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A Novel Hyper Spectral Video in to JPEG frame Transcoding through Dynamic Video Frame Skipping

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***Abstract* – Hyper spectral video is of interest in a large number of remote sensing applications, such as geology and pollution monitoring, in order to detect and analyze surface and atmospheric composition. The processing of these video, called spectral analysis, allows for the identification of the specific mineralogical and agricultural elements which compose an image. The research presented in this paper takes advantage of details specific to this processing in order to maximize the ability of compression algorithms to operate on the video with minimal loss in image utility. The research begins with the recommendation of new error determination utilities which incorporate spectral analysis techniques in order to model real usage, and then compares the results from others with the commonly used PSNR. Then, it continues by building on the results of these utilities with the recommendation of a dynamic frame skipping depending upon frame variation of each group of picture.**

Keywords: 3D-cube compression, hyper spectral data compression

I. INTRODUCTION

Hyper spectral video transcoding is the operation of converting a video from one format into another format. A format is defined by such characteristics as the bit rate, frame rate, spatial resolution, coding syntax, and content. Due to significantly improved spatial and spectral resolution provided by a hyper spectral imaging sensor, hyper spectral imagery expands capability of multispectral imagery in many. For example, a TV program may be originally compressed at a high bit rate for studio applications, but later needs to be transmitted over a channel at a much lower bit rate.

Hyper spectral video are widely used in a number of civilian and military applications. The images are acquired from plane or satellite borne spectrometers and cover large tracts of the Earth's surface. Through the analysis of the spectrum of reflected light present in these images, it is possible to identify what materials are present on the land and in the atmosphere. This information has been used for such varied purposes as environmental studies, military surveillance and the analysis and location of mineral deposits.

II. SPECTRAL HYPER SPECTRAL DATA COMPRESION

When data compression is performed, two different types of criteria must be specified. One is a design criterion used to develop a compression technique and the other is a performance criterion used to evaluate the effectiveness of a specified compression technique in performance. While these two types of criteria are considered as separate criteria, they are generally correlated to each other. Specifically, a performance criterion is always a major driving force to determine what design criterion should be selected to design a desired compression technique

Despite the fact that a hyper spectral video can be viewed as a 3D image cube, there are several major unique features that a hyper spectral image distinguishes itself from being viewed as a 3D image cube. The first and foremost is spectral features provided by hundreds of contiguous spectral channels. Unlike pure vowels' in a 3D image, a hyper spectral image pixel vector is specified by a range of wavelengths in a third dimension that characterizes the spectral properties of a single pixel vector. Using the spectral profile captured in the spectral domain a single pixel in a 3D image cube can be solely analyzed by its spectral characterization. Another important unique feature provided by hyper spectral imagery is that many material substances of interest can be only explored by their spectral properties, not spatial properties such as waste in environmental pollution, chemical/biological agent detection in bioterrorism, camouflaged combat vehicles and decoys in surveillance applications. In addition, certain targets such as chemical plumes, biological agents, which are considered to be relatively small with no rigid shapes but yet provide significant information, generally cannot be identified by prior knowledge. Instead, these targets can be only uncovered and revealed by their spectral properties. Therefore, when a compression ratio is high, whether or not a hyper spectral image compression technique is effective may not be necessarily determined by its spatial compression as do most compression techniques in image processing since small and subtle targets such as sub pixel and mixed pixel targets may be very likely sacrificed by low-bit rate compression due to their limited spatial presence.

III. AN OPTIMUM ALGORITHM BASED ON DYNAMIC CODING

In this section is to give a brief description of dynamic programming algorithm that produces an optimal encoding under on very reasonable assumption. A more detailed description can be found in Motta al. [6]. Although this is not likely to be precisely true in practice, it is likely to be a very good approximation to what happens. That is, two encodings of a frame at the same quality are likely to be equivalent in their ability to predict a subsequent frame.

The dynamic sub window scheme is summarized as follows:
If 1^{st} frame eq k^{th}
then
Skip the transcoding of the $k+1^{th}$ sub-window
else
Transcode the frame no=2

Hyper spectral images contain a wealth of data, but hyper spectral images are interpreting them requires an understanding of exactly what properties of ground materials we are references is provided on trying to measure, and how they relate to the measurements actually made by the hyper spectral sensor.

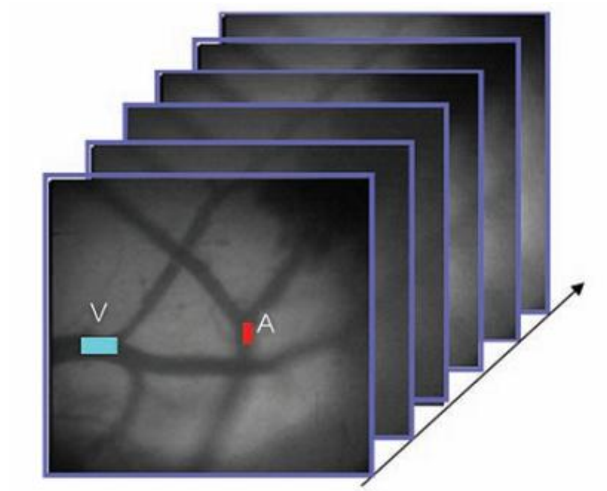

Figure1. Image cube

In multi spectral imaging, a series of images acquired at many wavelength producing an "image cube" in Figure 1.

IV. DYNAMIC HYPER SPECTRAL VIDEO FRAME SKIPPING

For the purposes of this paper, the planes of decreasing spectral energy were numbered beginning with the lowest level sub-band plane. Then, the multiplier for each of the data points in each plane was determined as follows

To assume that at a time t=n a new video frame should be transmitted through the variable network and at this time t the available bandwidth, say B(n), is less than the minimum required for transmitting a frame in one frame period, In case that the current bandwidth is greater than the requested one, all multimedia information can be delivered. A better solution is proposed here that performs a content-based sampling. In this way, among the current and the candidate frames for skipping (i.e., k, k+1, k+2, …,k+K-1), the most representative is selected to be delivered whereas the remaining frames are discarded.

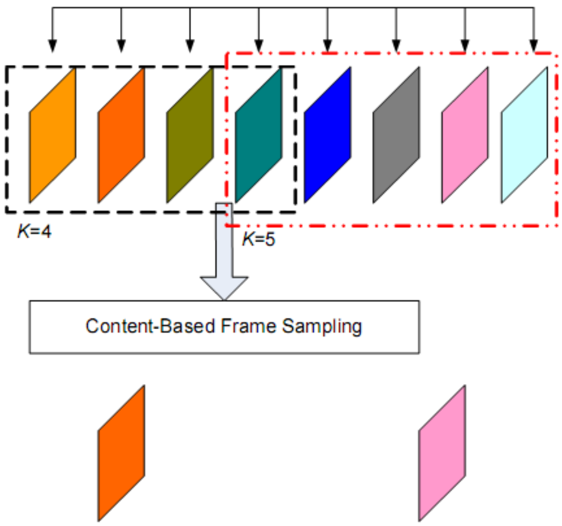

Figure 2. Video frame skipping

To calculate the average feature vector f over all K frames

$$F=1/K \sum_{i=1}^{k} f_i \quad (1)$$

To select as most representative frame for the one whose feature vector is closer in the sense of the L2 norm. Figure 3 presents a graphical representation of the proposed scheme. In this example, at time t=n, the algorithm estimates that the bandwidth is four times lower than the minimum required, i.e., K=4. Then, the algorithm selects as representative among the four successive frames the one whose feature vector is the closest to the min vector of the four frames. In this example, we assume that this frame is the second, i.e., J=2. We have also assumed that this frame completes its transmission within three frames instead of four, due to the fact the network bandwidth has slightly increase during the frame transmission. Thus, at time n=4 the current bandwidth is again evaluated resulting in K=5.
In this case, the new time is updated as in equation (1), i.e., n_{new}=max(J=n+1, c=n+2)=n+3. In the following iteration, one frame is extracted from the five successive frames, say +3. A pseudo code of the for example the fourth, i.e, J=new proposed algorithm is shown in Table I.

V. RESULTS

Table 1 shows the PSNR by using the original and new approaches described above. As indicated by these data, the interpolated motion

Figure 3. Input video frame

Figure 4. Output video frame

vectors fine-tuned by using small search range produce negligible image quality degradation.

Sequences (400 frames)	Average PSNR (MPEG4)	Average PSNR (New algorithm)	Difference
Foreman	33.65	33.63	-0.02
salesman	37.74	37.76	0.02
Mthr_dotr	33.57	33.54	-0.03

Table.1 PSNR Difference

VI. CONCLUSIONS AND FUTURE WORK

The primary purpose of this study was to explore the applicability of the commonly used error metrics PSNR and MAE to the spectral analysis of compressed hyper spectral images. This was accomplished through the creation of new error utilities based upon actual spectral analysis techniques which would reliably reflect this application, the results of which were compared with PSNR conferees. Biases were tested which resulted in an improvement in the ability to spectrally analyze reconstructed hyper spectral images (as measured by these new utilities), but that caused a corresponding decrease in PSNR

There are a number of areas in which this research could be continued in order to provide a usable mechanism for compression of hyper spectral images. One such would involve further exploration into the effect of various types of bias introduced in the spectral dimension and modification of the compression algorithm to accommodate a choice of bias, to be encoded with the compressed file. Another should involve additional spectral analysis tools and the compression of radiance data in order to verify the results as discussed here are applicable to a wide range of usage patterns. Additional compression algorithms should be examined to see how a spectral bias might be applied and tested with the error utilities presented here, as well.

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