Electromechanical Part Selection and Manufacturing and Cost Analysis

24-370 - Spring 2011

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Reminders and Announcements

- HW7 due Wednesday
- Project 3 due May 5th
- Today's lecture
  - Final note on motors
  - Other electromechanical parts
  - Manufacturing and Cost Analysis
- Project 2 Results:
  - Minimum Mass: Team 10
  - Lowest Prototype Cost: Team 11
  - Other fun data will be online soon…

Motor and gearbox selection

- What are the properties of interest?
  - Potentially all motor properties we have discussed
- Design by selection
  - Discrete number of available devices
  - Strong limitations due to electromagnetics, not salient to the consumer

Prominent Sources

- Small, high-performance robotics applications
  - Maxon: www.maxonmotor.com
  - Micromo: www.micromo.com
- Larger scale machine applications
  - Quick: through catalog distributors, such as:
    - Grainger: www.grainger.com
    - McMaster-Carr: www.mcmaster.com
  - Performance: from manufacturers, such as:
    - Allen Bradley: www.ab.com
    - Baldor: www.baldor.com
- Selection example: Maxon

Common Electromechanical Actuators

- Motors:
  - Most common, best developed drive technology
  - P_{max}, τ_{max}, ω_{max}, J_{rot}, R_{gear}, R_{coil}, I_{coil}, etc.
- Solenoids:
  - Simple, fast, linear motion
  - But, small operating range, low efficiency
  - V_{nom}, i_{max}, F_{max}, push/pull
- Exotic:
  - SMAs, EAPs, small, high potential
  - But, not fully commercialized

Other Common Transmission Elements

- Fluid Power:
  - Pressure, area, transmission, power source
- Hydraulics
  - High force, high power, high bandwidth, density
  - High friction, low speed, worse on small scales
  - E.g. Grainger, Caterpillar: cat.com
- Pneumatics:
  - Relatively high force, power, speed, density
  - Low bandwidth, high friction, worse on small scales
  - E.g. Grainger, Numatics Inc.: numatics.com

Common Electromechanical Sensors

- Digital vs. Analog:
  - noise, resolution, integration
- Optical encoders (digital): resolution, f_{sample}
- Hall-effect sensors (analog): linearity, $\Delta\theta_{max}$
- Potentiometers (analog): R, friction, $\Delta\theta_{max}$
- Load cells (analog): F_{max}, resolution, f_{sample}
- Switches (digital): displacement, force, bounce
- Inertial Measurement Units (IMUs): res., drift
- Proximity, sound, temperature, light, etc.

Common Control Components

- Microcontrollers:
  - Fairly low cost, energy use, performance varies
  - Wide range of specializations
    - Quadrature decoding
    - PWM motor control
    - Numerically-intensive calculation
    - Analog ins/outs
  - Some common suppliers:
    - sparkfun.com, gumstix.com, tern.com
- Professional control systems:
  - Higher performance, cost, difficultly of use
  - For example: DSpace, PC104, motor controllers

Manufacturing and Cost Analysis

- Complex dependence on many factors:
  - Manufacturing methods
    - Materials
    - Tolerances
    - Quality and expected failure rate
  - Quantity of parts to be made
    - Fixed and variable costs
- Entire domain in Mechanical Engineering
  - Design for Manufacture (DFM)
  - Engineering Design II
  - Integrated Product Development (IPD)

Manufacturing and Cost Analysis

- Not my area of specialization…
  - First year teaching this course, etc.
  - Others have said it better…
- Required reading:
  - Dieter & Schmidt Ch. 13 - Design for Manufacturing
  - Dieter & Schmidt Ch. 16 - Cost Analysis
  - Available on course website
- Wednesday:
  - Manufacturing and cost highlights
  - Tabular and online tools for cost analysis