Computer Vision in Space

Building maintenance by detection of cracks in a 3D printed concrete structure on Mars

Group #1 Report

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Introduction

Thanks to the efforts of multiple space agencies all over the World, the possibility of creating extraterrestrial habitats is slowly moving towards reality, first on the Moon as a test and then on the Red Planet - Mars. This enormous challenge will require experts from various branches of the Built Environment to get involved. The project, unlike on Earth, will require planning not only for the design and construction phase but also for safe and efficient maintenance predominantly for two reasons. Firstly, the conditions on Mars are unlivable due to a much weaker atmosphere with little oxygen, deadly solar and cosmic radiation, and temperature swings reaching down to negative 143 degrees Celsius. Therefore, the consequences of a structural failure on Mars are incomparably more deadly than on Earth. Secondly, the missions can take on a limited number of people with skill sets focused on researching the newly inhabited planet. Thus, employing the existing solution of certified structural inspectors is not viable in this context. There is a need for a specialised control system that will provide constant and thorough monitoring with little involvement from the mission's crew.

Problem setting

Currently, one of the most widely considered construction technologies for building on Mars is 3D printing with concrete made out of Martian dust. This project aims to provide a solution for a specialised control system which monitors surface and detects cracks in a 3D printed concrete building envelope modelling the desired behaviour on Mars with Martian regolith concrete. To achieve this goal the project is going to implement computer vision. The inputs consist of images and/or video footage (this still needs to be specified, do we use image or video or both) and the output is information about the appearance of a crack.

Hypothesis / expectation

The research question can be phrased as "How can cracks in 3D printed concrete structure be detected using computer vision?". The expected outcome of this study is a AI computer vision model which detects cracks when provided with images and/or video footage of cracks in a 3D printed concrete structure.

Further developments could consist of: outputting information regarding the size and number of detected cracks, assessment of danger posed on the structure by the crack, or a 3D model of the structure with marked exact location of the detected crack. (this could be further discussed in a meeting, maybe we manage to include one of these ideas too)

Methodology

Describe what you will do to answer the research question, describe how it was done, justify the experimental design, and explain how the results are / will be analysed. Specifically focus on the following four topics:

Model

Emphasise here on the model that you will use. What model suits your CV problem statement (classification, detection, generation)? Are there any related works that solve a similar problem?

Data

Describe the input and output data here, whether it is synthetic, whether it is partly from an already existing database, etc. What data do you need to train and/or evaluate your model? Does it need to be pre-processed? Are there other relatable data sources, or similar domains? What is the format of the input and output to be fed in and come out the model? Add figures of the data to make it more tangible.

Toolboxes and code

Specify the toolboxes and code that you used, and whether you used / will use already existing code bases. Make sure to include a python notebook and python files (if needed) as attachment to the report.

Experiments to conduct

List here the experiments you conduct. What parameters will you evaluate? What will be your experimental setup? Do not overdo the experiments. Better one done properly rather than a lot and done sporadically.

Results and discussion

Present concisely what you found when you conducted your analyses. Include limitations of your work and compare (if possible) with other sources. Make sure to have a couple of concluding sentences of your project.

References and Appendix

If you made use of references, put them at the end of text. If you have too many results or arguments that would clutter the main text, make sure to include them in the Appendix.

Deadline for the full report is the same as the whole design project.