**Accelerometer based localization for distributed off-the-shelf robots (Cots-Bots)**

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### Hardware/software setup

- **Custom accelerometer boards:**
  1. 1st Order low-pass filter with pole freq. 500Hz.  
  2. 1st Order low-pass filter pole freq. 15Hz.  
  - Acceleration data were sampled at 50Hz using the Atmega8L ADC on mica mote.  
  - Tradeoff: Higher pole freq. on the hardware permits more resolvable detail at the cost of SNR and processing cost.

- **Cots-bots:**
  1. A mote will read the accelerometer, accumulate 10 readings, and send results wirelessly to a computer.  
  2. A separate driver-mote is used to drive the robot semi-autonomously to minimize packet transmission.  
  3. A large board is mounted on the vehicle for positional acquisition by sonar. (This will be used to check the accuracy of localization system.)

- **Software:**
  1. A custom java program is used to control the robot wirelessly.  
  2. A separate program is used to collect data and write them to disk in matlab readable form.  
  3. Matlab is used to do all the analysis and digital filtering.  

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### Accelerometer data analysis pass 1

#### Hardware in use:
Custom accelerometer board with max sampling frequency limited by 1st order analog low-pass filter of pole frequency 15Hz.

#### Reasons for using this hardware:
Higher max sampling frequency will allow the mote to resolve higher-frequency acceleration signals without using more power for the accelerometer board. Higher resolution means the mote can acquire more acceleration data to compute its position.

#### Vibration analysis:
Vibration is proportional to speed in a non-linear fashion. The spikes seen in the frequency distribution around 12kHz is the result of high frequency gear noise aliasing down from 110 Hz. Connector noise from the 51-pin connector will start showing up as soon as the vehicle speed goes above 40cm/s (not shown in this graph). The spikes can show erroneous accelerations as high as 2G, which is huge compared to a nominal acceleration of 0.08G.

#### Results:
- Significant noise from the mechanical gear is comparable in magnitude compared to signal of interest, resulting in very poor signal to noise ratio of approx 2:1 at 10cm/s, and 1:1 at 40cm/s. (Typical acceleration is about 0.08G)  
- Gear noise is fairly predictable as a function of speed. However, at higher speeds, its frequency distribution will begin to spread, which makes it difficult to filter.  
- Gear noise is less predictable at high speeds.

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### Accelerometer data analysis pass 2

#### Hardware in use:
Custom accelerometer board with max sampling frequency limited by 1st order analog low-pass filter of pole frequency 15Hz.

#### Reasons for using this hardware:
Low analog low-pass filters will prevent high-frequency, high magnitude gear noise from aliasing down to interfere with signals of interest while being able to maintain low sampling rates.

#### Low freq. accelerometer data:
- Unlike digital filters, analog low-pass filters will prevent high-frequency, high magnitude gear noise from aliasing down to interfere with signals of interest.  
  - Empirical observation of the FT shows that most of the useful data lies within 1Hz of the observed acceleration, (large amplitude)  
  - When connector and gear noise are filtered out. Typical (useful) acceleration is extremely low. Peaking at 0.08G at its best. Code skipping on the ADC becomes a significant problem.

#### Unfiltered accelerometer integrated for displacement:
The integrated acceleration produced velocity as well as displacement information. Notice the acceleration was cleaner than those of pass 1 due to the lower analog low pass filter. (oscillating in 30cm block @ 2 Hz)

#### Filtered accelerometer integrated for displacement:
66th order low pass filter implemented in direct form transpose II

#### Results:
- The drift and noise contributed to unacceptable results. Total drift in 30 seconds @ 10m, in addition, relative position was not characterized accurately primarily because the useful signals were unexpectedly weak. Much higher gain in addition to drift compensation will be required to obtain better positional information.  
  - Despite the fact that filtering reduces visible high-frequency noise in measured acceleration significantly, it has very little impact on the displacement obtained.