Surface Discernment by Legged Robots Using Spectral Analysis of Leg Actuator Motion

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Surface Discernment

- The ability to detect and classify the relevant qualities of a surface.
  - Surface Hardness
  - Surface Friction
  - Slope
  - Irregularities/Obstacles
  - etc.

Surface Discernment by the AIBO

- No single gait (walking style) works well over a range of surface types
- In order for the AIBO to be capable of autonomous traversal over a range of surface types, it must be able to detect these changes and account for them.

The Challenges

- Limitations on the sensors available
- Process noise
- Measurement noise
- Time consuming to collect data
- Biological plausibility

Welcome to the Real World

Sensor Data Collected on Two Different Surface Types
Sensor Data Collected on Two Identical Surface Types

Data Collection
- 5 Surface types were considered:
  - Plywood
  - Short carpet
  - 2 Varieties of shag carpet
  - AIBO suspended in mid-air (no surface)
- 20 15-second realizations were collected for each surface type

The Methodology
- Generate a single smoothed periodogram for each surface type using the Welch-Bartlett approach.
- Find an appropriate balance between the bias-variance tradeoff for the desired feature extraction.
- Calculate the confidence intervals in order to determine the statistical significance of the results.

Magnified Periodograms for Plywood Surface Data

Smoothed Periodograms for All 5 Surfaces
Conclusions

- A frequency domain analysis of the leg actuator motion contains enough information for autonomous surface discernment.
- This approach is not well suited to real-time surface discernment due to the excessive variance of the periodogram for short sample lengths.
- This was the first examination of the information content of the available sensor data. There is much more data available for the discernment process than was used in this experiment.