

Tactile Terrain Classification Technique for Legged Robots

Jacob Shill, Eric Coyle, Emmanuel Collins, and Jonathan Clark

Department of Mechanical Engineering, FAMU & FSU College of Engineering, Tallahassee, FL, USA

Department of Aeronautical and Mechanical Engineering, Embry-Riddle Aeron University, Daytona Beach, FL, USA

Motivation

Animals vary their gaits according to the terrain they are traversing to both increase their stability and minimize energy consumption. We propose to endow legged robots with the ability to proprioceptively classify terrain as a mechanism to trigger optimal leg gaits.

Experimental Setup

I-Scan® Pressure Sensor



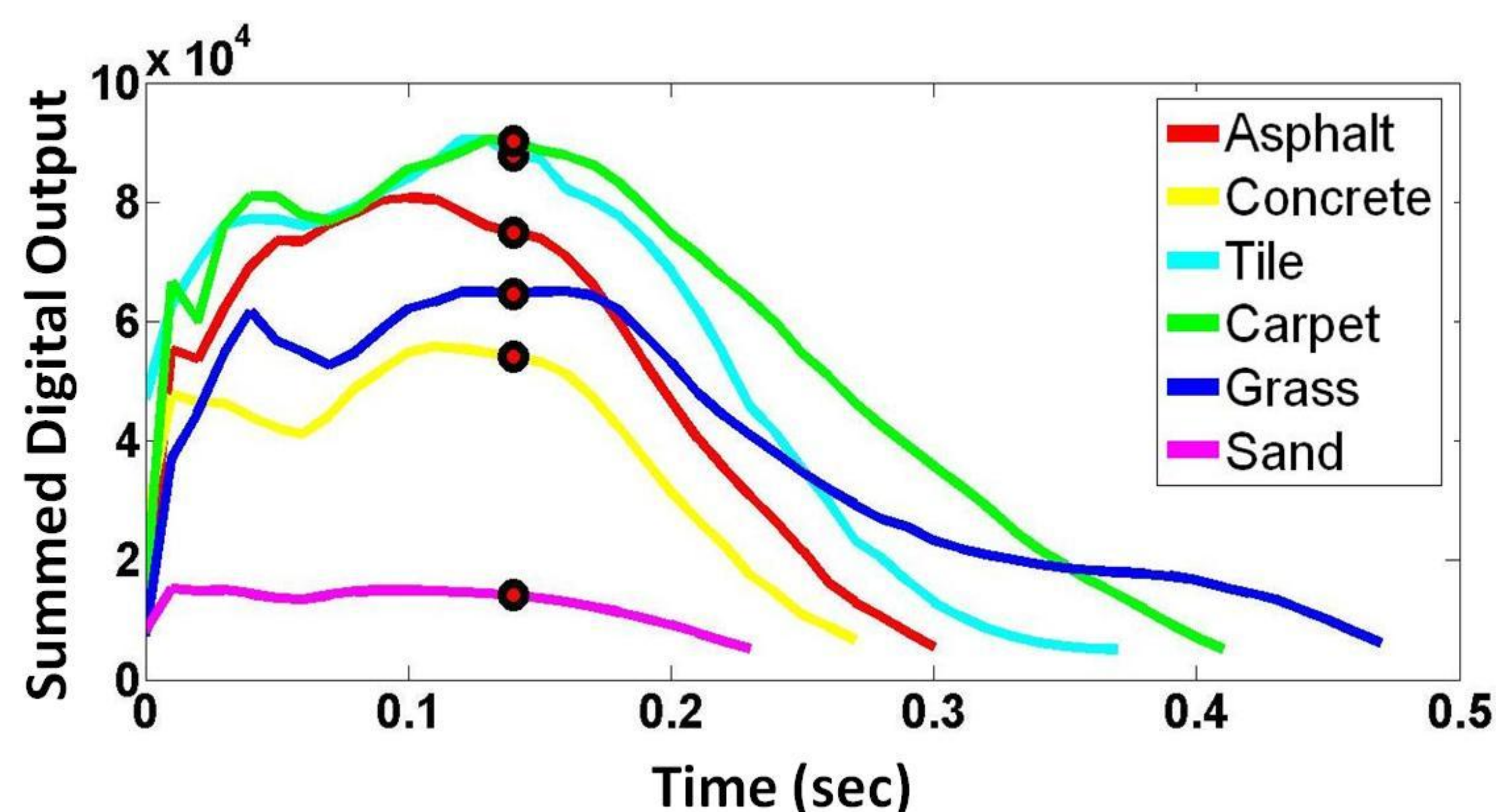
- Consist of 1936 individual piezoresistive pressure sensors array in a 44 x 44 matrix.
- 56 mm x 56 mm sensing area, and a 100 Hz recording rate.

Sensor on Hopper and Human Leg



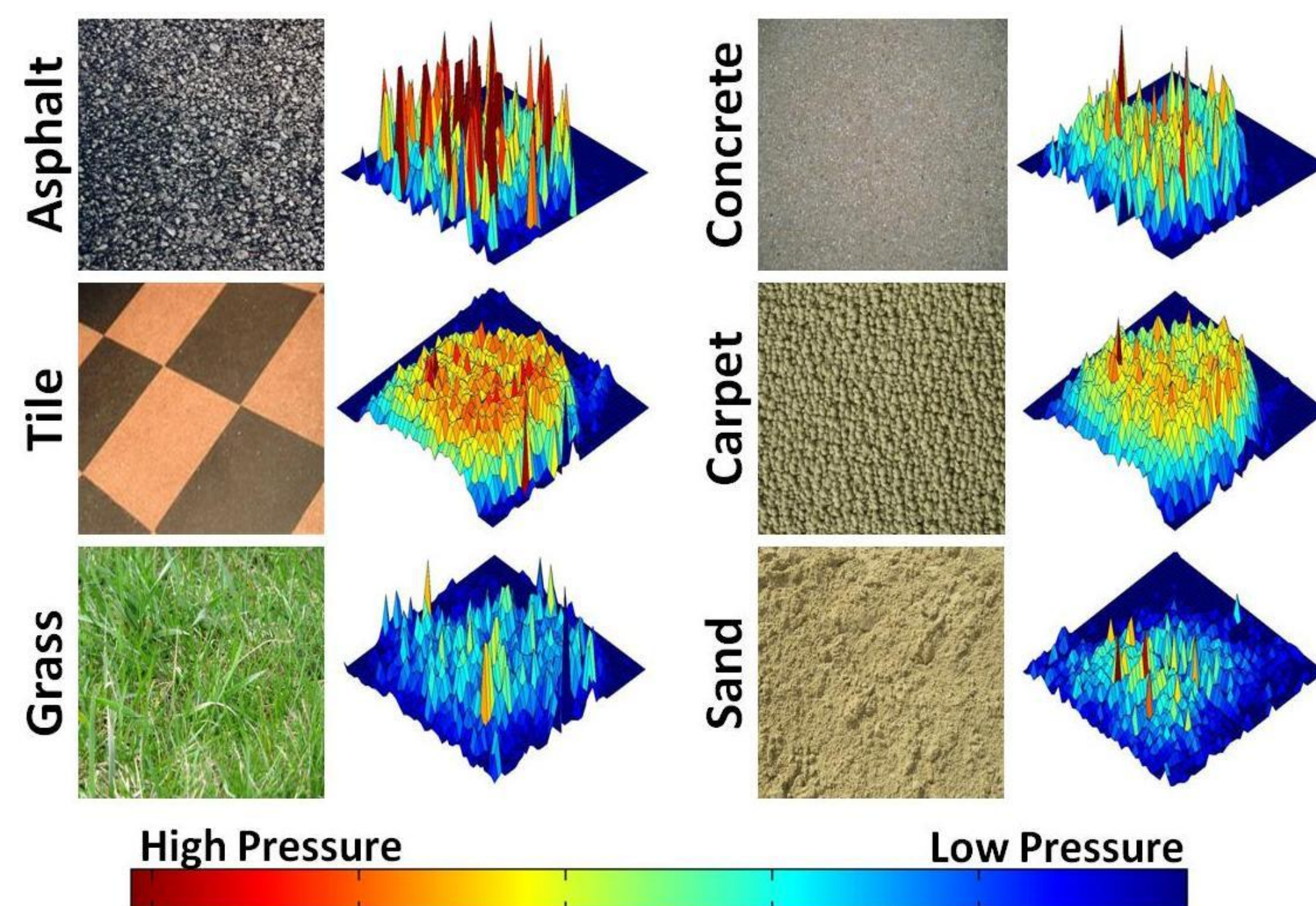
- A human foot is used to gather data on terrains prior to implementation on a one-legged hopping robot.
- Recorded data on six different terrains.
- Recorded 100 samples on each terrain.
- Experiments repeated for three walking speeds

Characteristic Step Profiles



- The initial spike in pressure caused by the impact of the foot.
 - This pressure spike is absorbed by tissue in the foot
- Data for classification was extracted 0.15 seconds after impact

Pressure Distributions



- Each pressure distribution is an 8-bit image.
- Clear distinction between terrain pressure distributions.

Classification Method

- Feature vectors for classification are calculated by taking the magnitude of the one-dimensional Fourier transform of the pressure distribution image.
- 240 feature vectors from each terrain and speed are used to train a Parzen Windows Estimation classification algorithm.
- The remaining 60 feature vectors from each terrain and speed are used to test the accuracy of the trained algorithm.

Classification Results

		Trained					
		Asphalt	Concrete	Tile	Carpet	Grass	Sand
Tested	Asphalt	98.3 %	1.7 %				1.7 %
	Concrete	1.7 %	98.3 %				
	Tile			100 %	1.7 %		
	Carpet				98.3 %		
	Grass					100 %	
	Sand						98.3 %

- Overall classification accuracy is 98.89%.
- High classification accuracy suggests this technique maybe viable for an actual robot.
- We experimented with other features (the magnitude of a two-dimensional Fourier transform and texture attributes) and classification algorithms (Maximum Likelihood Estimation and Support Vector Machines Estimation). High classification accuracies were also obtained with these methods

Ongoing Work

Work has already started on implementing this sensor on a one-legged hopping robot. Initial experiments show similar classification accuracies as those obtained on with a human leg. Our current goals are real-time terrain classification and gait adaptation for different terrains.