**“Justification of the use of CCSDS 122.0-B-2 Compression Standard in Space Missions over other Compression Methods through the assessment of Image Quality”**

CS39440 Major Project

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Abstract

Include an abstract for your project. This should be approximately 300 words.

The abstract is an overview of the work you have done. Highlight the purpose of the work and the key outcomes of the work.

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# **Background, Analysis & Process**

## **Background**

The European Space Agency (ESA) will soon launch the second part of their ExoMars mission. Rosalind Franklin is the rover that shall travel to the surface of Mars with the goal of attempting to establish if there is or ever has been life on Mars.

One of the rovers many instruments is PanCam, a camera system tasked with capturing how the planet looks and preparing these images to be sent back to Earth. Part of this preparation is the compression of the images to reduce their storage space and allow for a more streamlined and hopefully less error prone transfer back to Earth. The ESA has chosen to use the CCSDS 122.0-B-2 compression standard, the purpose of this report is to establish a justification for this, and reasons why other compression methods such as JPEG 2000 (J2K) are not used. This is done through the encoding of sample images taken from the Aberystwyth University PanCam Emulator (AUPE), through both compression algorithms, after which the results are compared against each other.

A sensible approach to begin seemed to be to conduct some preliminary research into image compression. This included not only image compression algorithms used in a variety of disciplines including medicine, graphic design, and military applications, but also, the theory behind image compression, i.e., lossy versus lossless compression, techniques used in image compression, including - but not limited to; quantization, discrete cosine transform (DCT), fractal compression – and performance comparisons of some compression algorithms.

The goal of this was to try and establish what sort of numerical operations these algorithms were performing, and through this, trying to build an understanding of how the quality assessment algorithms - that would be used as part of the overall analysis of the compression algorithms - might begin to calculate numerical quality in a general sense. This was very useful for understanding metrics such as Mean Square Error (MSE), Root Mean Square Error (RMSE), and Peak Signal to Noise Ratio (PSNR).

During this preliminary research, a grouping system of image quality assessment (IQA) methods was identified. Methods are grouped into Full Reference (FR), Reduced Reference (RR), and No Reference (NR) IQA methods. They refer to if a ‘perfect’ quality - original image is used as a reference as part of the algorithm to compare to the compressed version. For this project, FR seemed the most appropriate since there *are* original images to be accessed and so if the more comprehensive algorithms can be exercised as part of testing of PanCam and as part of this project, the greater assurance we can have as to our understanding of the level of compression and quality of the images being sent back by Rosalind Franklin.

One motivation for this project was having the opportunity to produce something that could potentially have real world implications towards the operational effectiveness of the European Space Agencies (ESA) Rosalind Franklin rover. Moreover, developing a tailored script (written in Python) that’s sole purpose is to facilitate the gathering, processing, and analysis of the numerical aspects of IQA algorithms.

## **Analysis**

The projects focus is on IQA algorithms. To that end, regardless of the direction of the project, these algorithms would have to play a significant role in any conclusions or findings. This led to the belief that a comparative study was the best approach, since the result that objective IQA algorithms provide are numerical values, for the quality of images. This leaves great scope for statistical analysis.

With this in mind, the logical progression was to compare the already selected compression algorithm with another - that was not selected to be a part of PanCam - to try and establish the reasons that the aforementioned algorithm was chosen over the other. This led to the construction of the overall research question for this project:

**Given the quality of compressed images, what reasons are there for the use of the CCSDS 122.0-B-2 compression standard on PanCam, and why are other image compression algorithms not used in the context of interplanetary communication?**

This in turn lead to more specific questions regarding the technicalities of the project and its process, such as; Which IQA algorithms would be best suited to a project of this nature? What sort of analysis and statistical metrics should be applied to any collected data? What would be the best method to approach this question?

The chosen research question also has the advantage of leaving the door open for further research or variations of this project, for instance, delving further into the question of which IQA algorithms are most suitable as metrics for assessing image quality in the context of space mission or conducting the same or similar research with other possibly more advanced image compression algorithms other than J2K.

## **Process**

This project is a comparison using objective measures. Mathematical processes conducted by the computer and then interpreted by the user. Due to this fact, the data collected was always going to Quantitative data. A positivism-based [1] research project, collecting primary data for processing and to develop conclusions from.

An inductive process, aiming to answer the overall research question first proposed at the beginning of the project. Moreover, the process may be described as exploratory given that the compression algorithm has already been decided upon for the rover, and that trying to produce a conclusive set of results would be beyond the scope of this project.[2] These are very blanket terms that best describe a process that was dynamic and constantly changing based on complications encountered at various stages and the capricious availability of pre-existing libraries and/or implementations of IQA algorithms.

Finally, regarding the production of a technical submission. The project was research focused and so, a technical submission was not going to be of the same nature or standard of complexity as the likes of a project involving the development of some bespoke software, because of this, following an Agile Development approach was challenging. Nonetheless, a SCRUM approach was loosely adopted and maintained over the lifecycle of the project, with a ‘sprint’ being a weeklong, and the planning for said sprint being conducted at the end of the previous sprint.

# **References**

1. Clark, A.M. (1998), The qualitative-quantitative debate: moving from positivism and confrontation to post-positivism and reconciliation. Journal of Advanced Nursing, 27: 1242-1249. <https://doi.org/10.1046/j.1365-2648.1998.00651.x>
2. Business Research Methodologies <https://research-methodology.net/research-methods/> accessed 20/04/2022