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

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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](http://www.python.org))
- **Mechanics:** Open Dynamics Engine (ODE 0.5)
  PyODE – python wrapper ([www.ode.org](http://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 *(mathematical model introduced by Ekeberg (1993))*

\[ T = (\alpha + \beta \Delta \phi)E + \gamma \Delta \phi + \delta \Delta \dot{\phi} \]

- \( T \) – 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
Results...

- Swimming
Side stepping
• Walking

A

B

Combination

Bending

Side-stepping

Trotting
Thank you