SEMESTER PROJECT

Design and implementation of a force/torque sensor for a quadruped robot

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PRESENTATION OUTLINE

Cheetah introduction
CPG’s and sensory feedback

Roombots’ sensor
Load-cells intro
Issues with roombot’s sensor
Experimental setup improvements

Leg sensor design
First design approach
Upcoming work
INTRODUCTION: CHEETAH

• Quadruped robot.
• Study base for CPG algorithms
• Goal: use real-time hardware information to find locomotion principles and improve control of the gait
• 3-segment pantographic leg, 2 active DOF
CPG’S AND SENSORY FEEDBACK

It is possible to use sensory information in a CPG so that the oscillator is better coupled with the mechanical system [1]

Stop before transition / fast transition

→ More stable gait, faster

Still many challenges, open subject

Cheetah : study platform

SENSOR FOR ROOMBOTS

First part of the project:
Resolve issues with previously developed sensor

• Roombots
• 4-axis
• Strain gauges measure deformation
• Experimental acquisition with labview

• Simulation results do not match experiments

Roombots
Sensor
LOAD CELLS : INTRO

- Composed of strain gauges
- Resistivity changes with deformation
  \( \Rightarrow \) Stress \( \Rightarrow \) Forces

- Measured through a Wheatstone bridge

- Here, half-bridge:

\[
\begin{align*}
R_1 &= R_2 = R : \text{fixed resistors} \\
R_3 &= R + \Delta R \\
R_4 &= R - \Delta R : \text{gauges with opposite deformations}
\end{align*}
\]

\[
V_{out} = V_{in} \times \frac{\Delta R}{2}
\]
LOAD CELLS : INTRO 2

Multi-axis system
→ local deformation often function of several forces
→ N axis measured : N bridges required

• Characterize the system :
  Apply forces and torques, measure voltages
• Invert the system :
  Voltages → forces/torques
ROOMBOTS SENSOR ISSUE

- Experimental results do not match simulations
- Simple tests for symmetries : fail → incoherent reactions

Possible explanations :
- Bad values of the gauges / resistors
  (ex : 300Ω and 360Ω instead of 340 Ω → 0.83% error)
- Placement and orientation of the gauges
- Gauges’ sensitivity differences (6% variation)

Main problem found : electrical connections between the gauges and the aluminium

→ short-circuits despite the insulating layer
EXPERIMENTAL SETUP IMPROVEMENTS

- Top beam for Mz, Fz
- Pulleys
- PCB for the Wheatstone bridge (double)
LEG SENSOR DESIGN

Hypothesis:

1. Three forces between foot and floor.
2. No moments transmission. (# Floor not sticky)
3. Position of contact can be determined. Angular positions of the foot segments and body known.

\[
T_{\text{floor} \rightarrow \text{foot}} = \begin{bmatrix}
F_x & 0 \\
F_y & 0 \\
F_z & 0 
\end{bmatrix}_A
\]

\[
\begin{bmatrix}
M_{x,B} = F_y \cdot z_{AB} - F_z \cdot y_{AB} \\
M_{y,B} = -F_x \cdot z_{AB} \\
M_{z,B} = F_x \cdot y_{AB}
\end{bmatrix}_B
\]
FIRST DESIGN APPROACH

• With previous hypothesis:
  • 3 forces unknown: 3-axis sensor
  • Possibility to choose which axis to measure
• Design inspired from robot’s finger 6-axis sensor [1]
  • Small, already tested and very precise
  • Same range of forces
• One Wheatstone bridge sensitive to only one axis by design
• Possibility to easily use it as 6-axis
  • Contact between foot and floor more flexible
  • Or better accuracy

FIRST DESIGN APPROACH 2

Solidworks FEA simulations

- Gauges
- Position

Fx

Fy

Fz
UPCOMING WORK

QUESTIONS?