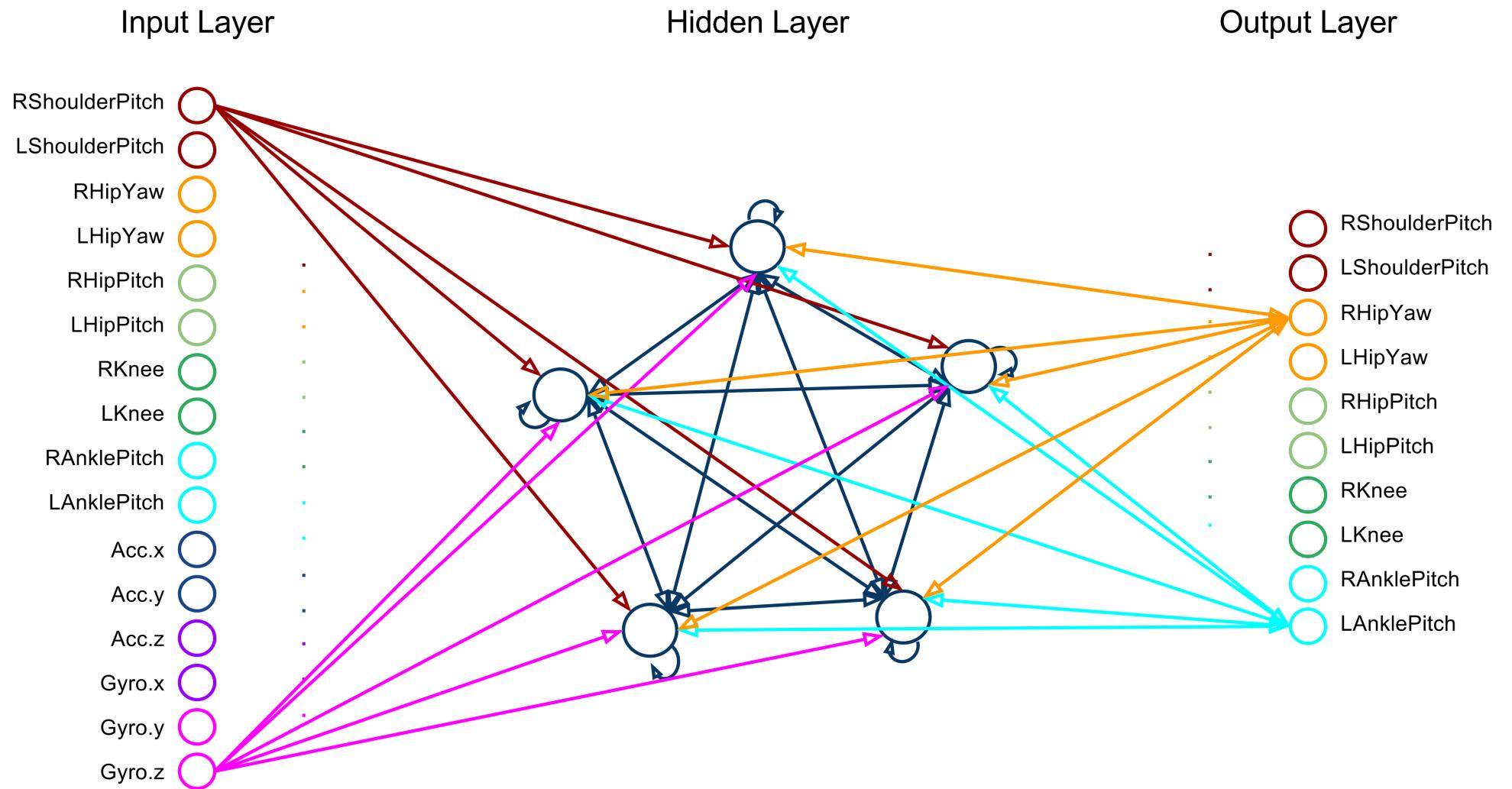
- Natural Selection
  - Replace losers (50%) by mutated winner offspring
- Tournament selection
  - Performs natural selection in a local area ( $2 \times 2$ )
  - Keep diversity but still forcing improvement
  - Runs in parallel

# Experimental Setup (1)

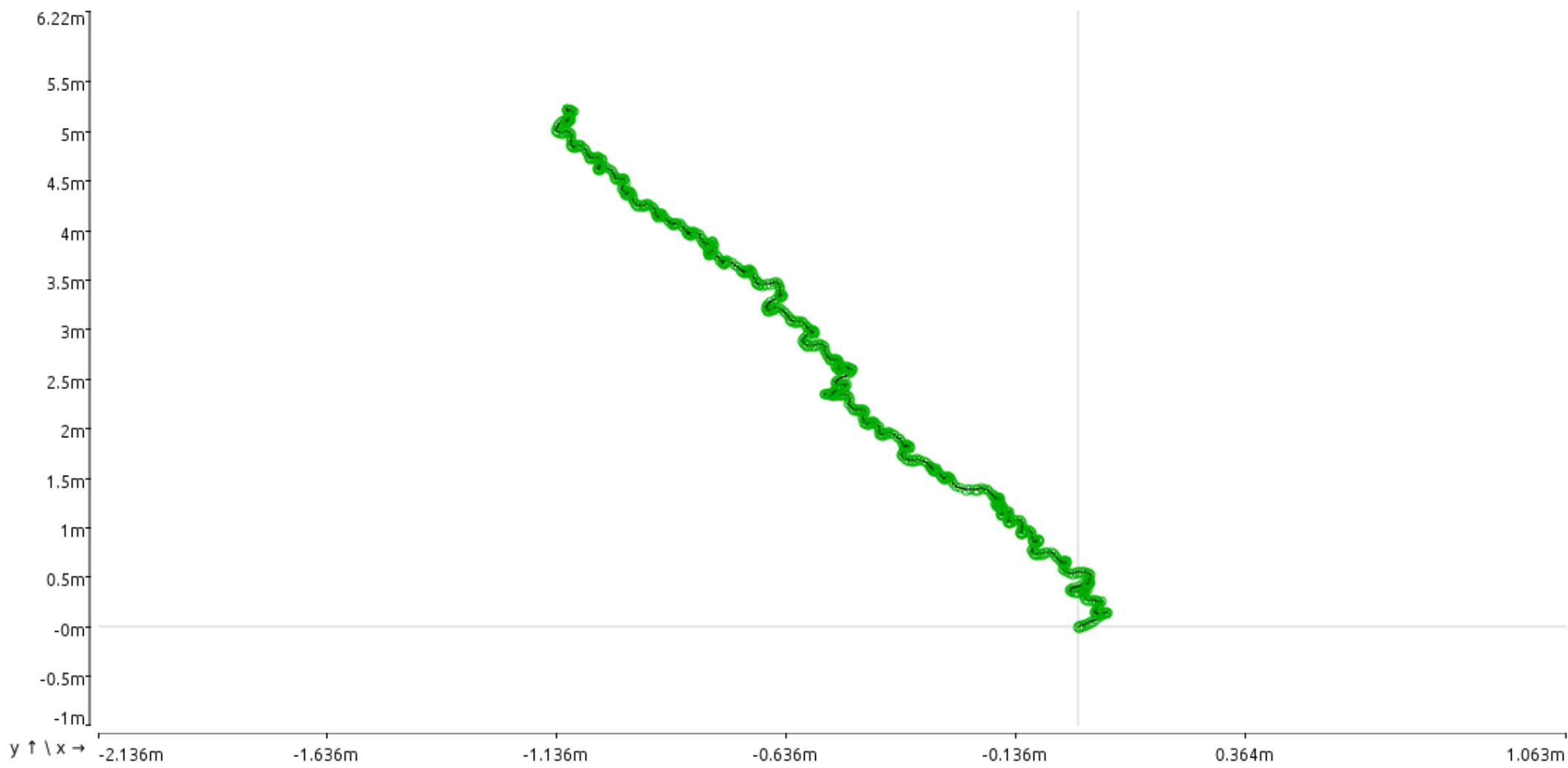


(Picture taken from [darwin-op.springnote.com](http://darwin-op.springnote.com))

# Experimental Setup (2)

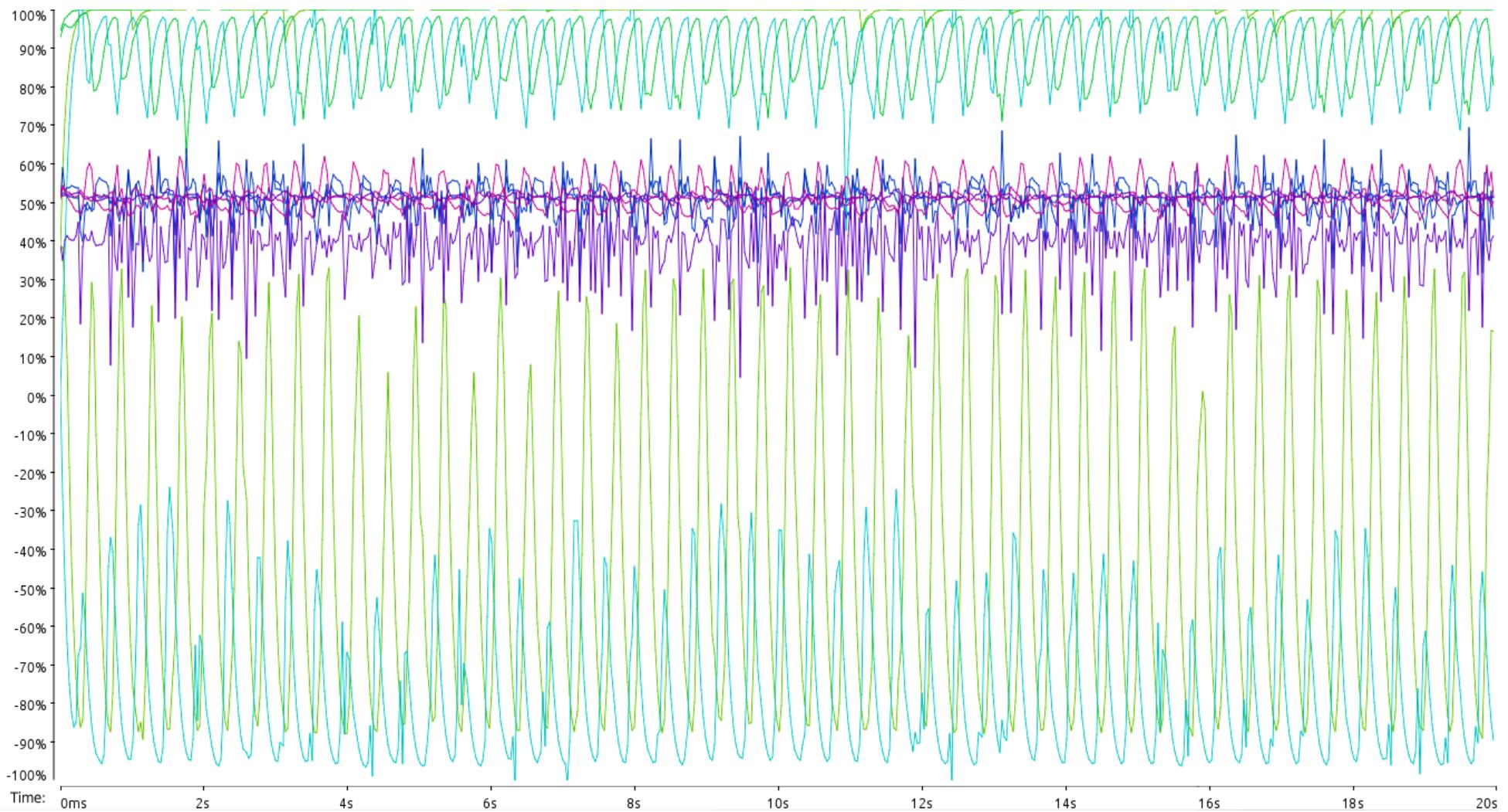


# Results (1)



20 second walk with a distance of more than 5.7 meter

# Results (2)



RLHipPitch, RLKnee, RLAnglePitch, Gyroscope, and Accelerometer

# Conclusion & Outlook (1)

- So far:
  - Interesting solutions with reasonable speed
- Expecting better solutions by:
  - Tuning the fitness function
  - Coupling of joints

# Conclusion & Outlook (2)

- Future Goals:
  - Walk along given waypoints
    - Robot knows position of the ball, goal, and obstacles
    - He can walk around obstacles and position itself behind the ball to be able to take a shot at the goal without repositioning. All controlled by the CTRNN.
  - Transfer a stable walk to the real Darwin

# References

1. C. Darwin, On the Origin of Species, 1859.
2. G. McHale and P. Husbands, “Gasnets and other evolvable neural networks applied to bipedal locomotion,” From Animals to Animats, vol. 8, pp. 163-172, 2004.
3. C. Paul, “Sensorimotor control of biped locomotion,” Adaptive Behavior, vol. 13, no. 1, pp. 67-80, 2005.
4. Orgel’s second rule: “Evolution is cleverer than you are”