EXPLORING CNN BASED ANOMALY DETECTION FOR ROBOTIC MARS EXPLORATION MISSIONS

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ABSTRACT

Bandwidth limitations do not allow the downstream of all the data stemming from the rovers' perception systems. Therefore, a posteriori, offline, analysis of all the sensors output is infeasible. In this context, Autonomous Science [1] can be used to determine the data that are most probable to contain significant/abnormal information and should be prioritized for Earth downstream and further expert analysis. The Novelty or Anomaly Hunter (NOAH) activity constitutes the evolution of MASTER activity (both led by Scisys) and aims to provide a system that can automate the accurate selection of those information-rich data. In this paper we present the exploration of Convolutional Neural Networks (CNN) in the context of the NOAH activity.

A visual anomaly detection algorithm typically incorporates two modules, namely the Region Of Interest (ROI) detection and the ROI characterization. During the first module, salient image regions are identified containing semantically distinctive entities, while the second one refers to the characterization of the detected ROIs as "novel" (unable of being classified) or "known" (capable of being classified into one of the pre-trained classes). Within the scope of MASTER activity, the above modules were performed by two discrete and subsequent steps. Though, here, we are interested in investigating a unified solution that treats the ROI detection and characterization functionalities as a single task using the classification properties of the FCN [2] algorithm.

Our goal is to use the FCN algorithm in order to segment the images based on a set of pre-trained classes (e.g. rocks, outcrops, etc). Then, looking into the output of the last CNN layer, we are able to extract useful information regarding each entity's classification certainty. The ROIs for which a clearly higher probability is found only for a single class can be treated as "known", while the rest will be characterized as "novel" since the respective classification results are equivocal.

We decide to use real and representative datasets for the evaluation of our system. The first part contains actual Mars images form the MER rovers, while the second one consists of images collected through several ESA funded expeditions on Earth Mars-like areas. The above sets were distinguished into three sub-sets, viz. *training*, *crosvalidation* and *testing*, containing 60%, 20% and 20% of the images, respectively. Finally, the training were performed using the Digits Library, provided by nVidia.

In this paper we will present the late breaking results concerning the aforementioned CNN approaches in the context of the NOAH activity.

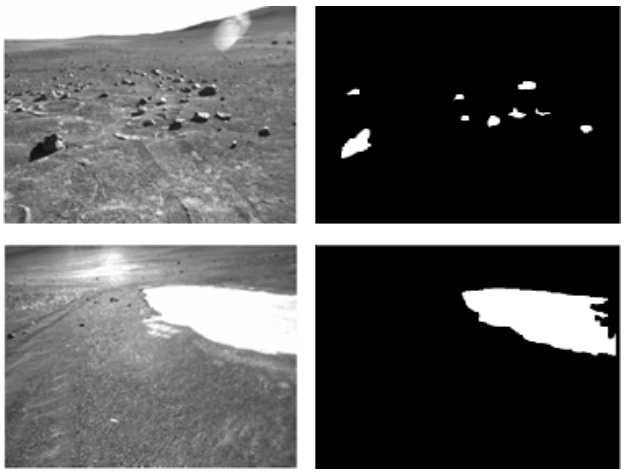

Figure 1. Sample masks of image features

Key words: Anomaly detection; Mars Rover imagery; Convolutional Neural Network.

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