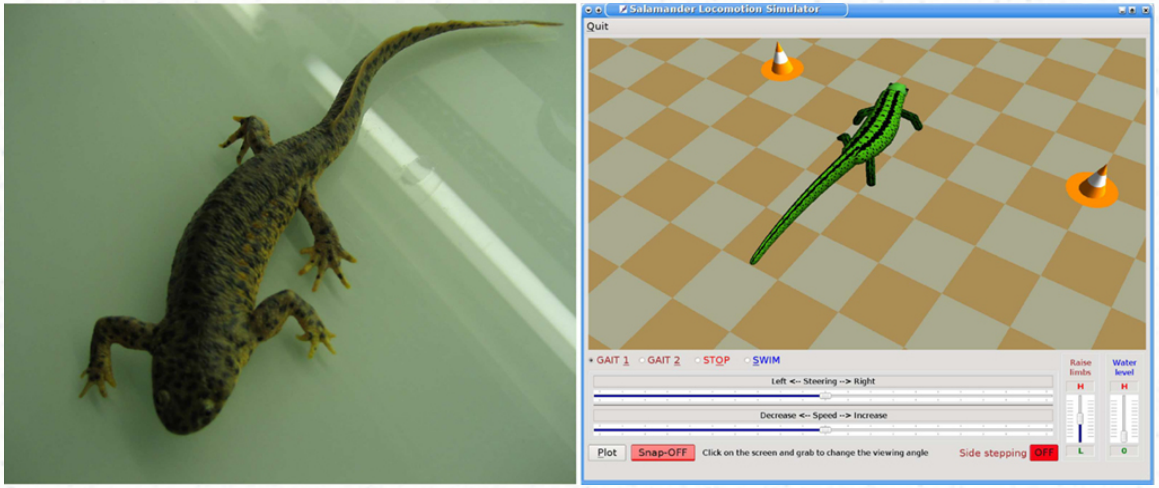
A 3D Musculo-mechanical Model of the Salamander for the Study of Different Gaits and Modes of Locomotion



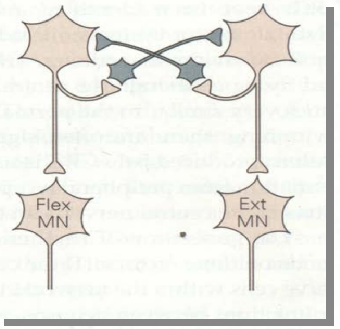
Nalin Harischandra, Jean-Marie Cabelguen and Örjan Ekeberg

Objectives

- To introduce a *simulator* of a 3D-biophysically realistic salamander locomotor model *(*Spanish ribbed newt- *Pleurodeles waltl)*
- To mimic *walking gait*, *trotting gait* and *swimming*
- To compare the turning behavior w.r.t. ***Bending*** and ***Side-stepping*** in over ground locomotion
- Additional behaviors (underwater stepping, swimming on ground)

Background

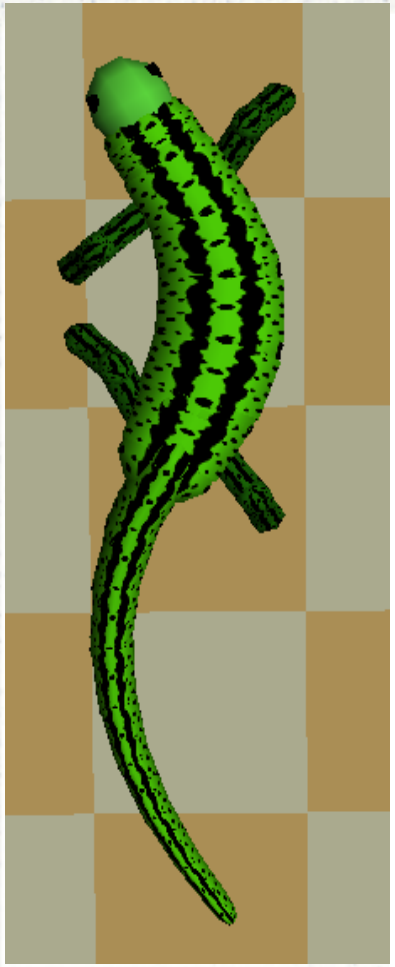
- **Central Pattern Generators (CPG)**: Provides the basic features of the movement –*the rhythm, the duration of the stance and swing phases, and the level of muscle activity*
  - *Time driven Pattern generators*
  - *Coupled Oscillator network*
  - *IF neuronal networks*

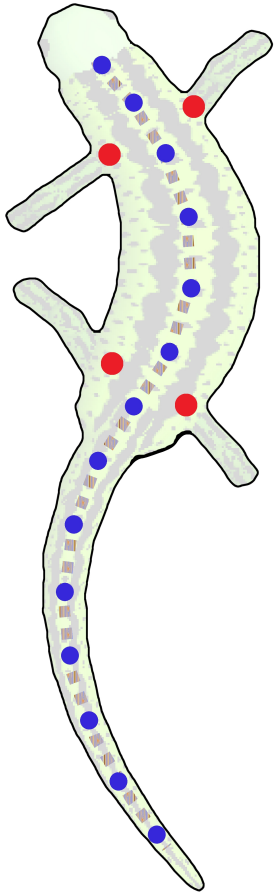


- **Sensory feedback:** Proprioceptive feedback (stretch), cutaneous inputs, vestibular inputs, *visual inputs*

Tools

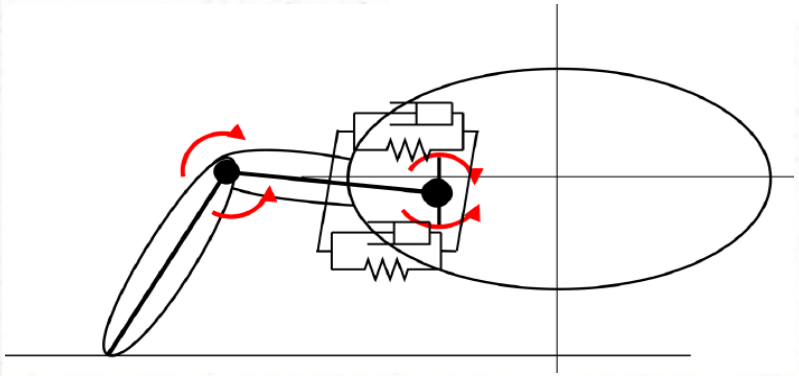
- **Scripting:** Python Language (python 2.5.5)
  (www.python.org)
- **Mechanics:** Open Dynamics Engine (ODE 0.5)
  PyODE – python wrapper
  (www.ode.org)
- **Graphics:** OpenGL,
  PyOpenGL – python wrapper
  pygame, Qt library





Model

- 15 rigid links interconnected via **1DOF** hinge joints
- Limbs (shank and thigh)- **1DOF** knee/elbow joint
- Limbs connected to the body via **2DOF** hinge joints



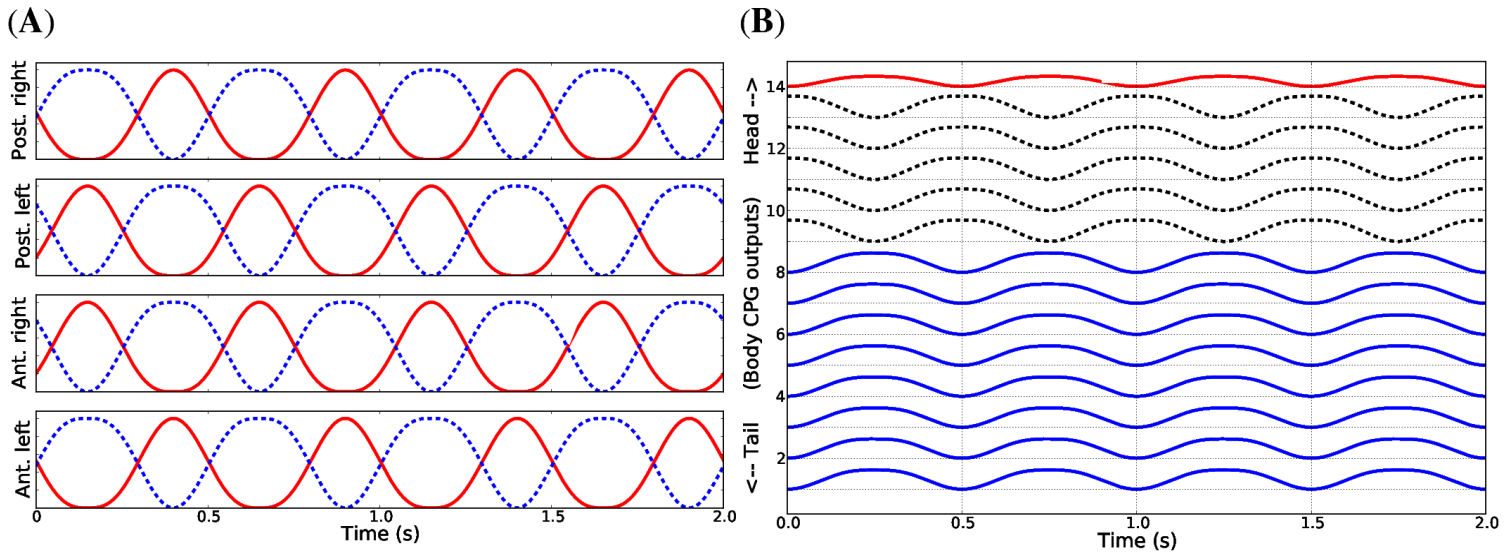
Model ...

- Muscle model: Spring and Damper system (*matheatical model introduced by Ekeberg (1993)*)
- $$T = (\alpha + \beta\Delta\varphi)E + \gamma\Delta\varphi + \delta\Delta\dot{\varphi}$$

T – Torque
- Gain
- Stiffness gain
- Intrinsic stiffness
- Damping coefficient
- Difference between the actual angle of the joint and the resting angle
E - Neural activation

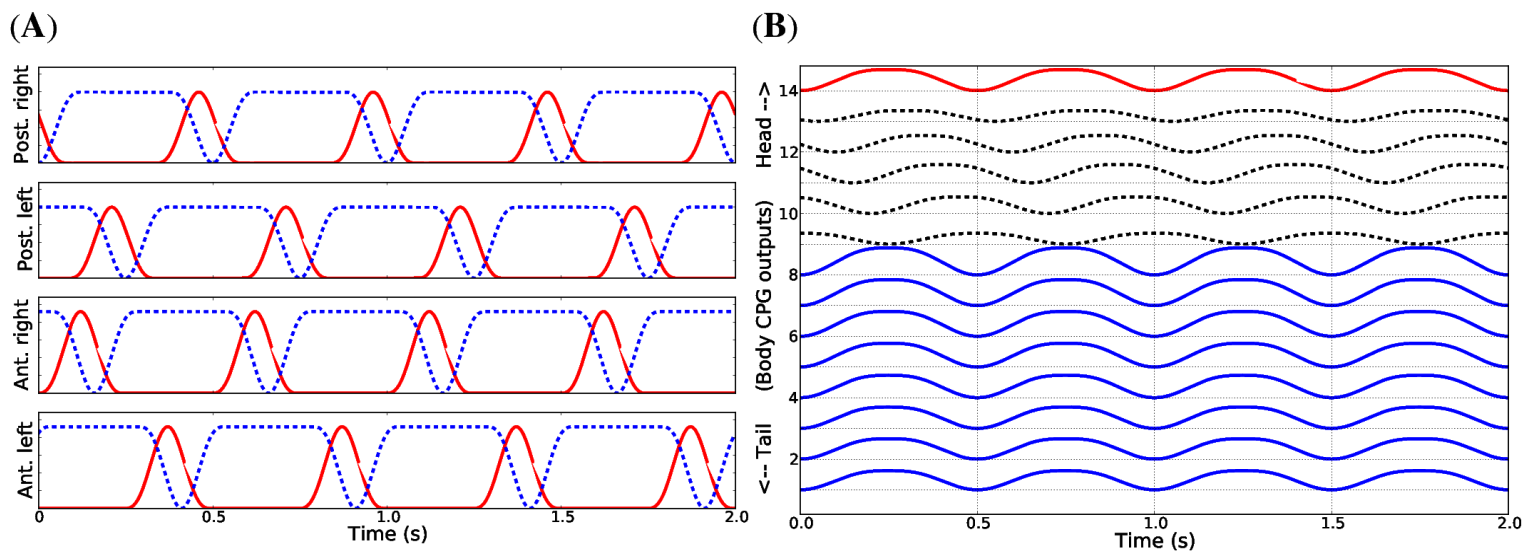
Results

- **Trotting**

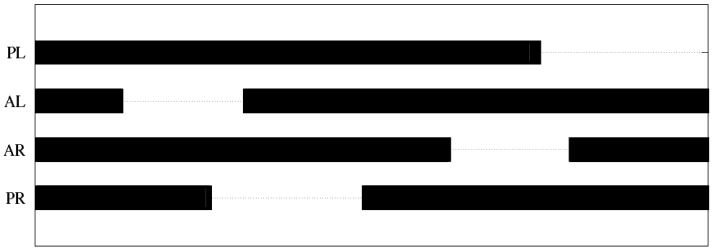


Results...

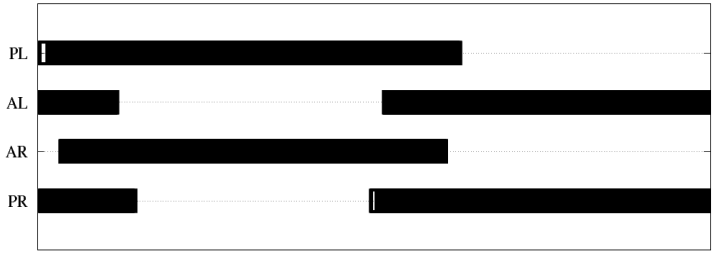
- **Walking**



(A)



(B)



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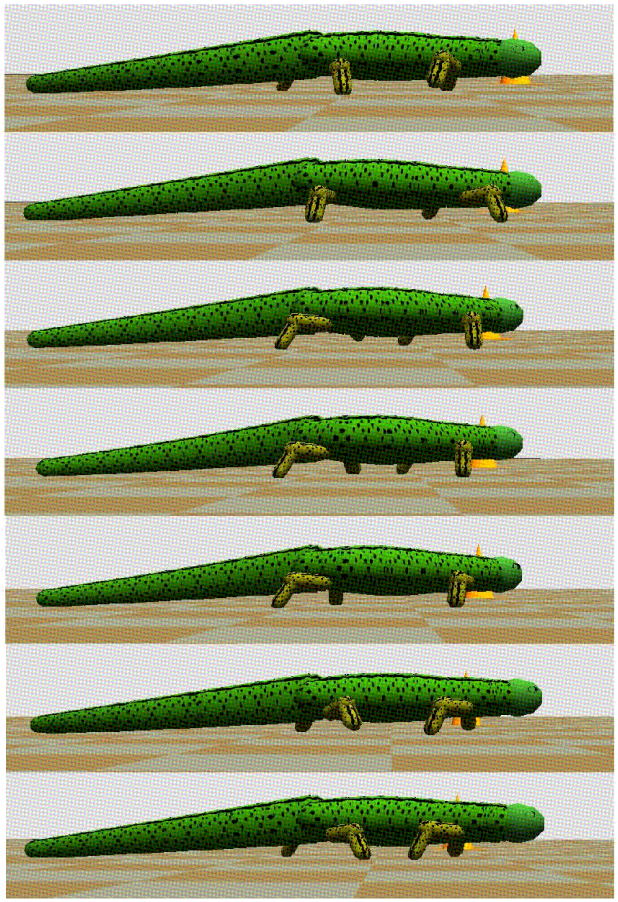
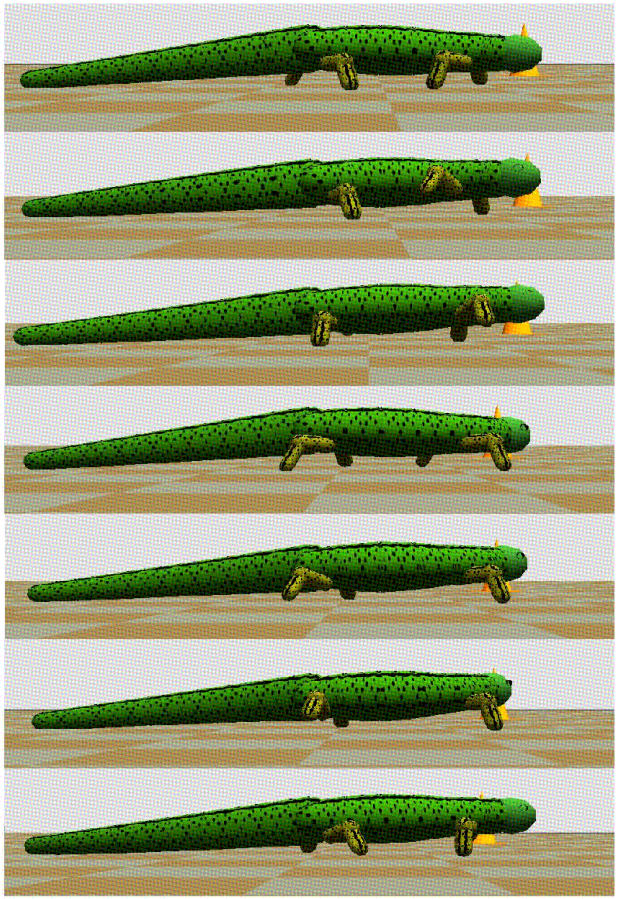
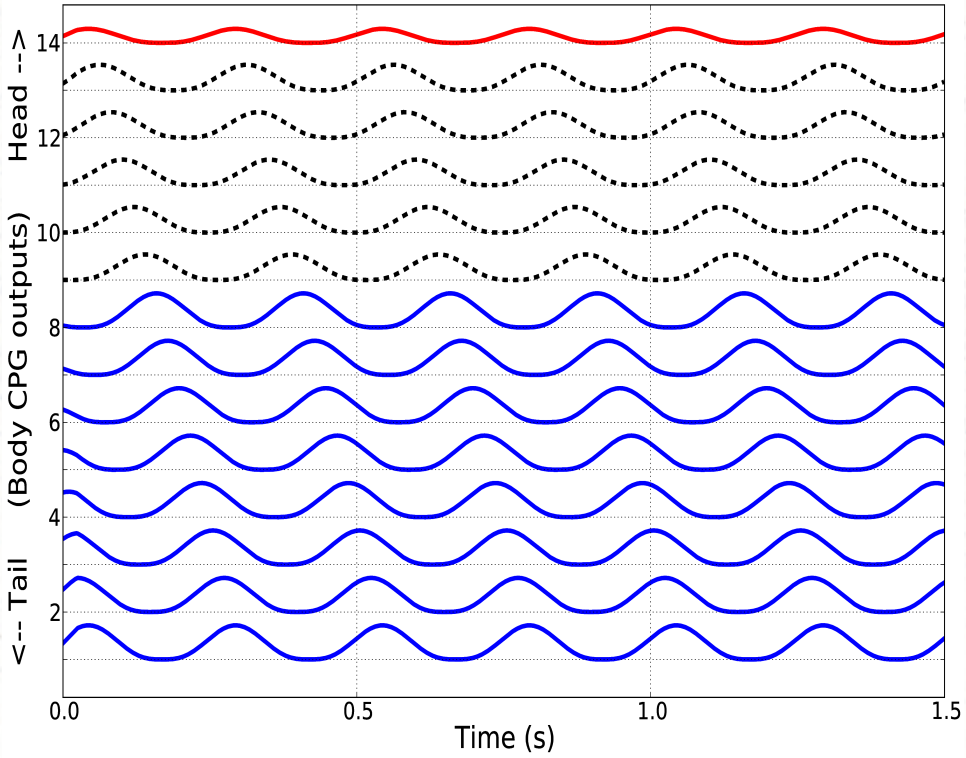


(D)

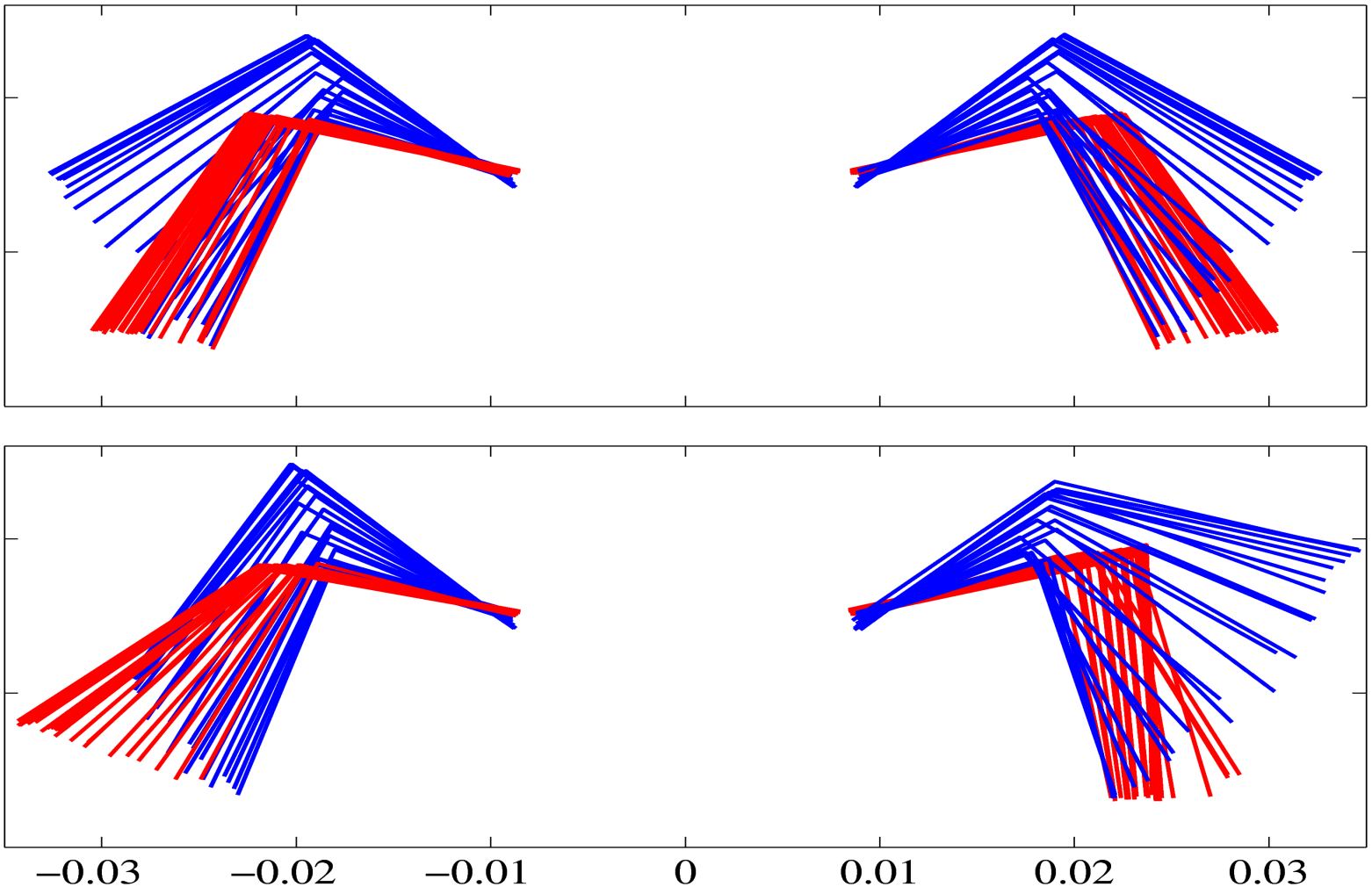


Results...

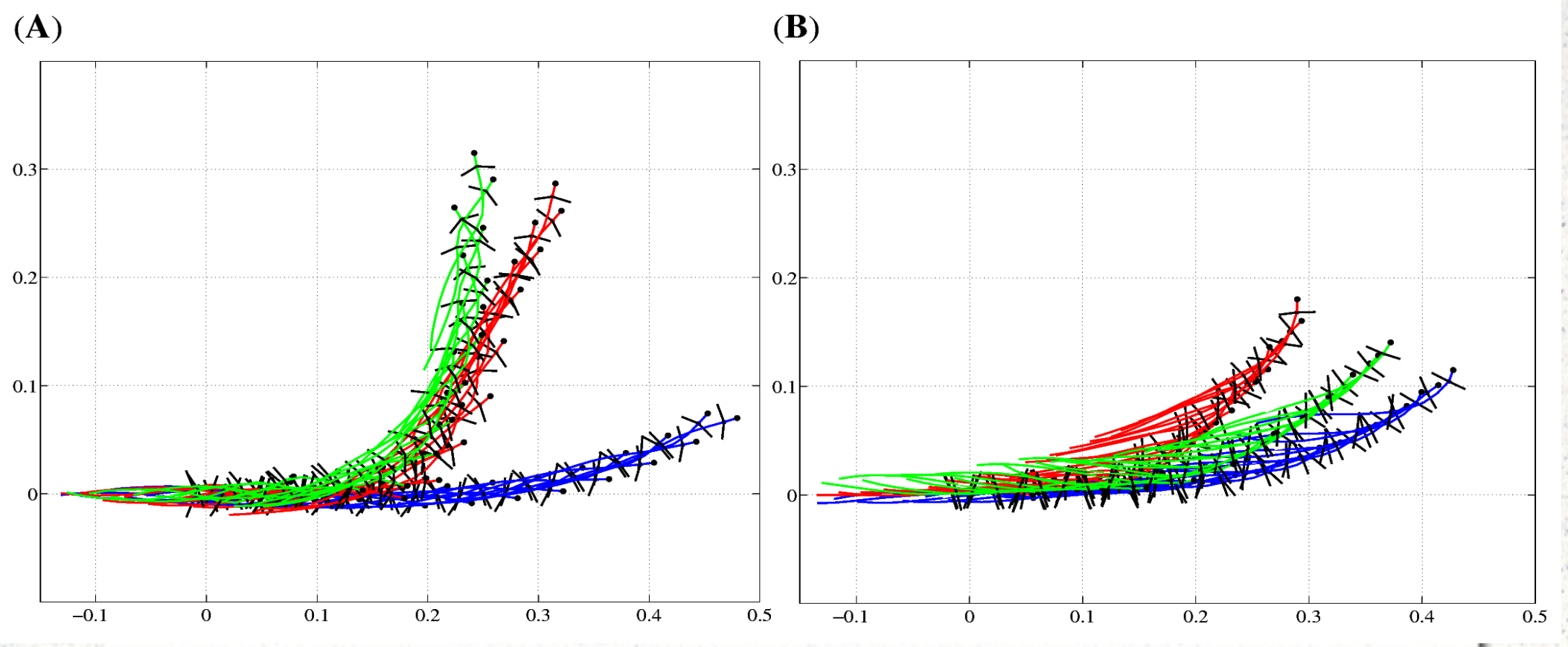
- **Swimming**



Side stepping



- Walking Trotting



Combination Bending Side-stepping

Thank you