Design of a real-time compression and transmission system of hyperspectral images taken from unmanned flight platforms

Adán Jiménez Delgado
Institute for Applied Microelectronics (IUMA)
Universidad de Las Palmas de Gran Canaria (ULPGC)
Las Palmas de Gran Canaria, Spain
ajimenez@iuma.ulpgc.es

***Abstract*— Remote sensing has been an increasing area of interest for the research community in the last decades. It brings the possibility of studying objects from the distance, which provides a lot of benefits as a non-invasive action. In particular, this Master Thesis has been oriented to resolve two existing problems around this area of interest. Firstly, the real-time transmission of the hyperspectral information collected by the aerial observation platforms to the ground segment has been addressed. It permits to send the spectral data as soon as they are sensed in order to be analyzed before the flight mission is completed. However, this possibility cannot be realized without addressing the issue around data compression, a critical factor that allows, once the information is captured, to reduce the size of the data to be managed and thereby, to fulfill the requirements imposed by the restrictive bandwidth of the downlink systems.**
Keywords – remote sensing, UAV, image compression, data transmission, hyperspectral technology

I. INTRODUCTION

Hyperspectral images represent an area of great scientific interest, this kind of pictures differs from a classic RGB snapshot in that it contains many more wavelengths (from tens to hundreds), allowing a deeper understanding of the object under study for the purpose of applying classification, target detection algorithms, etc. Currently, IUMA has a UAV which carries a hyperspectral camera, used for capturing hyperspectral data during its flights [1].

Sometimes these results are not satisfactory, a fact that is verified once the data is downloaded to the laboratory and that involves repeating the flight tests previously performed, with the consumption of time and resources that this entails. Thus, it seeks to try to solve this problem. First, it is planned to design a transmission infrastructure composed of a rotary antenna system that points to the in-flight drone, establishing a communications link that allows the information to be downloaded as captured.

However, the data rate generated by flight missions is very high, around 350-500 Mbps. This fact makes it difficult to send data in a real time constraint, so a lossy compression system is also proposed, which allows to reduce this amount of information so that shipment with a lower bandwidth can be done and project requirements are met.

II. COMPRESSION SYSTEM

A. HyperLCA compression algorithm

IUMA researchers have developed the Hyperspectral Lossy Compression Algorithm (HyperLCA) which is characterized by high compression rates, good performance and a reduced compression load [2][4]. In addition, it provides the possibility to process independent hyperspectral pixel blocks, without the need for spatial redundancy between them. In this way, it becomes the algorithm that best meets the needs set out above.

This algorithm is based on endmember extraction techniques, also defined as pixels that enhance the rest present in the analyzed image. For extraction, the HyperLCA algorithm employs orthogonal projection techniques based on Gram-Schmidt's famous mathematical method. In particular, this algorithm consists mainly of four stages of processing, as shown in Figure 1. This compression algorithm is based on transformation, since this stage is the one that mostly introduces losses.

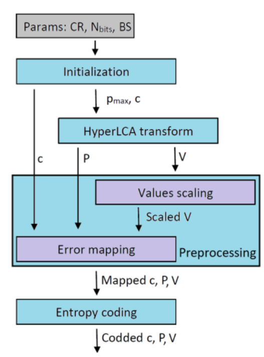

Fig. 1. Stages of HyperLCA compressor

B. Adaptation of the compression algorithm to the current capture system

The implementation of this algorithm has been divided into two stages, the first composed of transforming and scaling the V vectors, which is performed on GPU, and another composed of Error Mapping and Entropy Coding, executed on the CPU [3]. Thus, the architecture shown in

Figure 2 has been adapted to the current platform way of working.

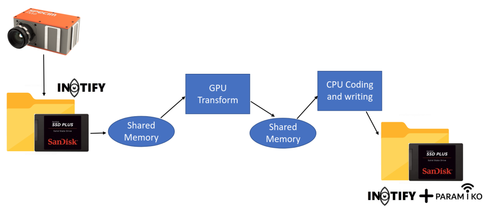

Fig. 2. Arquitectura general del sistema de compresión

The operation is as follows: it captures a hyperspectral frame, saves it to disk, communicates to the transform stage, which executes its task; it communicates it to the encoding process, where once it has performed its process, it saves the compressed bitstream to disk. Finally, these are sent to land independently.

III. TRANSMISSION SYSTEM

A. Antenna system structure

A structure that allows movement in elevation and azimuth has been used to design the aiming system for the aim of pointing to the flight platform during its mission as shown in figure 3

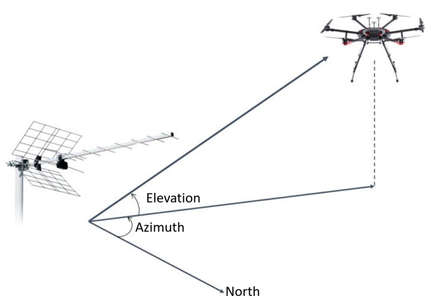

Fig. 3. Pointing system

B. Mechatronic system design

The system at the mechatronic level has been designed by the inclusion of sensors that allow to know the orientation of the system (Inertial Measurement Unit, IMU), the location (Global Position System, GPS) the motors to perform the movements and the Bluetooth communication interface to exchange messages with the ground station as well as the power supply of the assembly. Its diagram is shown at figure 4.

IV. RESULTS

First, it is shown in the image 5 the rotating structure where the antenna pointing at drone will be installed.

Finally, the quantitative results of compression and transmission in real time are shown in figure 6.

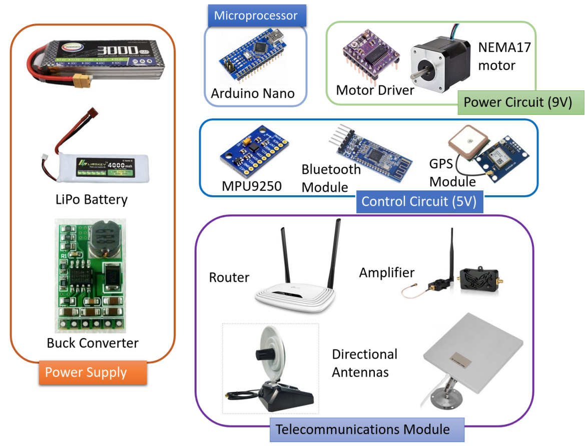

Fig. 4. Diagrama general del diseño mecatrónico del sistema

Fig. 5. Estructura de la antena

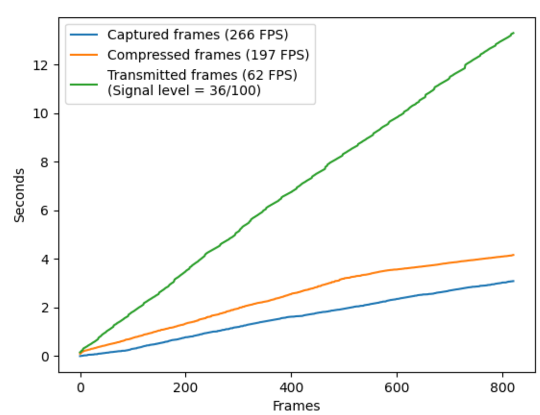

Fig. 6. Resultados del sistema de compresión y transmisión

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