Adaptive Locomotion Controller for a Quadruped Robot Sensory-Feedback

SEMESTER PROJECT PRESENTATION
6.11.2007

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Summary

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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: directly 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
  o Pitch
  o Roll

• Cutaneous feedback
  o Paw contact sensors
  o Stumbling contact sensors

• Proprioception
  o 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 benches
  - 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?