Concept Paper for CCSDS-123.1-B

Low-Complexity Near-Lossless Multispectral & Hyperspectral Image Compression

CalTech, 27 March 2015

1. Purpose

The Multispectral and Hyperspectral Data Compression Working Group (SLS-MHDC) falling under the Space Link Services (SLS) Areas of the CCSDS, has identified the need for a Recommended Standard that will define a multispectral & hyperspectral image compressor as an extension to CCSDS-123.0-B-1 by defining a quantization feedback loop and associated output data structures. This allows the CCSDS-123.0-B-1 compressor to provide near-lossless compression of multispectral and hyperspectral (three-dimensional) images.

2. Key Technical Features

This Recommended Standard extends the multispectral and hyperspectral lossless compression algorithm defined in CCSDS 123.0-B-1, in order to enable near-lossless compression. The resulting standard will constitute a flexible toolset for lossless and lossy compression, with very high compression efficiency at high quality levels, and low complexity. It will feature the adaptive predictor employed in CCSDS 123.0-B-1, which will be inserted in a quantization feedback loop. The standard will provide flexibility in allocating qualities to different pixels of the image, allowing to optimize its operation in several ways.

There are no patent issues for this technology that are known by the CCSDS community.

3. Benefits

Future space missions will make increasing use of multispectral and hyperspectral imaging instruments, which significantly increase the volume of data to be collected and transmitted to the ground. Exploiting data dependencies in all three dimensions (two spatial, one spectral) of multispectral and hyperspectral images provides a significant increase in compression ratio at a given fidelity level, thus enabling increased data return over space communications channels. This extension of CCSDS 123.0-B-1 allows implementers to leverage existing hardware implementations, and enables precise quality control, thereby adapting to different mission needs. It is expected that this standard will be appealing for missions requiring high quality levels, or flexible quality adjustment, and low implementation complexity.

4. Requirements of prospective missions

The transport mechanism used for the delivery of a compressed image must provide the ability to locate the header of the next image in the event of a bit error or data loss on the communications channel.

5. Relationship to existing standards

This Recommended Standard will make use of the CCSDS-123.0-B-1 adaptive predictor.

6. Deficiencies, flaws, and limitations in existing standards

Existing standards CCSDS-121.0-B and CCSDS-122.0-B define data compression approaches that are essentially one-dimensional and two-dimensional respectively. These standards were not specifically designed to exploit data dependencies in all three dimensions of multispectral and hyperspectral images, and thus are significantly less effective.

The existing CCSDS-123.0-B standard defines a state-of-the-art lossless compressor for multispectral and hyperspectral imagery. However, it does not provide lossy compression that is often needed to meet compression ratio requirements. The CCSDS-122.1-B Recommendation under development provides lossless and lossy compression, and effectively exploits correlations between spectral bands. However, this transform-based method is significantly less effective at high bit rates, and does not provide users with a quantifiable guarantee on the maximum reconstruction error of any sample. This transform-based approach also has substantially higher complexity.

7. Resources and Schedule

The Multispectral and Hyperspectral Data Compression Working Group identified the following Candidate Resources and Schedule.

Book Editor	8 mm	ESA
Prototype 1	5 mm	NASA
Prototype 2	3 mm	ESA
Contributing Agencies		CNES, NASA
Monitor Agencies		
Start of Work	June 2015	
End of Work	May 2018	

For more details please refer to the CWE Project at

http://cwe.ccsds.org/fm/Lists/projects/DispForm.aspx?ID=517 .