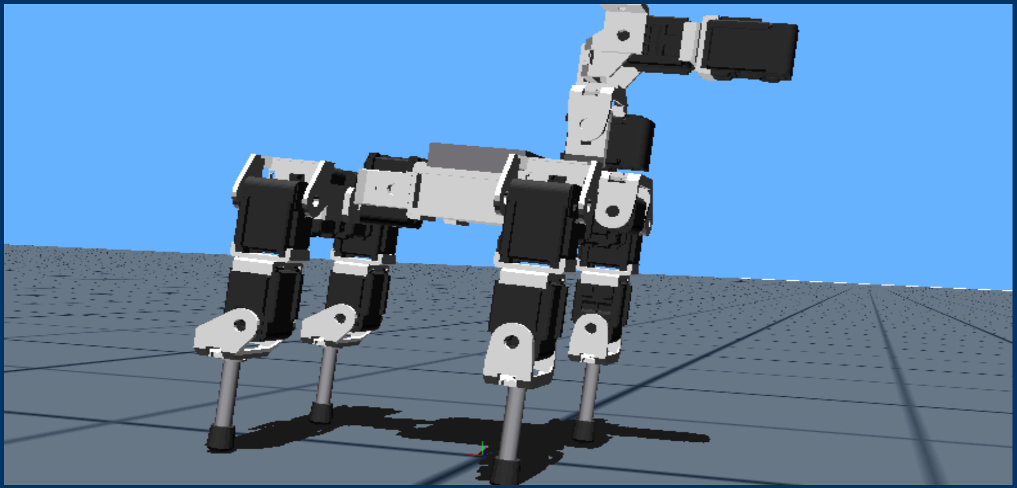
BIOLOID Project – Final presentation

5th July 2007

Swiss Federal Institute of Technology - Lausanne

Biologically Inspired Robotics Group (BIRG)



Jean-Christophe Fillion-Robin

Project Supervisor(s): Prof. Auke Jan Ijspeert (BIRG), Olivier Michel (Cyberbotics), Yvan Bourquin (Cyberbotics, EPFL)

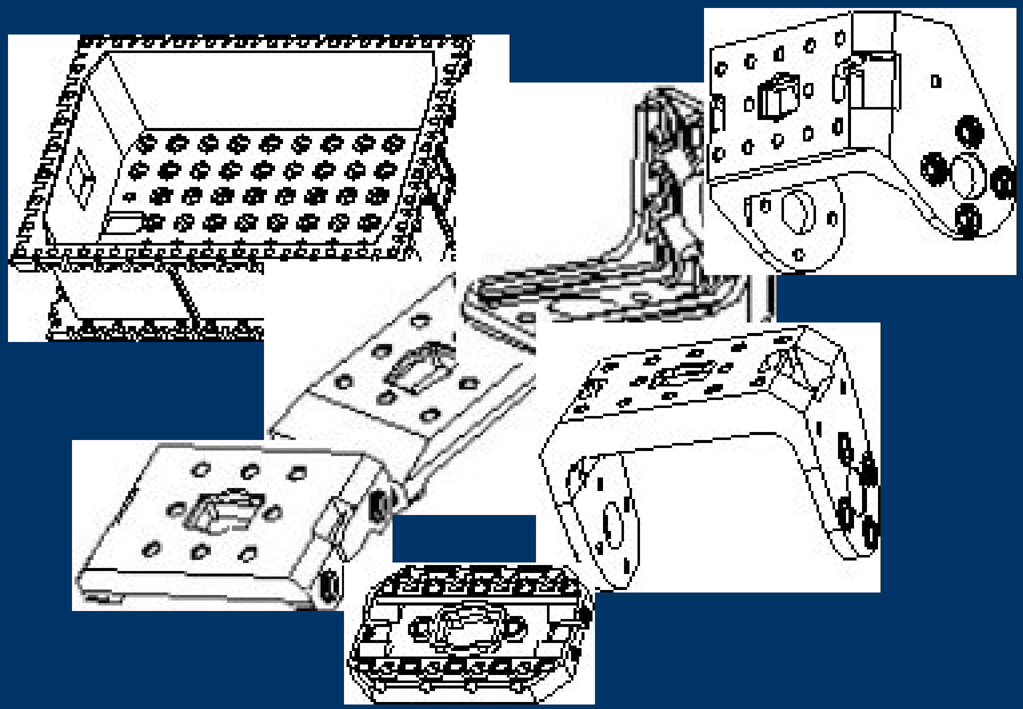
Project Collaborator(s): Peter Turner (Tribotix, Australia)

Outline

- Bioloid: State of the art
- Webots and 3D model
- Model and Physics
- Validation
- 2 approaches to define a gait

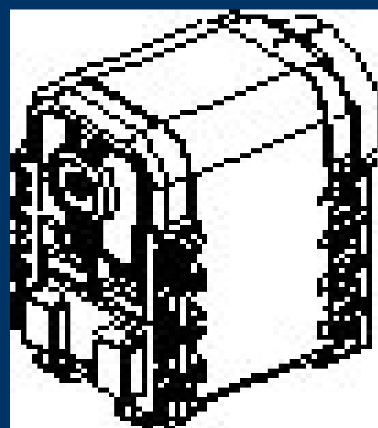
Bioloid: State of the art (1)

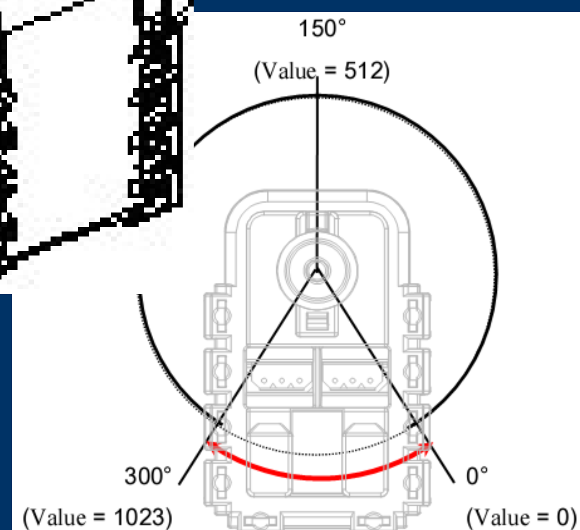
- Collection of block-shaped parts



Bioloid: State of the art (2)

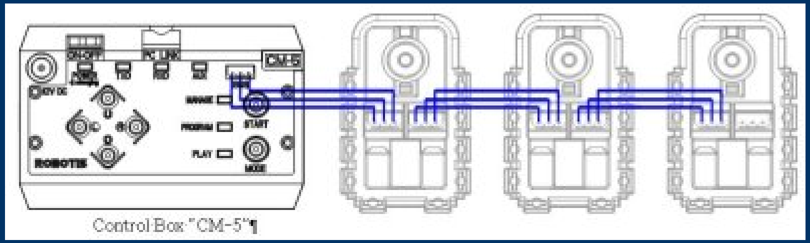
- Control unit, servos and sensor module

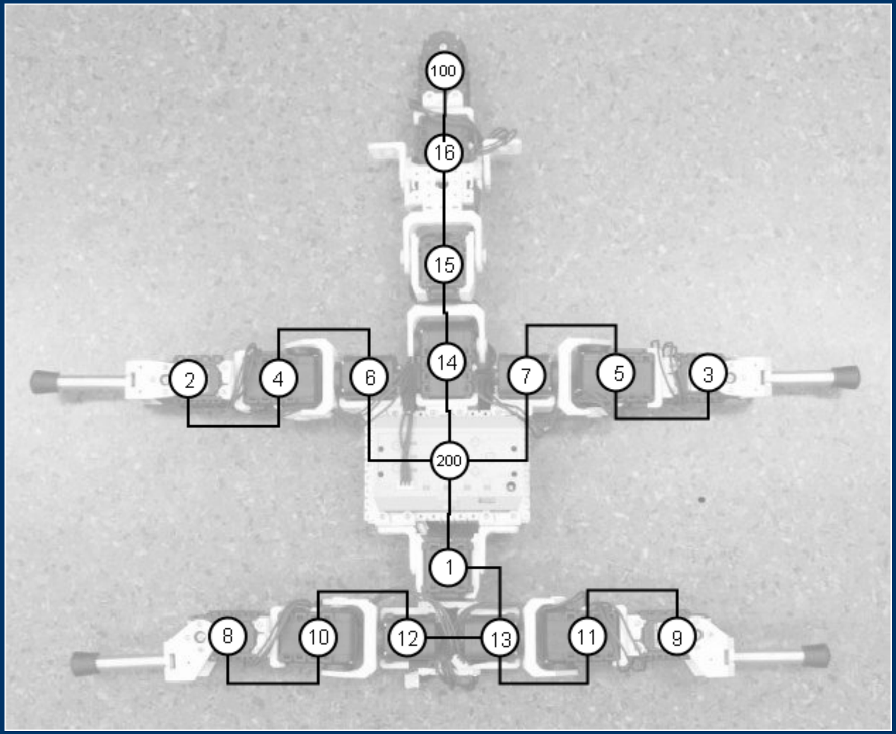




Bioloid: State of the art (3)

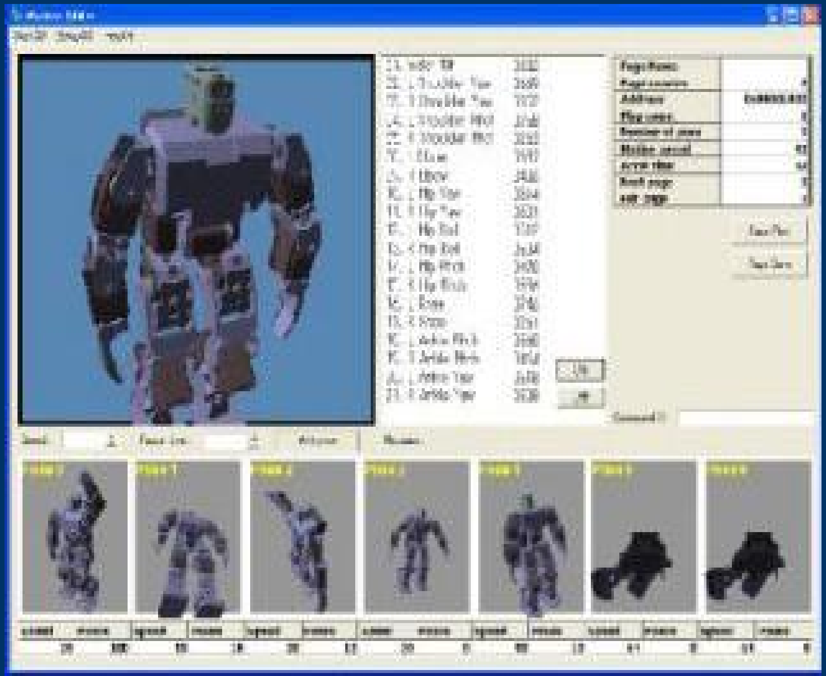
- All together





Bioloid: State of the art (4)

- Apply motion and behavior



Motion editor

Behavior editor

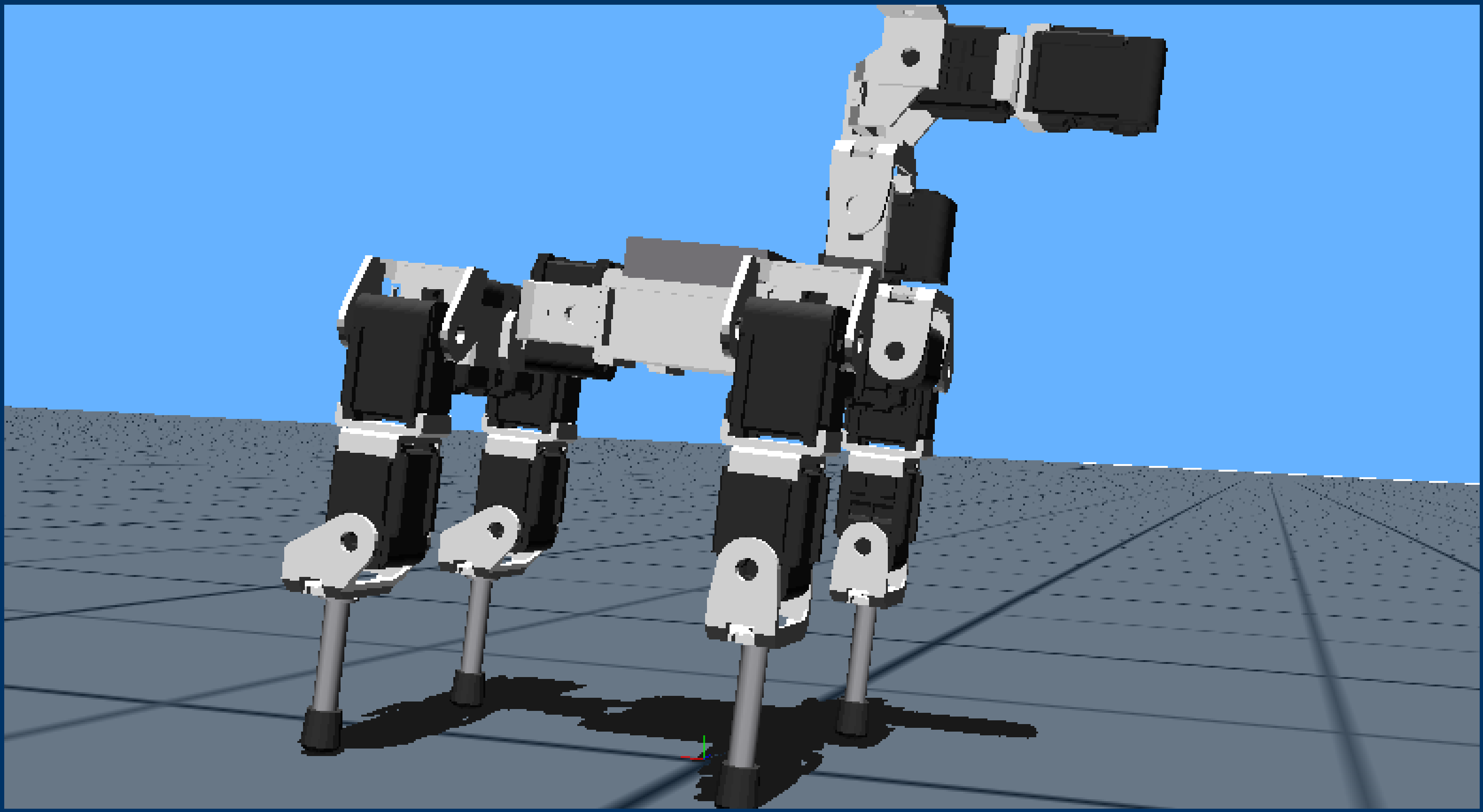
Webots^{TM}

"Webots^{TM} is a commercial software developed by Cyberbotics Ltd. It is a **mobile robotics simulation** software that provides you with a **rapid prototyping** environment for **modeling**, **programming** and **simulating** mobile robots."

Source: O. Michel, Cyberbotics Ltd – WebotsTM: professional mobile robot simulation. International Journal of Advanced Robotic Systems (2004) Volume 1 Number 1: pp. 39-42.

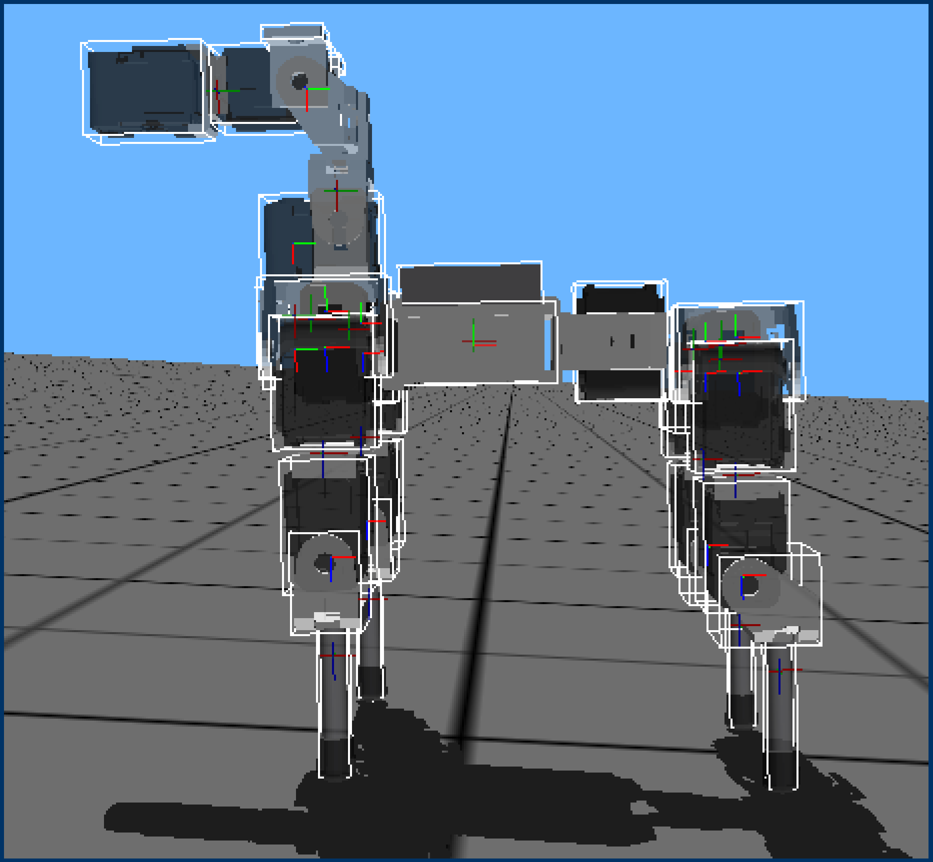
3D Model

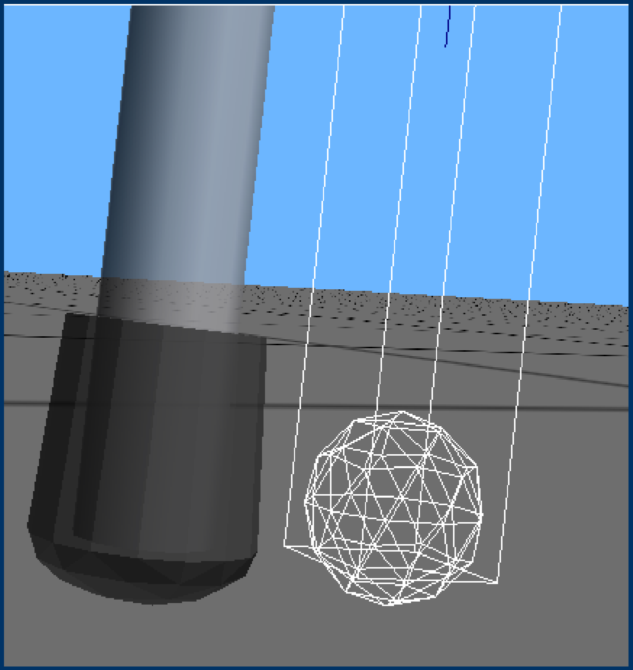
- Construction of an accurate 3D model



Applied Physics to the model (1)

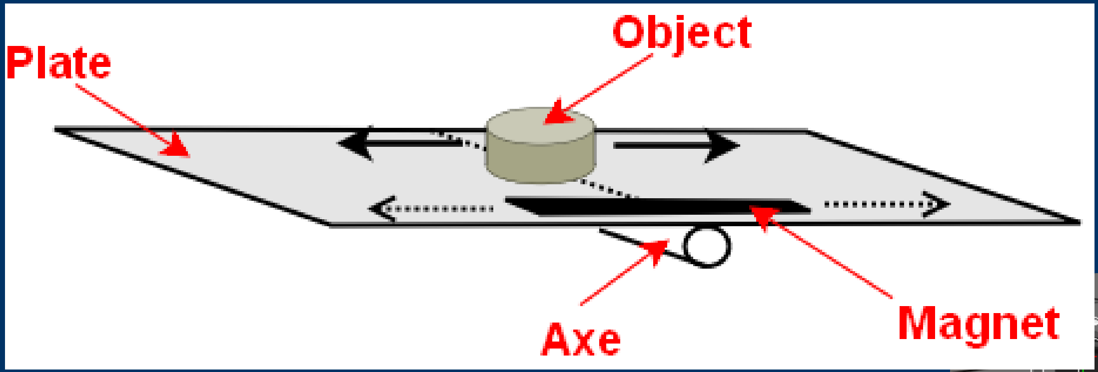
- Approximation of the bounding objects

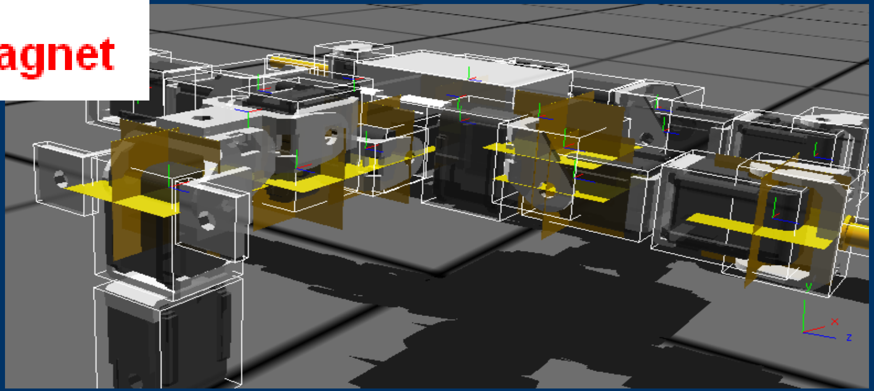




Applied Physics to the model (2)

- Letter scale to weight all parts
- Position of CoM ?





Using the CoM measurer !

Validation of the static properties

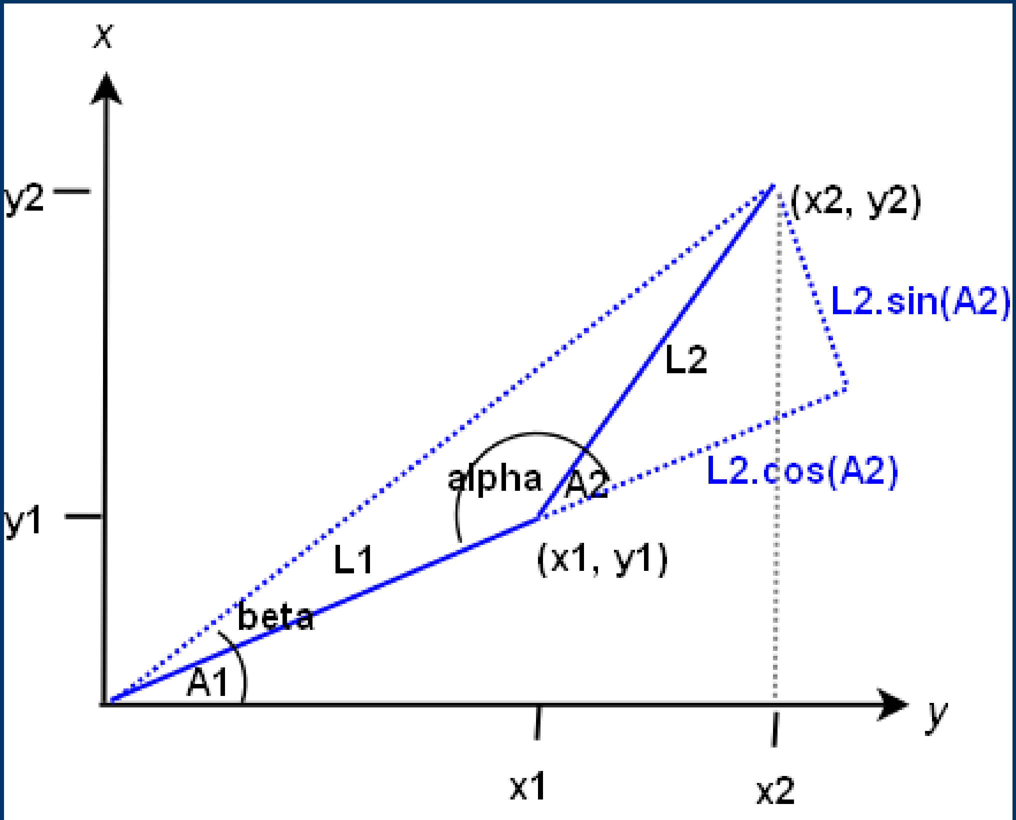
	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7	Exp 8	Exp 9
Real	571	482	479	535	261	274	478	537	542
Webots	531	X	O	X	363	375	466	527	531
Diff.	40	X	O	X	102	101	12	10	11
Diff.(deg)	11.72	X	O	X	29.88	29.59	3.52	2.93	3.22

Apply motion to the model (1)

- 2 different approaches
  - Use of Inverse kinematics
  - Use of optimized Central Pattern generator

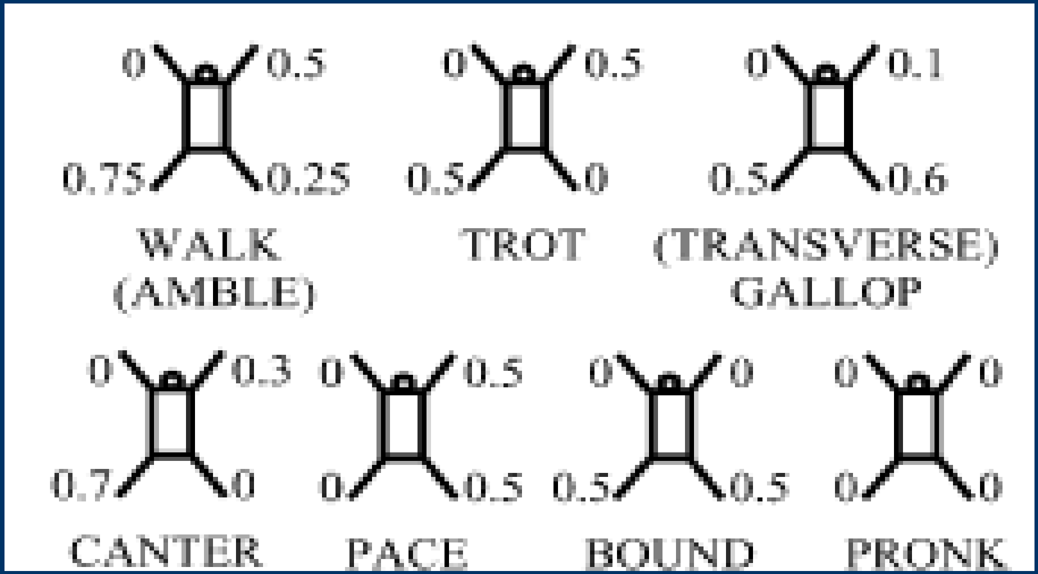
Inverse Kinematics (1)

- Find angle A1 and A2 given (x2, y2)



Inverse Kinematics (2)

- Different setup of gaits



Source: R. M. Alexander, Locomotion of Animals. Glasgow, London, U.K.:Blackie, 1982.

Inverse Kinematics (3)

- Results

Freq [Hz]	Trot	Walk	Gallop	Canter	Pace	Bound	Pronk
0.5	8.68	2.63	1.25	1.11	0.93	1.19	2.98
1	11.29	3.16	0.33	0.27	2.88	0.39	0.68
1.5	11.06	4.17	0.84	0.83	2.81	0.58	2.43
2	12.41	3.80	6.32	1.70	3.55	0.26	1.41

Move forward

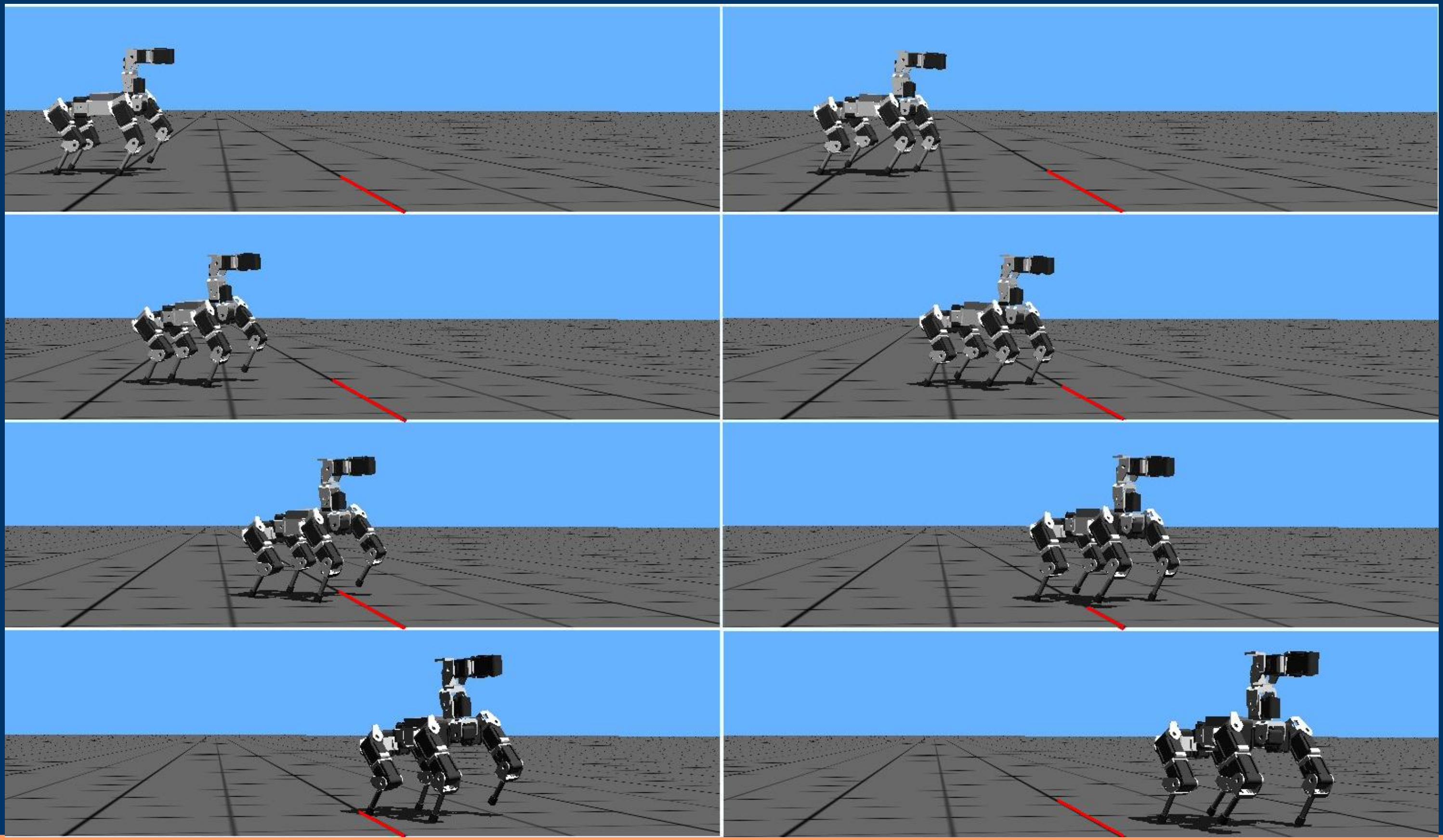
Fall on the head or the side

Walk backward

Stay on the spot

Inverse Kinematics (4)

- Trotting gait with at frequency 1.5Hz



Optimized CPGs (1)

- Optimized using PSO distributed over 50 nodes
- Different kind of coupling Model
- Energy based oscillators

$$\tau \dot{v}_i = -\alpha \frac{x_i^2 + v_i^2 - E}{E} v - x + \sum_j^N \frac{(a_{ij} x_j + b_{ij} v_j)}{x_j^2 + v_i^2}$$

$$\tau \dot{x} = v$$

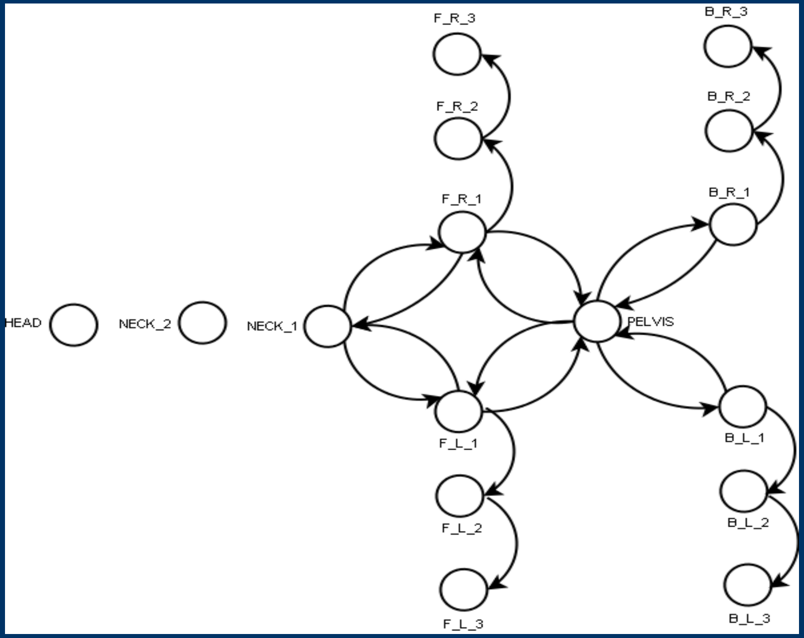
Source: Y. Bourquin, Self-Organization of Locomotion in Modular Robots. MSc Dissertation, p16, p26

Optimized CPGs (2)

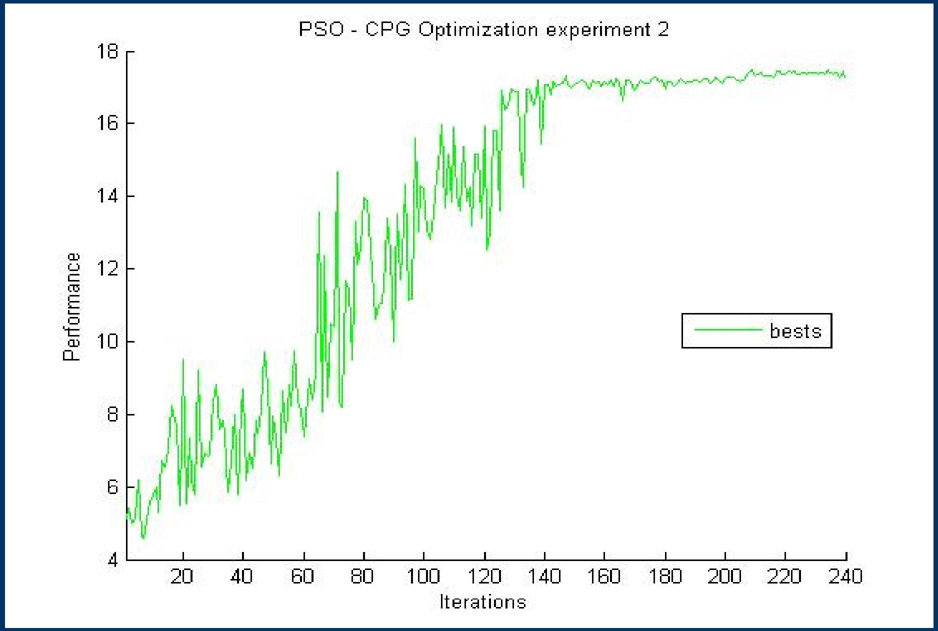
- Different hypothesis = different coupling models
- 6 different experiments

Optimized CPGs (3)

- Cornerstones
  - Number of parameters
  - Performance function of PSO



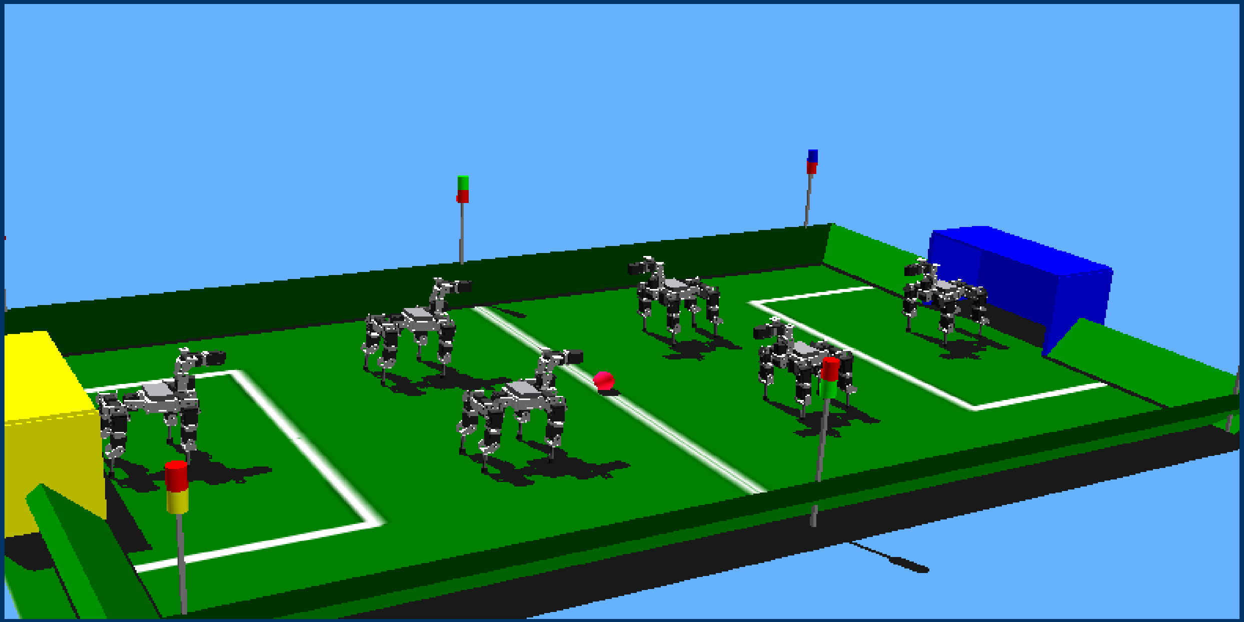
CPG coupling model experiment 2



Experiment 2 - Plot of PSO performance over 240 iterations.

Team of quadruped

- Trotting gait is used
  - Turn right/left implemented using stride length variation

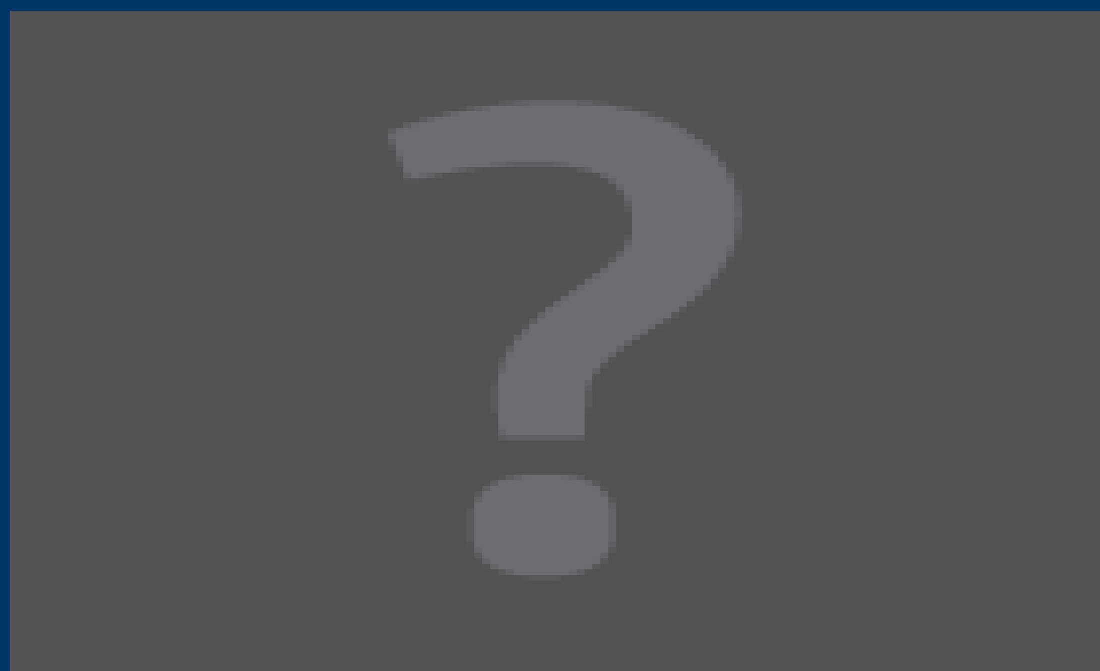


Conclusion

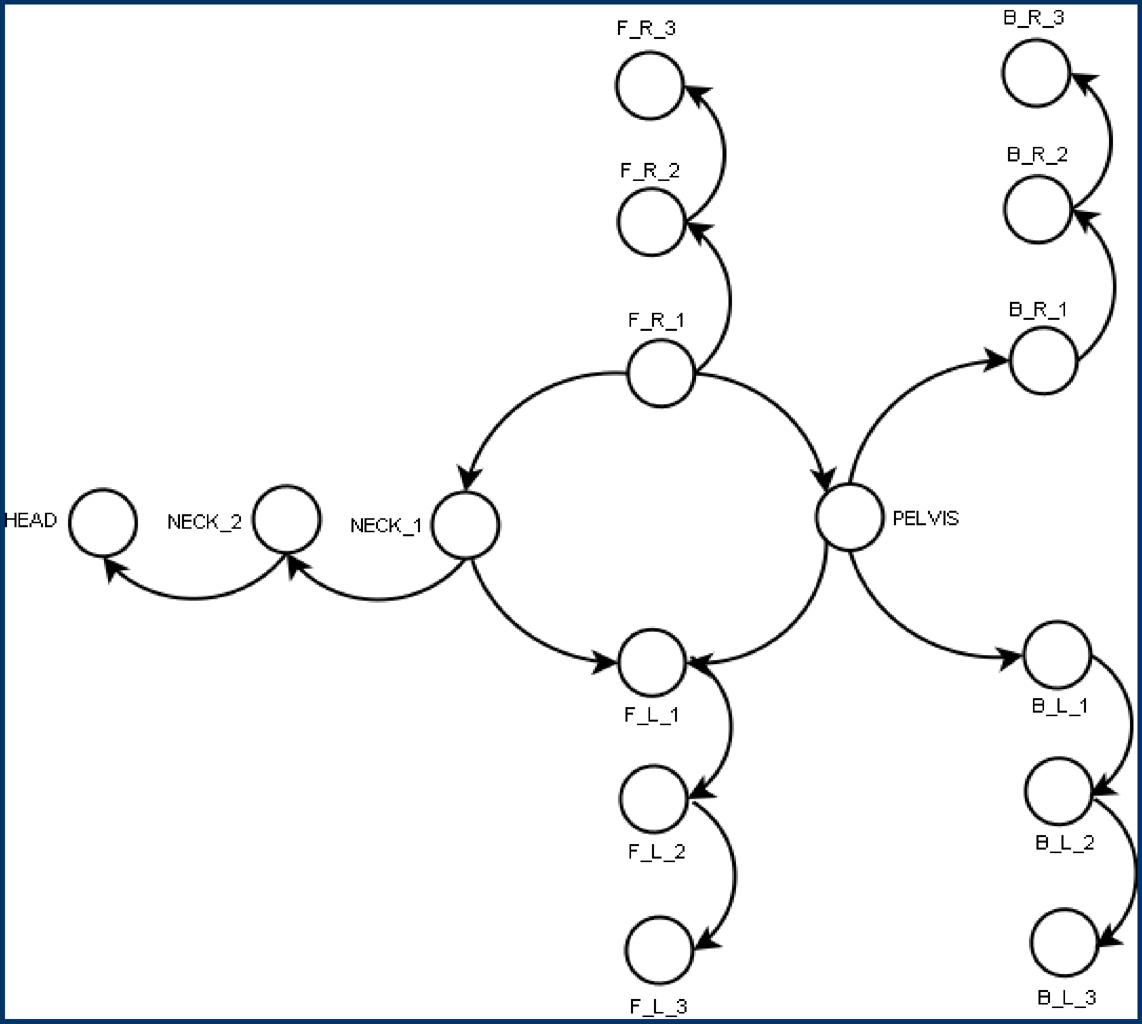
- Trade off between model efficiency and accuracy
- Worked achieve so far settle the foundation for future researches and developments.
- PSO is a powerful tools hard to tune

Thanks you

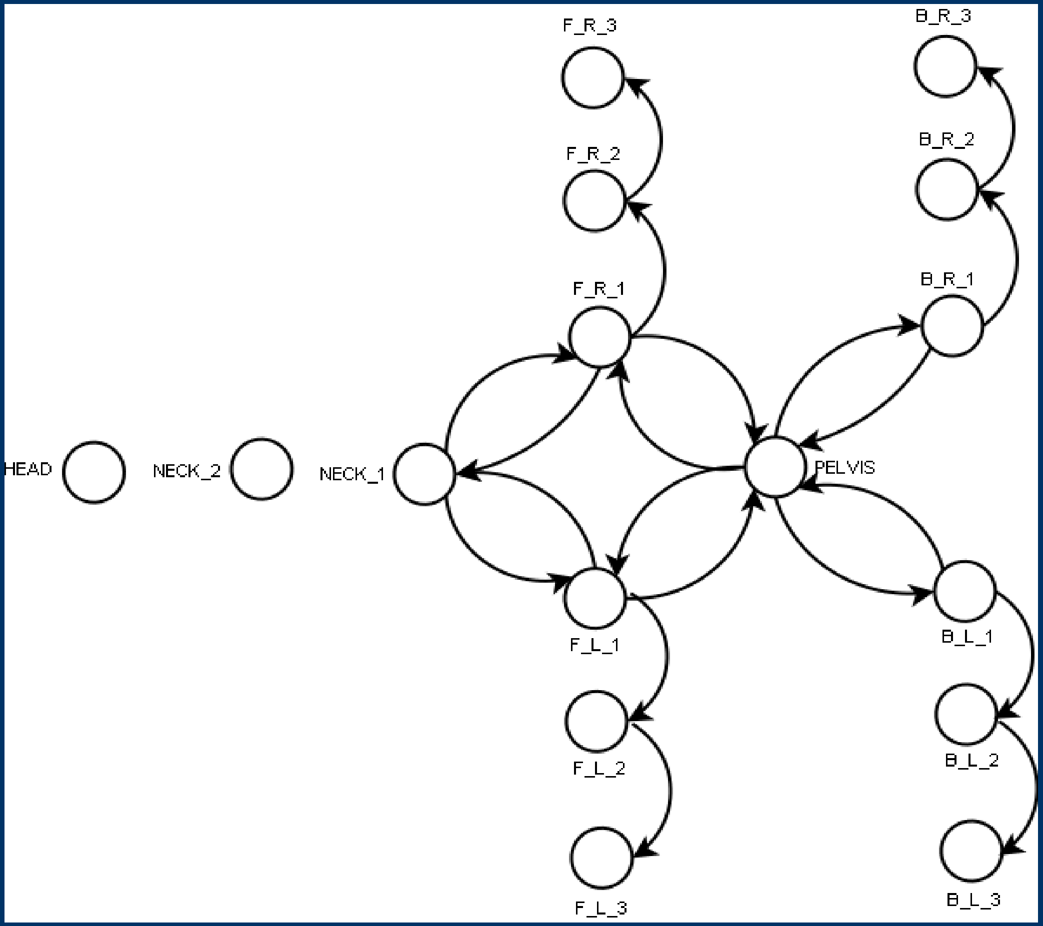
- Comments / remarks?



CPG Model 1

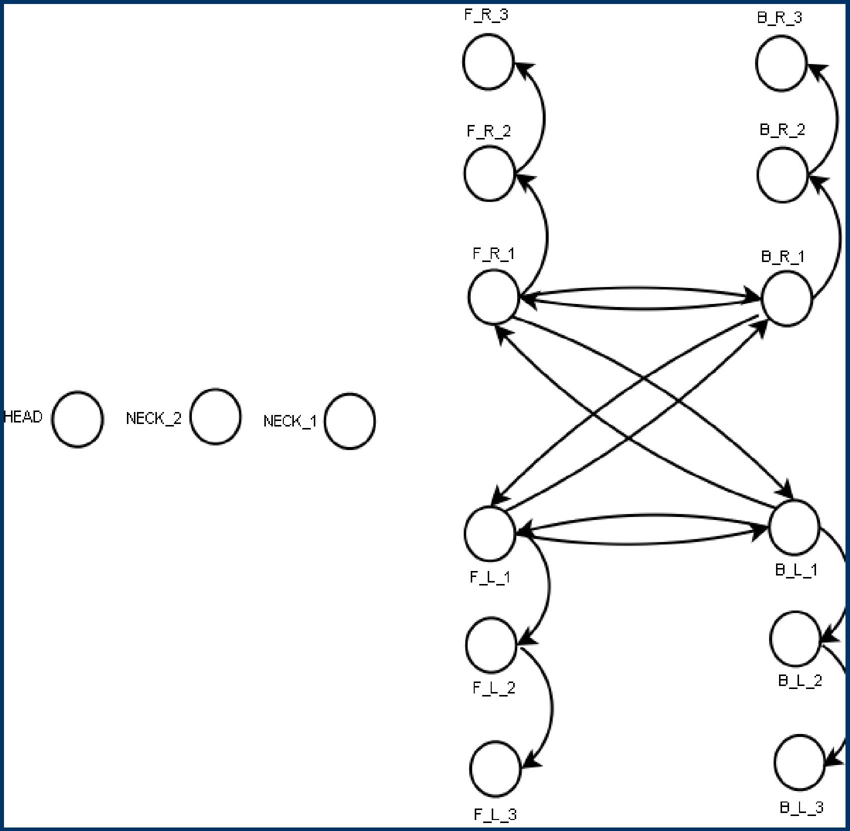

F_R_3
B_R_3
F_R_2
B_R_2
F_R_1
B_R_1
HEAD
NECK_2
NECK_1
PELVIS
F_L_1
B_L_1
F_L_2
B_L_2
F_L_3
B_L_3

CPG Model 2



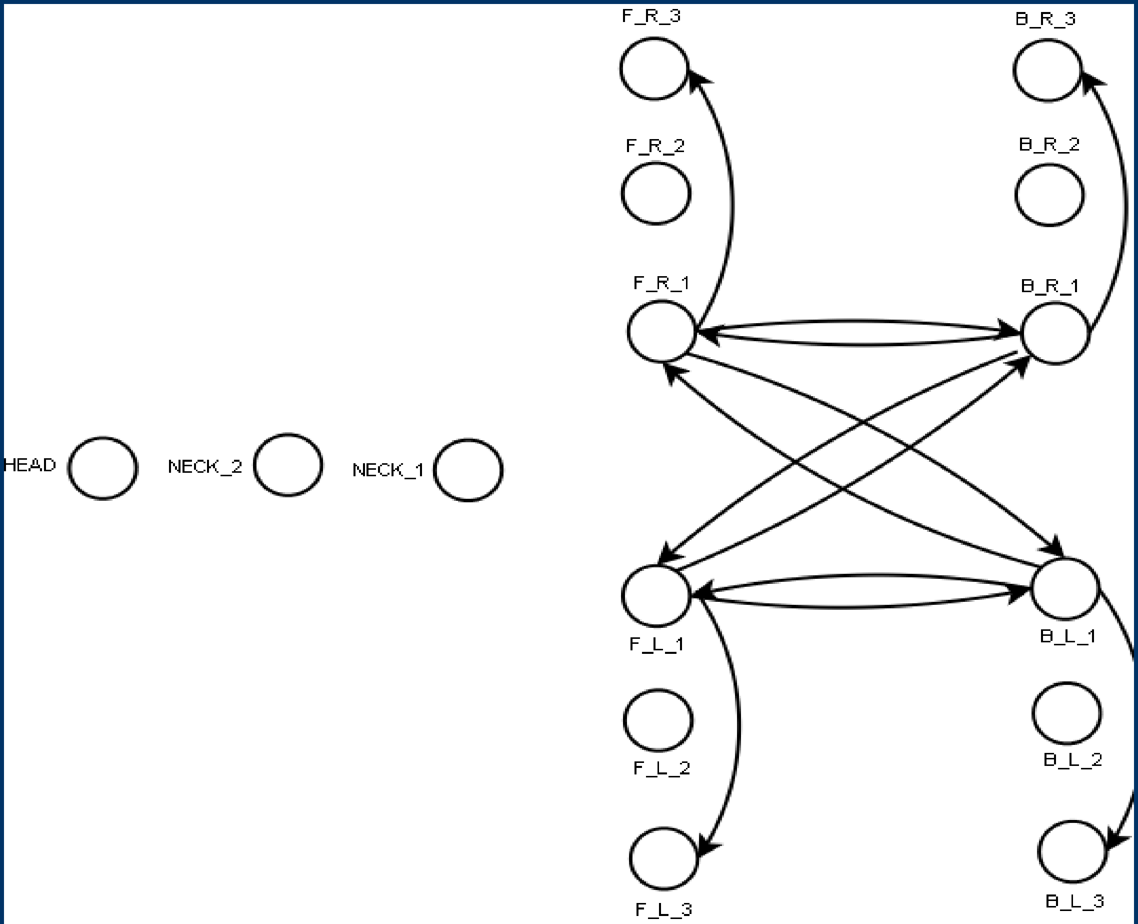
F_R_3
B_R_3
F_R_2
B_R_2
F_R_1
B_R_1
HEAD
NECK_2
NECK_1
PELVIS
F_L_1
B_L_1
F_L_2
B_L_2
F_L_3
B_L_3

CPG Model 3



F_R_3
B_R_3
F_R_2
B_R_2
F_R_1
B_R_1
HEAD
NECK_2
NECK_1
F_L_1
B_L_1
F_L_2
B_L_2
F_L_3
B_L_3

CPG Model 4



F_R_3
B_R_3
F_R_2
B_R_2
F_R_1
B_R_1
HEAD
NECK_2
NECK_1
F_L_1
B_L_1
F_L_2
B_L_2
F_L_3
B_L_3