Novel Proprioceptive Sensors for a Legged Robot

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What can robots do with sensors?

• Lots of useful and interesting behaviors, such as…

Hill-climbing

System Protection

http://www.youtube.com/watch?v=vVibsNBIZkg&t=3m34s
My Project

- My project works towards implementing two proprioceptors on the X-RHex robot[3]

  - The first measures each motor’s core temperature
  - The second measures the robot’s pitch
  - Each sensor replaces an existing method of sensing on the robot with a “software sensor”

Sensing Temperature

- The resistance of a motor’s windings is an affine function of temperature
  \[ R(T) = R_{25}(1 + \alpha_{Cu}(T - 25^\circ C)) \]
- Inverting this function solves for T in terms of known constants and the motor’s resistance
  \[ T = \frac{1}{\alpha_{Cu}} \left( \frac{R(T)}{R_{25}} - 1 \right) + 25^\circ C \]
- Measuring T requires only a measurement of R
- Using knowledge of the motor’s dynamics, R can be found using Ohm’s Law: \[ R = \frac{V}{I} \]
Temperature Sensor Results

• Plotting I vs. V for data gathered at 23°C and at 85°C gives two different slopes and thus two different resistances

• Estimating the temperature from resistance data at 85°C gives a range of ±3°C and a standard deviation of 1.68°C
How can pitch be measured?

- The angle between each leg and gravity can be estimated (more to come on that)
- And the angle of each leg relative to the robot is known based on the motor’s encoders
- Adding these two angles gives the robot’s pitch
Leg Angle Approach and Results

- Create a simulated leg that does not feel the effects of gravity
- Compare this simulation to an actual leg spinning
- The differences seen arise from gravity’s effect
Applications of these Sensors

• The temperature sensor provides accurate thermal modeling to prevent damage and extend runtimes

• It may also enable safe high-power behaviors from the robot in the future

• The pitch inclinometer can be used for behaviors which rely on an IMU for pitch measurements

• This new software sensor is preferable to avoid electrical interference with the IMU’s magnetometer

• And to avoid damaging the IMU where damage seems likely
Questions?