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THE DRILL OF THE ROSALIND FRANKLIN ROVER AS A SCIENCE INSTRUMENT TO CHARACTERIZE THE MARTIAN SUBSURFACE

Abstract

Rosalind Franklin, set to be launched in 2028, will be the first Mars rover capable of reaching a depth of 2 m with its drill. The drill is designed to collect subsurface (or surface) samples and deliver them to a suite of analytical instruments that will characterize them and look for the presence of possible biomarkers [1]. In addition to sample-studying instruments, the rover will also provide context information about the shallow subsurface environment the sample is taken from. The subsurface-characterizing instruments include CLUPI, a close-up imager, WISDOM, a ground-penetrating radar, and Ma_MISS, a miniaturized reflectance spectrometer embedded in the drill tip. Ma_MISS will perform spectral measurements on

the wall of the just-drilled borehole, providing information about the mineralogy and stratigraphy of the drilling site [2].

To improve and extend the characterization of the subsurface environment, the rover instruments' measurements can be complemented with information about the mechanical properties of the rocks and soil the drill bores through. While there is no dedicated instrument for directly assessing mechanical properties, the drill itself can be used for this purpose: useful information can be retrieved from drill telemetry data using suitable analysis techniques.

We are thus devising methods to extract science information about the mechanical properties of the Martian subsurface from drill telemetry data. The techniques we are developing include a combination of feature engineering and various machine learning algorithms. For example, some unsupervised clustering algorithms are proving effective at telling apart stratigraphy layers with different properties, without requiring any *a-priori* knowledge. We have also developed a supervised classification model based on a 1D Convolutional Neural Network trained on data coming from drilling tests performed with the rover's GTM (Ground Test Model). This classifier achieves very high accuracy on the GTM dataset (98% classification accuracy on the test set), but more drilling tests and larger datasets are needed to extend it and assess its performance on broader classification tasks.

We are also developing an instrumented laboratory drill to start accumulating more data quickly and independently from the GTM test schedule. The dataset this drill will provide will aid the development and validation of improved data analysis techniques, that could then be adapted to the rover's drill system.

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References: [**1**] Vago et al. (2017) Astrobiology 17,471. [**2**] De Sanctis et al. (2022) PSJ 3:142.