Adaptive Locomotion Controller for a Quadruped Robot

Sensory-Feedback

SEMESTER PROJECT PRESENTATION

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BIOLOGICALLY INSPIRED ROBOTICS GROUP (BIRG)

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

Supervisors
Auke Ijspeert
Sarah Degallier
Ludovic Righetti

Simon Ruffieux

Summary

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  - Integration
- Existing models
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  - Matsuoka oscillators
  - Kimura model
  - Righetti model
- Model development
  - Some possibilities
  - Model of vestibular integration
- Webots implementation
  - Introduction
  - Some graphs
- Future work

Goals

- Goals of the project
  - Design a model integrating sensory feedback for quadruped locomotion
  - Implement this model for the AIBO
  - Test the model with Webots
  - Test the model with the Real AIBO
  - Test the model with other(s) robot model(s) (Icub/Ghostdog)

Biological S-F – Resume

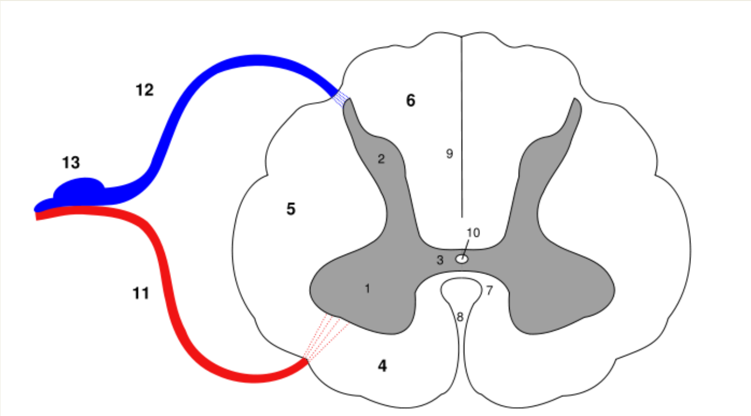
- Sensory feedback
  - Important component of locomotion
  - Steady-state locomotion can be achieved without SF
  - Sensory feedback is needed to face unpredicted terrain

Biological S-F – Main sensory paths

- Main sensory pathways
  - From higher brain
    - Visual
    - Auditory
    - Vestibular
  - Proprioceptive afferents
    - Golgi tendon organ
    - Muscles spindles
  - Cutaneous afferents
    - Any stimuli on the skin (heat, contact)

Biological S-F – Integration

- Spinal cord
  - From higher brain
    - Preprocessed information
  - Proprioceptive afferents
    - Integrating response in spinal cord
  - Cutaneous afferents
    - Often results in quick reflexes



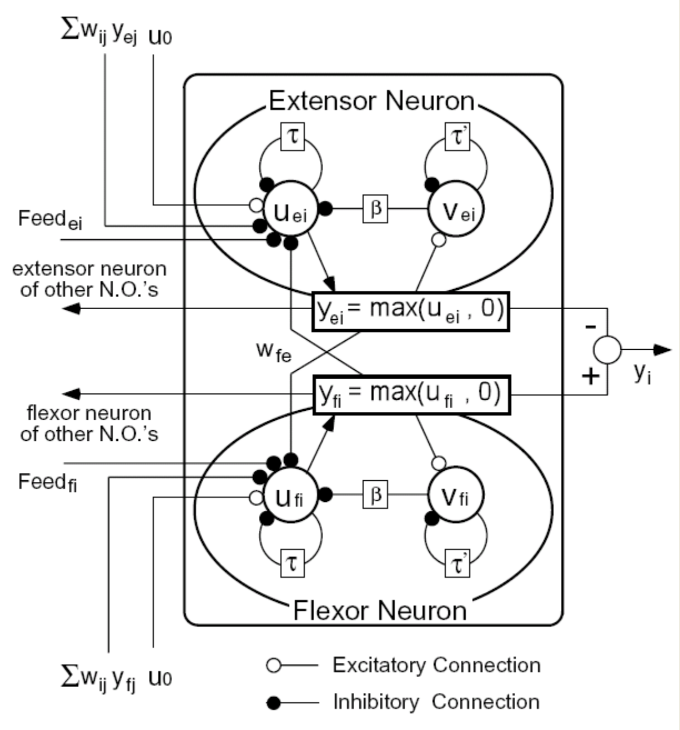
Existing models - Introduction

- Various models exist
  - For hexapod locomotion
  - For biped locomotion (walking)
  - For quadruped locomotion

- Two types of sensory feedback integration
  - Reflexes: direcly modify joint torque
  - Responses: modify the CPG output

Existing models – Matsuoka oscillators

- Biologically-inspired neural oscillator
  - Two mutually inhibiting neurons
    - Simulate flexor and extensor muscles
    - Very interesting from a biological point of view
    - A bit complex



Existing models – Kimura-Fukuoka

- Quadruped walking on natural ground
  - Various reflexes and responses implemented
    - Flexor reflex (stumbling corrective response)
    - Vestibular reflex/response
      - Vestibulospinal response
      - Tonic labyrinthine response
      - Sideways stepping reflex
    - Corrective stepping reflex
    - Crossed flexor reflex

Existing models - Righetti

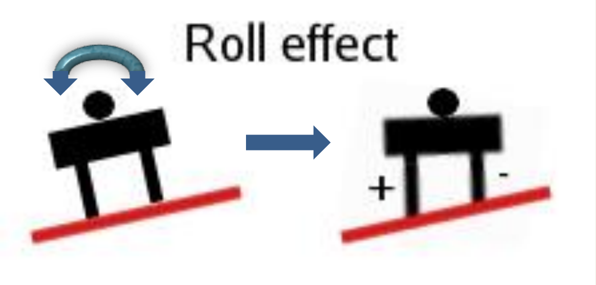
- Stance/swing transition control
  - Simpler but « well thought » use of Hopf oscillators
- Allows to force or stop transitions
  - According to phase and contact sensors
- Generic model
  - Easily transposable to various robot models

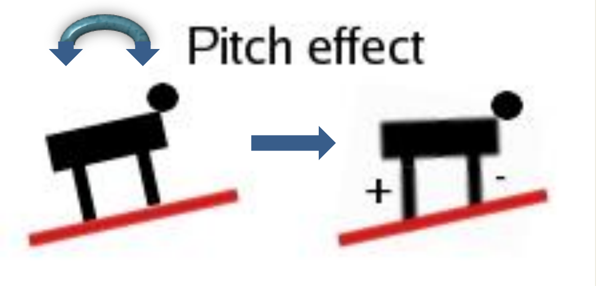
Model development – Some possibilities

- Vestibular feedback
  - Pitch
  - Roll
- Cutaneous feedback
  - Paw contact sensors
  - Stumbling contact sensors
- Proprioception
  - Forces on muscles

Model development – Vestibular integration

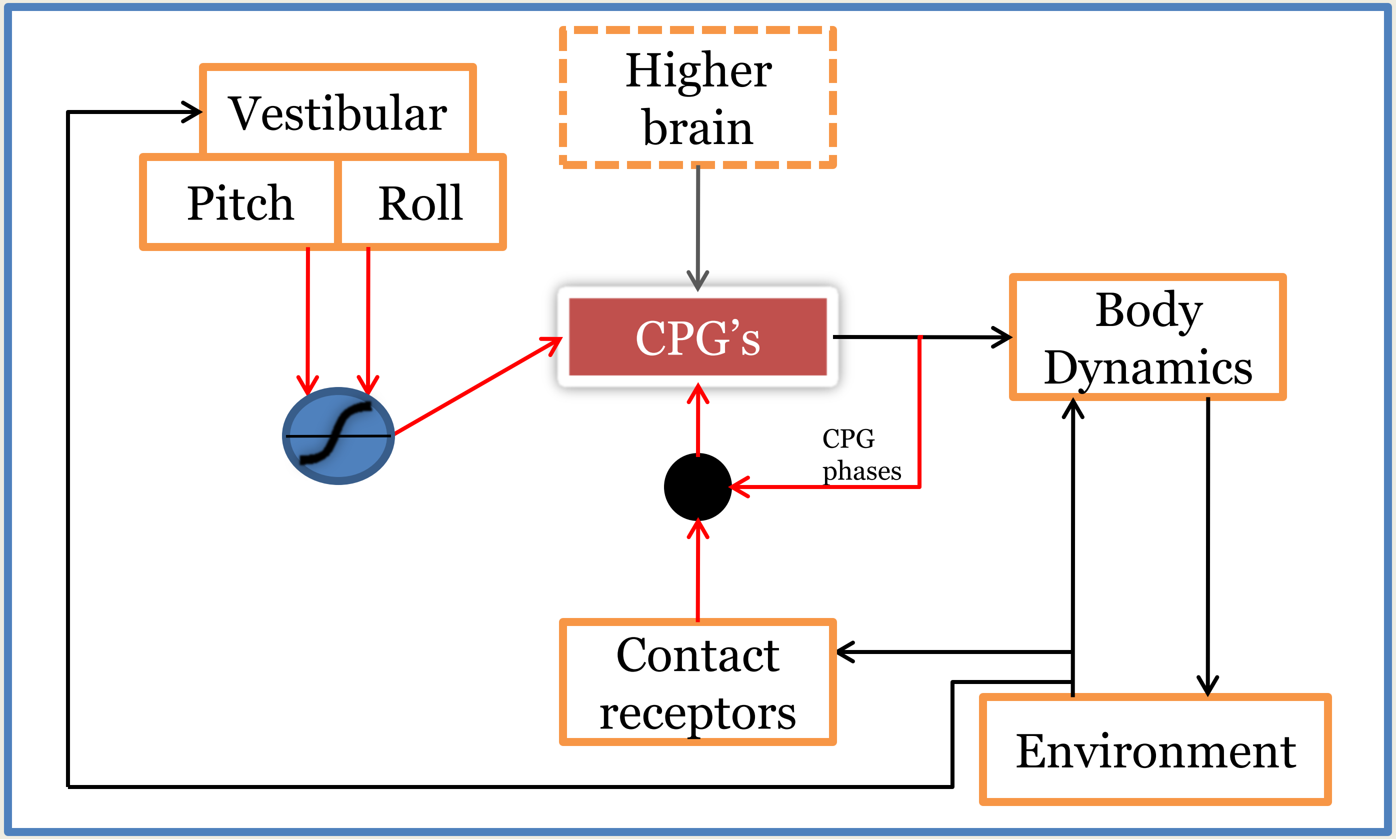
- Modification of the limit cycle
  - Increasing/diminishing amplitude





Model development – Vestibular integration

- Schema of the model



Webots implementation – Introduction

- Addition of a GPS to AIBO model
  - Euler angles
  - Strange values

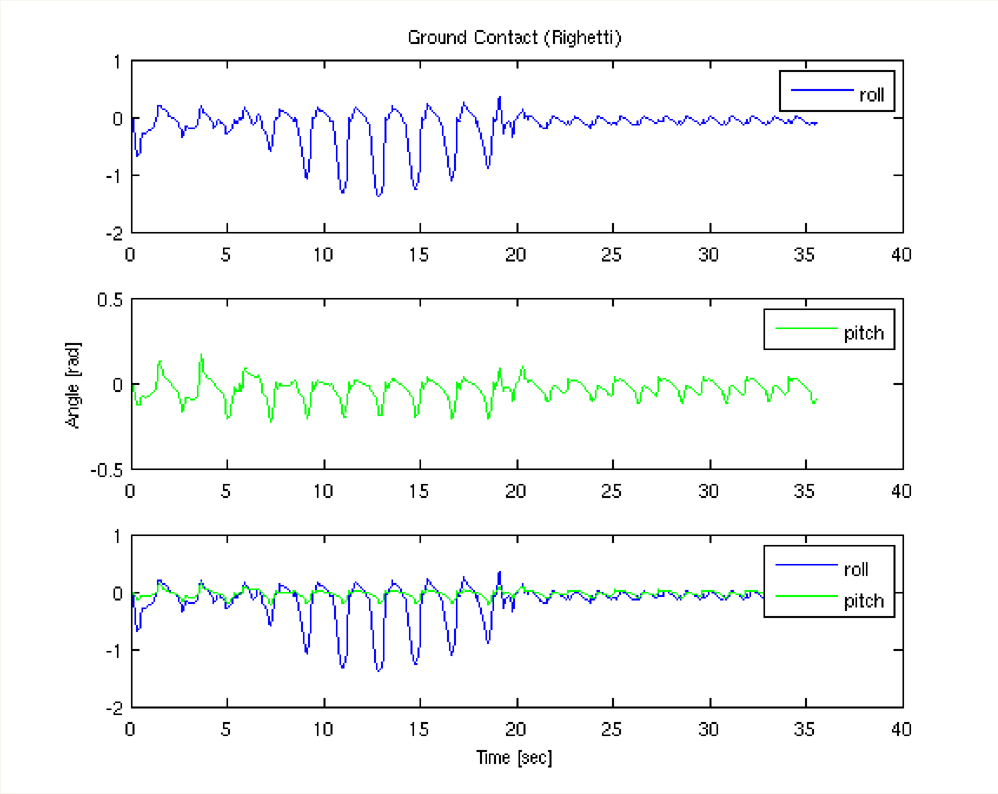
- Retrieving pitch & roll
  - Local body coordinates → global coordinates
  - Pitch & roll calculations

Webots implementation – Introduction

- Design of test worlds
  - Various slopes
  - Uneven ground
- Test benchs
  - Vestibular plots
  - Phase plots (amplitude)

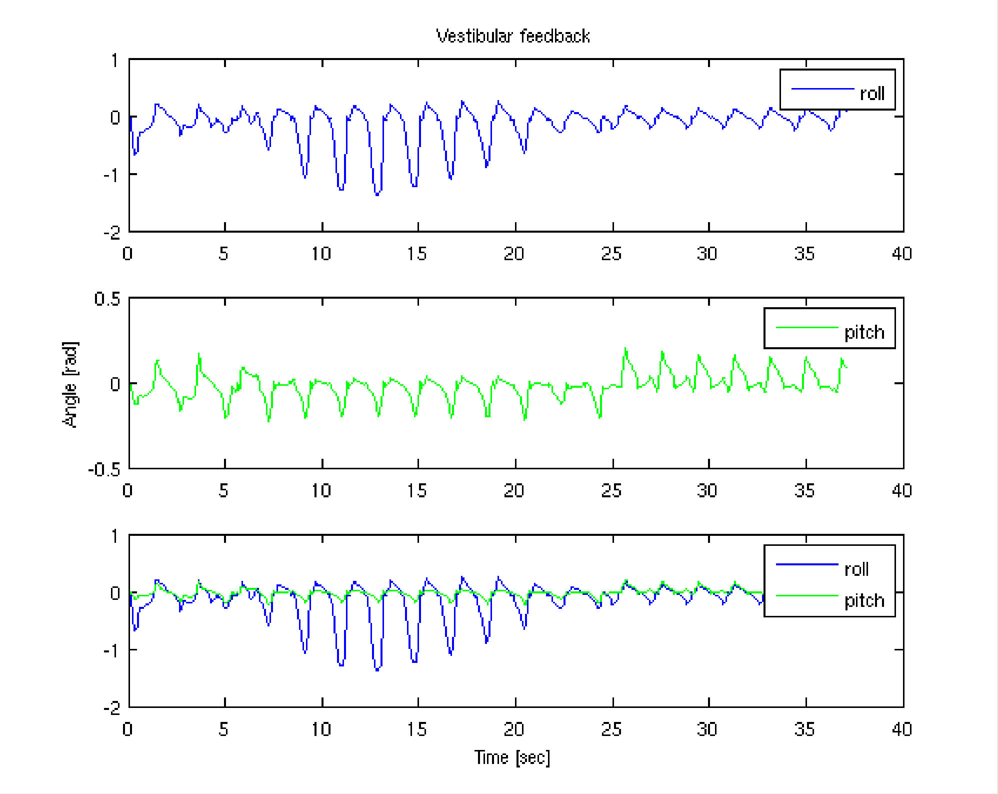
Webots implementation – Some graphs

- Vestibular output
  - Ground contact
  - Implemented by Righetti



Webots implementation – Some graphs

- Vestibular output
  - Vestibular feedback



Upcoming work

- Further tests of the model with Webots
  - Possibility to mix with Righetti feedback
  - Various terrain
- Test with real AIBO
  - GPS → accelerometer
- Test the model on different robots with Webots
  - Icub / Ghostdog

Your turn !

Any questions ?