Sensor Fusion for Estimating Position of a Legged Robotic Soccer Player

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Dr. Jim Ostrowski, Advisor
• Cooperative robots playing soccer
• Legged Robot League
  • Sony Dogs
Problem: Sensors

- Accelerometers and Gyros
- Audio Communication
  - speaker
  - microphone
Frequency Analysis

- Discrete Fourier Transform (DFT) and Fast Fourier Transform
More Frequency Analysis

- Quadrature Detection

\[
\left( \sum_{k=0}^{N} \sin(\omega kT) * f(kT) \right)^2 + \left( \sum_{k=0}^{N} \cos(\omega kT) * f(kT) \right)^2 \right) / N
\]

<table>
<thead>
<tr>
<th>N = number of samples</th>
<th>g(t)</th>
<th>g(t) * sin (\hat{u}t)</th>
<th>g(t) * cos (\hat{u}t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \hat{u} = 2\Delta f )</td>
<td>( \sin (\hat{u}t) )</td>
<td>( a(t) )</td>
<td>0</td>
</tr>
<tr>
<td>( f = ) desired frequency</td>
<td>( \cos (\hat{u}t) )</td>
<td>0</td>
<td>( b(t) )</td>
</tr>
<tr>
<td>( fs = ) sampling frequency</td>
<td>( \sin (\hat{u}t + \varphi) )</td>
<td>( c*a(t) )</td>
<td>( d*b(t) )</td>
</tr>
<tr>
<td>( T = 1/ fs )</td>
<td></td>
<td></td>
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</tbody>
</table>
Sound

• Examples from Sony
  • playing wave and midi files
  • recording sounds

• Producing tones
  • finding out how sound is produced
  • creating the data needed for the speaker

• Detecting tones
  • noise
  • range
Strategy

- Morse code
- Single frequencies
- Message passing via binary numbers
  - 1 000
  - 1 001
  - 1 010
  - 0 xxx
Implementation

- Quadrature detection with 64 samples
- Choosing frequencies
- Determining thresholds
Determining Thresholds
Results

• Software modules
  • producing tones
  • identifying tones

• RoboCup Competition!
Future Work

- Determining thresholds
- Timing issues with hearing and playing tones
- More messages
  - increase the number of bits
  - no carrier frequency
Gyros

- Testing rotation
Accelerometers

- Acceleration, velocity, and distance traveled
Solution

- Implement existing sensor software
- Create and perform experiments to test sensors
  - collect data
  - calibrate sensors
- Data Analysis
- Aperios - Sony’s Object Oriented Operating System