Design and integration of a multi-axis force sensor for the Roombots

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Type: Semester project
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Roombots

- Self-Reconfiguring Modular robot
- Designed for two main tasks:
  - Self assembly and reconfiguration of static structures
  - Building block for locomotion with modular robots

Picture taken from [1]
Purpose of Load-Cells in Roombots

- Detect collision, direction of a contact
- Closed-loop control for locomotion

Video by S. Pouya and J.v.d. Kieboom
Load-cells

• Convert forces and torques into electric signals
• Are places in series with the structure of interest

6 axis load-cell in the arm of the iCub. Pictures taken from iCub.org
Structure mechanics

- Stress $\sigma = \text{force} / \text{surface}$ (pressure)
- Strain $\varepsilon = \text{elongation/initial length}$
- $\varepsilon = \sigma / E$ (E: elasticity)
- Stress in bending beams: 2 ways of measuring
  - Bending: $\sigma = \gamma * M / I$
  - Shear: $\sigma = P * S' / (I * B)$

Picture taken from [2]
Strain gauges

• Resistors which resistance changes as a function of strain: $R = \rho \times \frac{L}{A} \rightarrow \frac{\Delta R}{R} = K\varepsilon$

• Two different types:
  – Foil strain gauges ($K = 2$)
  – Semiconductor strain gauges ($K = 100$)

  • As small as 1mm long
  • 10 to 20 $ each

Picture1 taken from micro-measurement.com/PrincipalWebs/MFL.html, picture2 taken from www.microinstruments.com
Electronics: Wheatstone bridge

- Converts resistance change into tension change.
- Half-bridge: two anti-symmetrical strain gauges in one arm of the bridge. Compensates for non-linearity and thermal sensitivity.
- $V_g = \Delta R \times V_{in}/2$

Picture from Wikipedia
Electronics: acquisition

- Wheatstone bridge $\rightarrow$ Low-pass filter $\rightarrow$ Amplification $\rightarrow$ Multiplexing $\rightarrow$ A/D conversion
Mechanical design: location

Good locations

A 4-axis load-cell is enough for our purpose

Cross-section of half a Roombot module, picture take from [1]
Mechanical design: model 1

Strain gauges pairs

Measures bending strain

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Ring structure

Torque structure
Simpler structure and less parts to modify than model 1, but cross-talk problem for now.
References


• iCub project: iCub.org
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Thank you

Questions?