IMPLEMENTATION OF WALKING GAITS ON ROBOT WALKING TEST BENCH: USE OF CENTRAL PATTERN GENERATORS

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OUTLINE

- ✓ Introduction
- ✓ Test Bench
- ✓ Cognitive Robotics Laboratory
- ✓ Physical Structure
- ✓ Software Structure
- ✓ Implementation

INTRODUCTION

Legged locomotion with the advantages:

- Moving on an irregular terrain
- Motion in multi direction,
- Have the ability to overcome obstacles,
- Have the ability to orient the body on irregular surfaces.

Producing the coordinated movement of the legs allowing robot motion is the elementary step of the robot walking.

Gait generation can be produced in different ways considering engineering software, mathematical tools, etc.

As an alternative to these approaches, there are other means of gait generation based on the inspirations from nature.

INTRODUCTION

In biological systems, control system architecture is based on the brain, central nervous system, neurons, muscles, intelligence, and so on.

Multi level architecture exists.

In the bottom level, fast reflex loops exist.

In the top level, offline processing such as motion planning appear.

Cerebellar control exists in between .

Rhythmic locomotion patterns are generated by central pattern generators (cpg) that exist in central nervous system.

Software part includes simulation software, optimization algorithm, and the real time control architecture.

Hardware part consists of a legged body, sensors, actuators, and data acquisition hardware.

Multi level control architecture similar to the one in biological systems systems can be implemented and researched on the test bench.

The aim of this test bench is to implement the control structures inspired from biology and find optimal parameter sets that are used within the bioinspired control structures for legged locomotion.

Cognitive Robotics Laboratory – CRL

www.mechatronics.atilim.edu.tr/CRL

Bioinspired Control Structures Key terms and words are as follows. Implementation of bioinspired control structures for legged robot locomotion. Central pattern generators. Evolutionary gait generation. Biped walking. Legged locomotion test bench.

Cerebellar Robot Arm Control Key terms and words are as follows. Reaching movement. Mimickin human arm. State estimation in cerebellum. Integration of vision and estimation. Optimal motions.

Bionic Arm Key terms and words are as follows.
Human signals. Control of bionic arm based on the references as human signals.

Target Detection and Tracking with a 2D Pan Tilt Servo System Key terms and words are as follows.
Human head. Stability. Vestibular system. Inertial measurement. Vision.

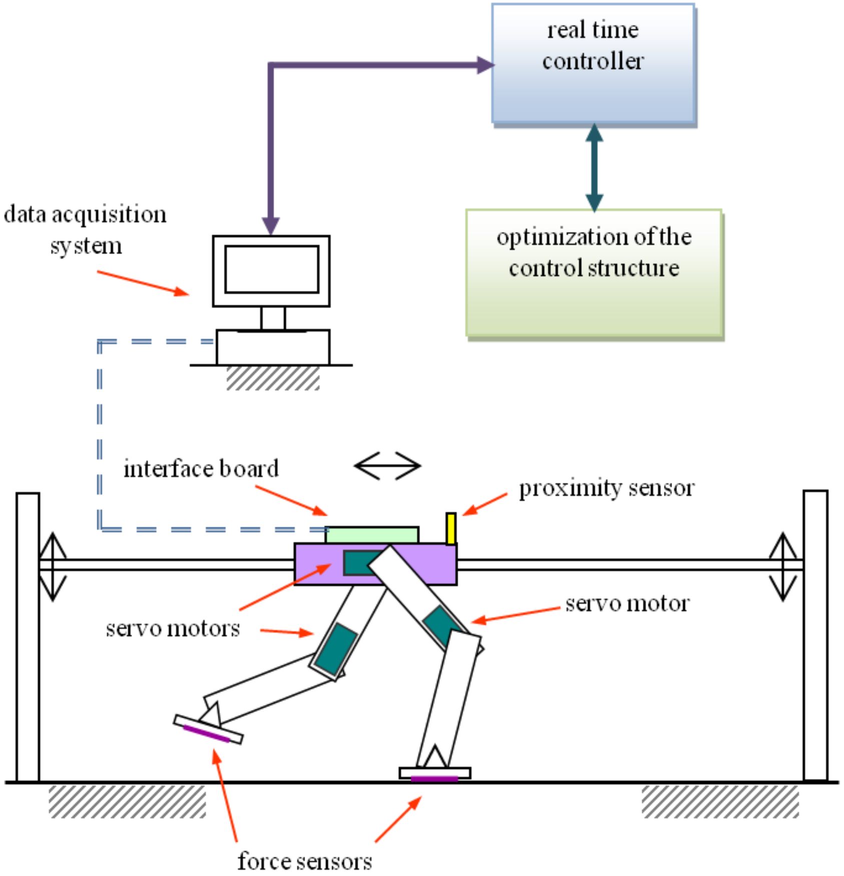
Central pattern generators based on Rowat-Selveston neuron model.

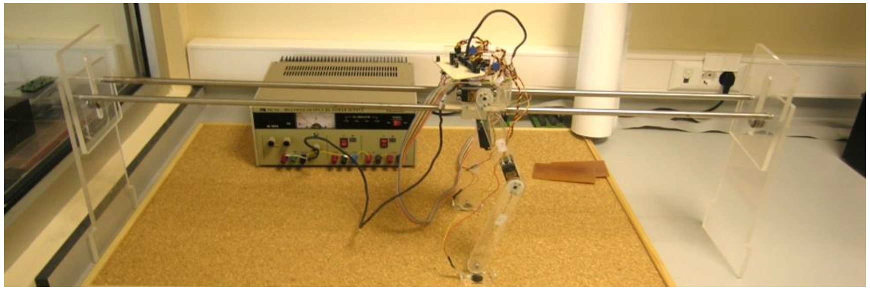
$$\tau_m (dV/dt) = -F(V,\sigma_f) - q + I_{inj}$$

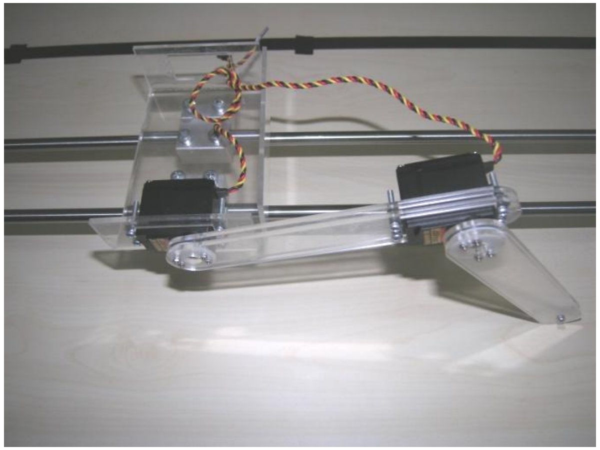
$$\tau_s (dq/dt) = -q + \sigma_s V$$

$$F(V,\sigma_f) = V - A_f \tanh(\sigma_f V / A_f)$$

PHYSICAL STRUCTURE







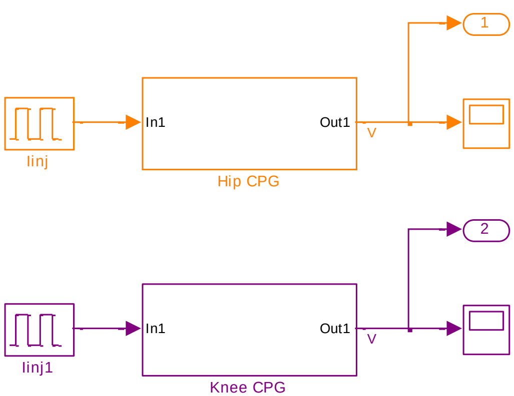
SOFTWARE STRUCTURE

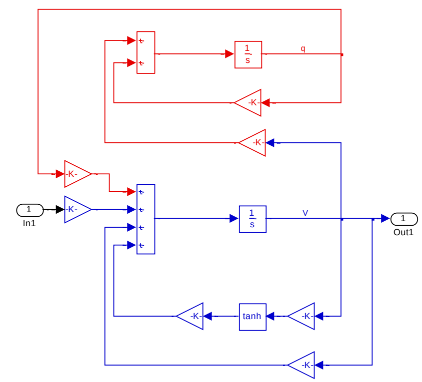
Kinematic model runs in MatLab m-file.

Parameters of the central pattern generator are adjusted by evolutionary means.

Angle sequences for hip and knee joints are generated by CPG built in Simulink.

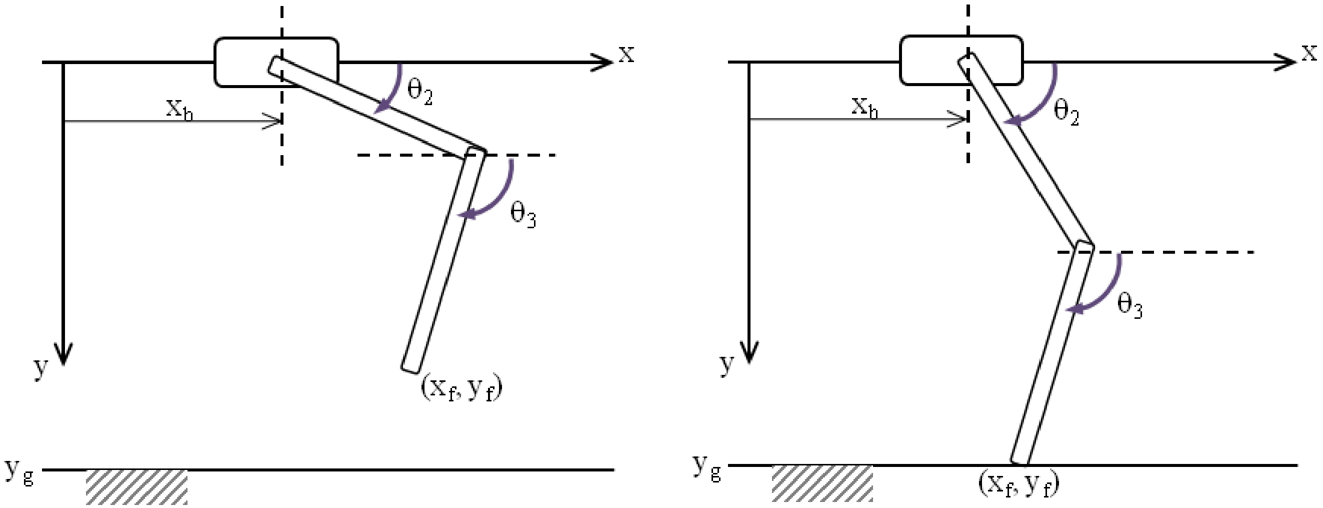
$$p_i = \{A_i, A_{fi}, \tau_{si}, \tau_{mi}, \sigma_{fi}, \sigma_{si}\}, i=2,3.$$



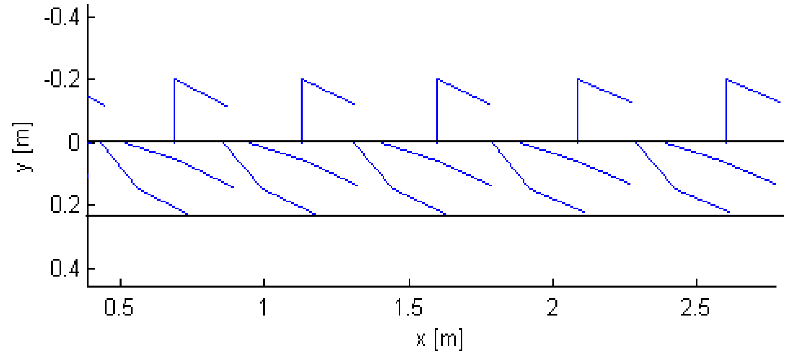


SOFTWARE STRUCTURE

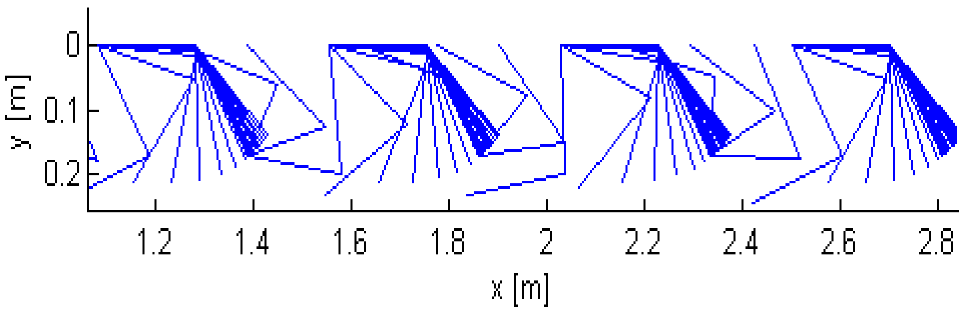
$$J_1 = -\sum_{k=1}^{N} x_b(k) \qquad J_2 = -\sum_{k=1}^{N} x_b(k) + \sum_{k=1}^{N} \theta_2^2(k) + \theta_3^2(k)$$



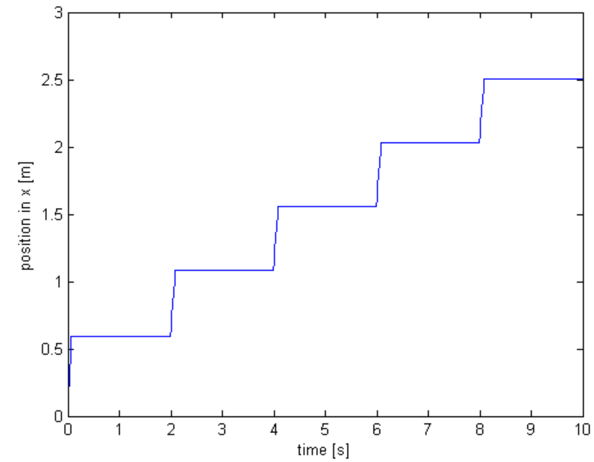
RESULTS



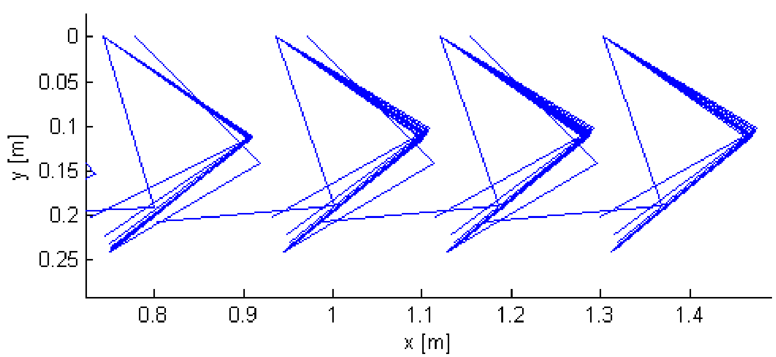
-0.4
-0.2
0
0.2
0.4
y [m]
0.5
1
1.5
2
2.5
x [m]



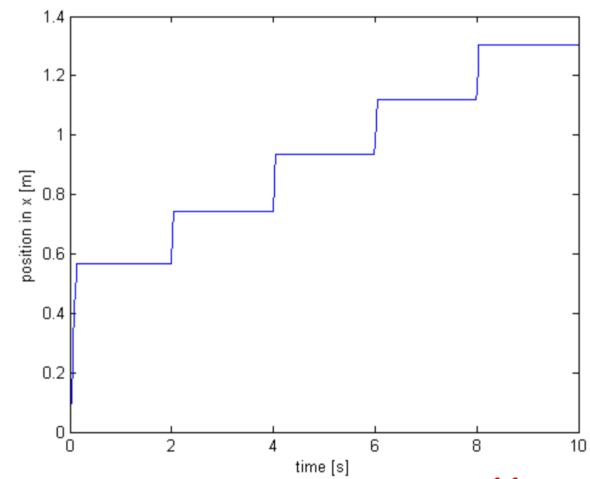
0
0.1
0.2
y [m]
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
x [m]



0
0.5
1
1.5
2
2.5
3
position in x [m]
0
1
2
3
4
5
6
7
8
9
10
time [s]

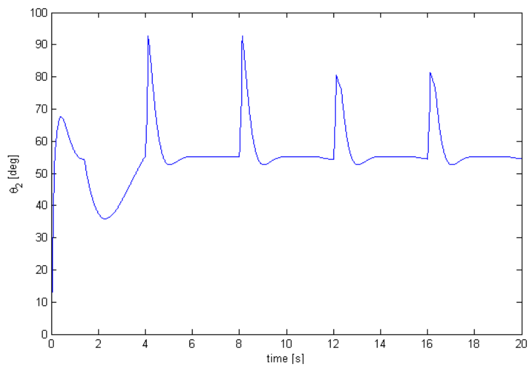


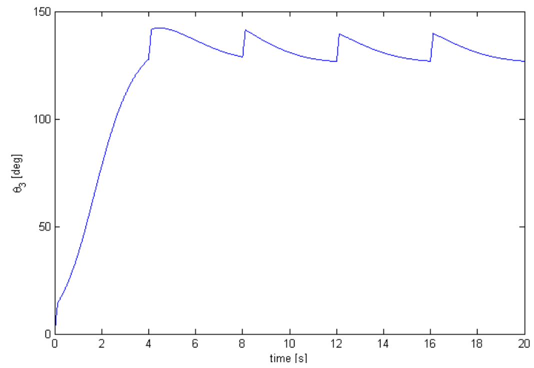
0
0.05
0.1
0.15
0.2
0.25
y [m]
0.8
0.9
1
1.1
1.2
1.3
1.4
x [m]

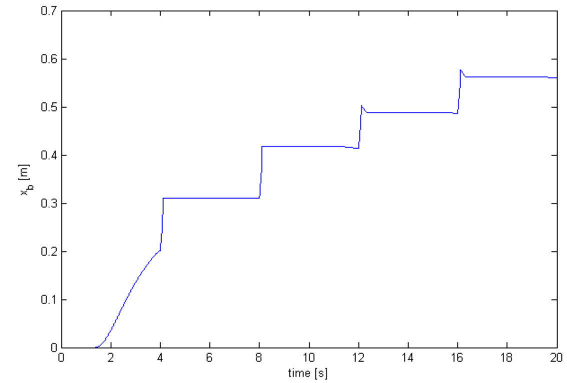


0
0.2
0.4
0.6
0.8
1
1.2
1.4
position in x [m]
0
2
4
6
8
10
time [s]

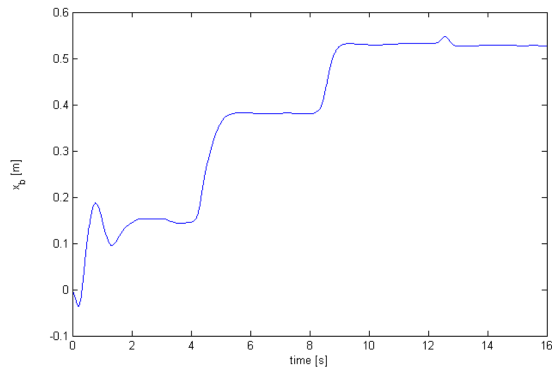
Hip and knee angles and the corresponding displacement on guide way - simulation:







Implementing the same cpg on physical system - the real displacement on guide way:



IMPLEMENTATION

Videos:

DISCUSSION

Physical implementation of the generated gaits – biped walking.

Use of kinetic models to impose actuator characteristics, limits, etc. → Multibody dynamics.

Use of sensor feedback with cpg’s.

Improve the mimicked biological control structure by adding new layers.

Adding the cerebellar control level with additional inertial sensors.

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