Development of a Measure While Drilling System

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This presentation describes the results a series of experiments surrounding the development of a measure while drilling (MWD) system for planetary drills. The measure while drilling system is designed to interface with a rover-based auger or drill capable of acquiring and transferring intact subsurface samples. The end objective of the system is to transform the planetary drill from a tool to an instrument capable of estimating substrate type and moisture content. The information collected during the drilling process can be used to complement the other data collected from processing samples and other measurements taking place on a rover mission.

For the experimental investigation, the instrumented parameters included: thrust, drill rate of penetration, drill rotation speed, drill motor current, thrust motor current, mechanical vibration and acoustic emission (AE). The features used for classification included statistical and auto regressive features under a range of segmentation ranges. A range data acquisition sample rates were tested to simulate different processor capabilities on the rover control system. Two approaches to training and operation of the system were tested and compared: supervised classification and novelty detection (one class classification approaches.

Before resorting to advanced and more computationally intensive methods of signal processing or high dimensional feature extraction and classification for MWD, the work first investigated the basic response and relationships of the control parameters (rotation motor current, measured rate of penetration and measured thrust) to the varied levels of moisture content and substrate types in the unconsolidated material. This portion of the work concluded that MWD is a non-trivial classification problem. If the drill data is to be classified, it will require the use of additional parameters, features and multi-dimensional classification tools. The computational task of substrate identification for MWD amounts to a task of pattern recognition. The tasks associated with pattern classification are commonly referred to as segmentation, signal processing, feature extraction, and classification.

Two rounds of testing were conducted. From the first round of testing, which involving a supervised training approach, it was concluded that with reasonable accuracy, the MWD system was capable of differentiating between various ranges of moisture contents of unconsolidated material and identify types of rock. However, a major limitation of this approach was that it would require prior training of the drill in simulated conditions prior to the mission. The second round of testing employed the novelty detection approach and assumed that there was no data available for training in advance of the mission. This type of classification involves an in-situ

training scenario where the MWD system learns to recognize previously encountered substrates during the mission. This round resulted in excellent classification results. However, the capability of MWD would be limited to the data generated by processing, analyzing samples and confirming substrates during the mission. The system would get smarter as it processed more samples.