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SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Poster Session (P)

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AUTONOMOUS VISUAL ROCK CLASSIFICATION SYSTEM FOR FUTURE PLANETARY EXPLORATION MISSIONS

Abstract

The high cost of planetary rover missions limit risk-taking and as a result restrict scientific explorations. Currently, Mars rover missions invoke a three to four day command cycle, which imposes significant delays to their scientific productivity.

This paper offers a robust and cost effective solution where the exploration rover can perform sample return missions with little to no human intervention. The proposed autonomous visual rock classifier collects textural information from the surface of rock samples. Thirty hand-sample rocks were utilized for this study. To ensure that the autonomous system covers a broad range of samples, only some of the thirty rocks have already been detected on Mars: andesite, basalt, conglomerate, komatiite, and limestone. Moreover, to warrant a robust classifier, six sample images from each rock was collected and an average of their textural information was computed. The inputs are black and white images of samples taken under controlled environment (i.e. fixed lighting). To ensure a directionally insensitive system, the classifier first applies a Gray Level Co-occurrence Matrix (GLCM) to the input images. Following the second-order textural extraction, Haralick parameters (1973) are used to obtain information about the rocks' textural patterns. Due to limited computational resources available onboard the planetary exploration rovers, only seven of the popular Haralick parameters were used: angular second moment, contrast, correlation, inverse difference moment, entropy, sum average, and sum of squares. These selected parameters offer relatively computational simplicity in comparison to the others. The extracted features are compared against 180 catalogued sample points of pre-processed rocks. Based on its former exposures, the system uses Bayes' theorem to evaluate the statistical probability of classifying each sample. The autonomous system has illustrated a classification accuracy of 80%.

The unique system is ideal for exploration missions when it is too costly and dangerous to send humans to the hazardous environment. This work implements preliminary steps toward an autonomous geologist system for the next generation of Mars exploration rovers. The robotic geologist can autonomously scout its surroundings and analyze the sample, allowing the scientists and the crew to focus on more complex studies.