Problem 1 : Orders of magnitude ...

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20 octobre 2022

1 Statement

The International University Space Center (IUSC) has launched an unprecedented university level space mission, aiming at finding the best landing sites for the next Mars plate-form. To this end, a lander-rover pair needs to be designed in order to send images from the surface of Mars to the ground stations, via an orbiter which will be placed in orbit around Mars.

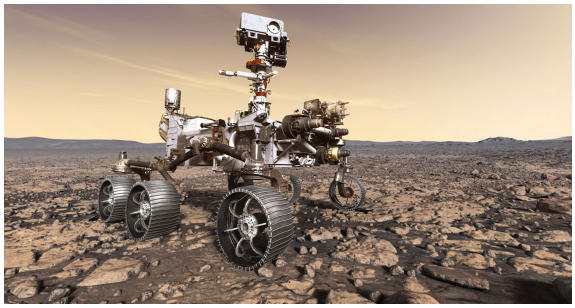


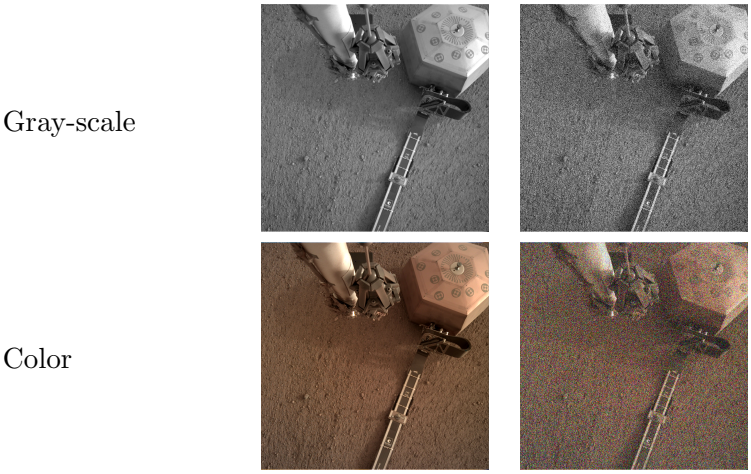
FIGURE 1 – Source : https ://www.mq.edu.au/t

The mission involves universities from all over the world, each responsible for the deployment of a part of the mission. Your university has been selected as a responsible for the *Information Engineering* part of the space mission. As such, your university, and more specifically the Department of Electrical Engineering (DEOS), will lead the deployment of the image compression part, the communication chain and the cryptography packages. To this end, each work package for information engineering will be assigned to a group of preferably 5 to 6 students and from distinct academic backgrounds.

Prior to the selection of the group of students which will be working on each of the work packages, a pre-screening phase will be carried out based on whether the students have all the prerequisites for information engineering, an more specifically, a satisfying academic level in probability theory and its applications to information theory.

To this end, the following problem is submitted to all students for investigation.

The present space missions is particularly interested in images of Mars. A previous implication of your university in the *InSight* mission allows them to have previous samples of images to help with the information engineering specification.



Based on these samples, the department seeks rough orders of magnitude of :

- The best theoretic compression ratio (in bits/pixel) which could be achieved by a lossless image compression scheme. Lossless compression is key to maintaining all information contained in the image alike in Figure 2 (a).
- The maximum bit rate (in bits/sec) which could be transmitted through the rover-orbiter-DSN (Deep Space Network) channel of bandwidth $B = 500Hz$. This communication channel is impacted with an additive noise, as shown in Figure 2 (b).

Using the set of figures given to you, and resorting to the notions of entropy and mutual information, answer the two previous.

You will need to prepare a few slides to present your work, emphasizing the methodology you used to solve the problem from theory to numerical derivations.

2 References

For this problem, you can rely (not exclusively) on the following references

- Information theory textbook (webpage of the course)
- Probabilities lectures and textbook (webpage of the course)
- Problem Based Learning : Learners guidelines (webpage of the course)

3 Working material

- A set of 8-bit grayscale images (cf webpage of the course)
- A set of RGB colored images (cf webpage of the course)
- A set of 8-bit grayscale and colored noisy images (cf webpage of the course)