Single Session Walking Robot Workshop for High School Students

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Organization: 12 students per session, 3 students per robot, 1 lecturer.

Duration: 4 hours intensive work, short breaks included.

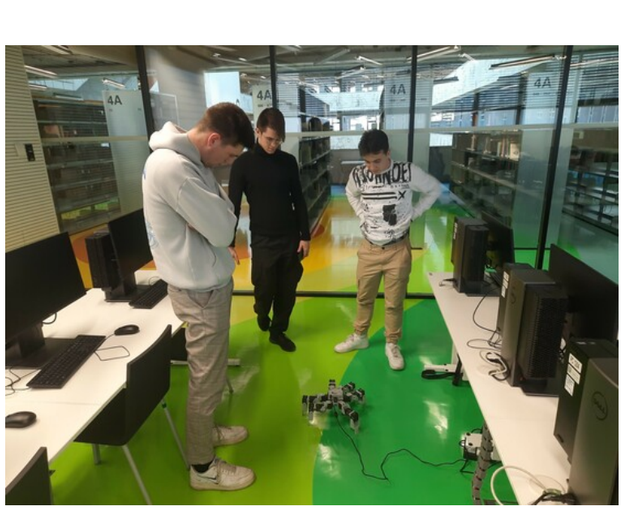
Hardware: Robotis Premium (3x "King Spider", 1x "Humanoid A Type")
https://emanual.robotis.com/docs/en/edu/bioloid/premium/

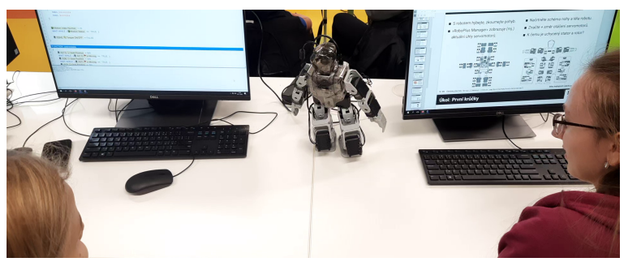
Programming: Semi-graphical Robo Plus Task 1.0, wired, no battery.
https://emanual.robotis.com/docs/en/software/rplus1/task/getting_started/

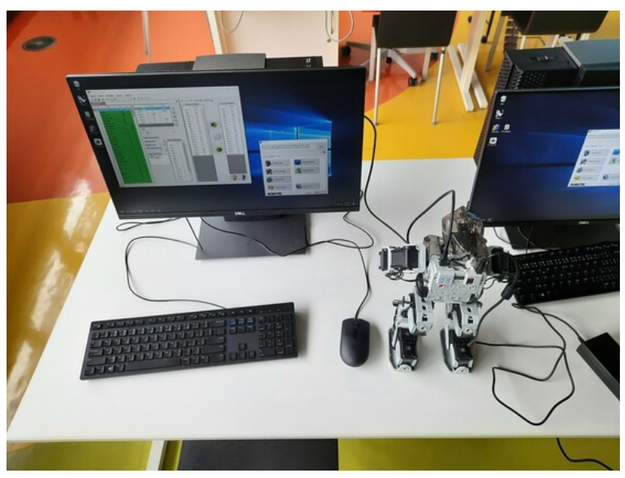
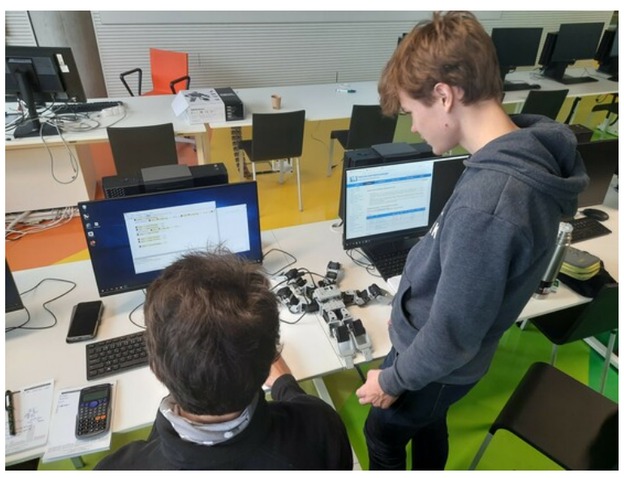
Student Goal: Make the robot walk from scratch.

Teacher Goal: Show science behind robotics, motivate to learn.

Sylabus: Introduce Robots • How Servomotor Works • Repetitive Movement • Servomotor Kinematics • Leg Kinematics • One-Step Motion Primitive • Gait Pattern • Walking • Free Play




Our Robots – Today's »Robota«

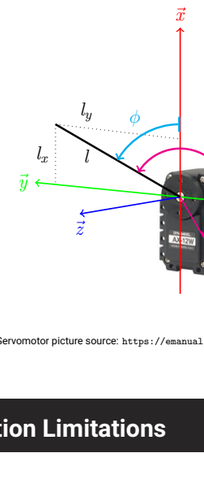
Hexapod ~ ant

- 6 legs, 3 joints per leg.
- 24 degrees of freedom altogether.
- Statically stable walk is possible.
- Different gaits - 3pod, 4ped, 5pod...

Humanoid ~ biped ~ člověk

- 6 joints per leg, 3 joints per arm.
- 18 *controllable* degrees of freedom.
- Walk not stable!

Servomotor

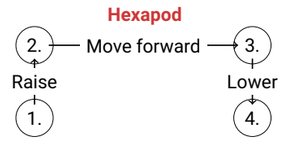


Robotis Dynamixel AX-12W

- DC gear electromotor with position control. (Beware! Shock may damage the gearbox!)
- Position feedback by potentiometer. (Dead angle! Rotor can not stop upside down.)
- Commanded from control unit by digital protocol. (Each servo was assigned unique ID number!)
- We can read or set different servo properties. (Speed, maximum torque, angle, temperature, stall...)
- Reference manual here.

Task: Program One Leg Step

Hexapod



Humanoid

- Mind the mass! Always catch the robot!
- »Motion Index 25« lowers the torso.
- Move only the ankle and hip.

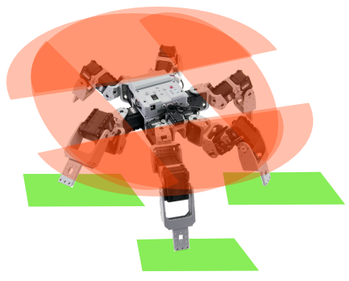
- You need to identify which particular angles to set!
- Divide your work. (Each identify one leg...) Mind the servo orientation!
- There are different step trajectories. (Triangle, square, ellilpse, adaptive, ...)
- Do not forget to wait before each intermediate move finishes.

Servo Described by Math

- Angle ψ: Defined by manufacturer.
  - (We set/read this when programming.)
- Angle ϕ: Kinematically meaningful.
  - Positive angle along z-axis.
  - Zero-angle aligned with x-asix.
  - (Right-hand rule.)

$$l_x = l\cos(\phi)$$
$$l_y = l\sin(\phi)$$
$$\phi = \psi - 150°$$

Motion Limitations



- Robot has many degrees of freedom. Can it use them fully?
- Joint angles are limited by design.
- Legs operation spaces intersect.
- Walk needs to take this into account!
- Also, environment might get in the way. (Terrain, obstacles, people, machines...)

NTK
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