CHAPTER I

INTRODUCTION TO HYPERSPECTRAL VIDEO DATA PROCESSING FOR WEB BROWSING

1.1 Overview of Hyper Spectral Video Signal

HyperSpectral Video is a representation of real world scene which is sampled spatially, temporally and spectrally. A moving Hyperspectral signal is produced by the process of sampling that is repeated at intervals which satisfies the condition is as follows:

\[ f_s \geq 2f_m \]  

(1.1)

where \( f_s \) is the sampling frequency and \( f_m \) is the modulating frequency.

![Figure 1.1 Still Hyperspectral Image (HSI) from Natural Video Scene](image)

HyperSpectral Video Coding is the process of compressing and decompressing a digital hyperspectral video signal. A typical Hyperspectral real world scene is composed of multiple objects each with their own characteristic shape, depth, texture.
illumination and color component. The color and brightness of natural hyperspectral video scene changes with varying degrees of smoothness throughout the scene. A typical still hyperspectral image from natural video scene is shown in Figure 1.1 and the process of spatial and temporal sampling of a hyperspectral video sequence is given in Figure 1.2.

Figure 1.2 Spatial and Temporal Sampling of a HyperSpectral Video sequence

For hyperspectral video processing and compression, spatial and temporal characteristics of a typical video scene alone are relevant and they only are to be processed. It is known that computer video deals with the recording and display of a sequence of images at a reasonable speed between 18 and 26 frames per second to create an impression of movement. Each individual image of a sequence of images is called a frame.

Hyperspectral Video information travels in natural media in the form of light waves, which are analog in nature. In order for the computer to be able to understand
video information, light waves must be converted from analog form to digital form. Hyperspectral video camera is a transducer that is commonly used to convert light waves into electrical signals. Conversely, in order to display the sequence of frames in hyperspectral video monitor requires light signals which are converted from the electrical signals. For that, one needs A/D conversions and D/A conversions are shown in figure 1.3.

1.2 Hyper Spectral Video Coding Concepts

The condensing of data into a smaller number of bits is the main process of compression. The process of condensing a digital video sequence into a smaller number of bits is known as video compression. Uncompressed hyperspectral digital video typically requires a larger bit rate so that compression is necessary for practical storage and transmission of hyperspectral digital video.

A hyperspectral data compression system requires a complementary pair of systems such as a compressor (encoder) and a decompressor (decoder). The hyperspectral encoder converts original data into a compressed form prior to transmission or storage. The Hyperspectral decoder converts the compressed form back into a representation of original hyperspectral digital video data.

Figure 1.3 explains the Hyperspectral Encoder/Decoder which is known as Hyperspectral CODEC.

![Diagram of Hyperspectral EnCODer/DECoder](image-url)
The process of removing redundancy is done by HyperSpectral data compression. In lossless hyperspectral compression, the statistical redundancy can be removed from that the reconstructed data at the output of decoder which gives a perfect copy of the original hyperspectral data. In lossy hyperspectral compression, the subjective redundancy can be removed by without significantly affecting the viewer’s perception of visual quality.

Most hyperspectral video coding methods are used to achieve compression by way of exploiting spatial, temporal and spectral redundancy. A high correlation (similarity) between frames of hyperspectral video were captured at around the same time in the temporal domain. If the temporal sampling rate(frame rate) is high, then the temporally adjacent frames (successive frames in time order) are often found to be highly correlated. When high correlation exists between pixels that are closer to each other ie., the values of neighbouring pixels are often very similar in spatial domain.

Figure 1.4 shows that Spatial and Temporal Correlation in a HyperSpectral Video Sequence

Figure 1.4 Spatial and Temporal Correlation in a HyperSpectral Video Sequence
1.3 Hyper Spectral Video CODEC

A hyperspectral Video CODEC encoder [1] encodes a source hyperspectral image or video sequence in-to a compressed form and decodes this to produce either an exact replica or an approximation of the source sequence. If the decoded hyperspectral video sequence is identical to the original, then the coding process is lossless. The hyperspectral CODEC represents the original image or video sequence by a model.

Figure 1.5 shows that hyperspectral video encoder block diagram consists of three main functional units: Temporal Model, a Spatial Model and a Hyper Spectral Entropy Encoder.

![HyperSpectral Video Encoder Block Diagram](image)

The input to the temporal model is an uncompressed hyperspectral image or video sequence. The temporal model attempts to reduce temporal redundancy by exploiting the similarity between neighbouring video frames, usually by constructing a prediction of the current video frame [1]. The output of the temporal model is a residual frame (created by subtracting the prediction from the actual current frame). The residual frame forms the input to the spatial model which makes use of similarities between neighbouring samples in the residual frame to reduce spatial redundancy. The proposed standard is achieved by applying a transform to the residual samples and
quantizing the results. The transform converts the samples in to another domain in which they are represented by transform coefficients [1]. The output of the spatial model is set of quantized transform coefficients. The parameters of the temporal model (motion vectors) and the spatial model (coefficients) are compressed by the HyperSpectral Entropy Encoder. This removes statistical redundancy in the data and produces a compressed bitstream or file that may be transmitted and or stored. A compressed sequence consists of coded motion vector parameters, coded residual coefficients and header information.

The hyperspectral video decoder reconstructs a video frame from the compressed bitstream [1]. The coefficients and motion vectors are decoded by an HS entropy decoder after which the spatial model is decoded to reconstruct a version of the residual frame. The decoder uses the motion vector parameters together with one or more previously decoded frames to create a prediction of the current frame and frame itself is constructed by adding the residual frame to this prediction.

1.4 Temporal Model

Transmitted frames are formed from a predicted frame and subtracting the frames from the current frame. The output is obtained from a residual frame(difference frame) and prediction process gives more accurate frames and less energy is obtained from the residual frame. The residual frame is encoded and sent to the decoder which recreates the predicted frame[1], adds the decoded residual and reconstructs the current frame. The predicted frame is obtained from one or more past or future frames(reference frames). The accuracy of the prediction can be usually improved by compensating for motion between the reference frame(s) and the current frame. The objective of this model is to remove the redundancy between transmitted frames.
1.5 Overview of Transcoding Proxies in Proposed Research

Using Transcoding Proxies is an efficient solution for Temporal Hyperspectral Video Transcoding in Web Browsing.

Transcoding Proxies are intermediaries between the client devices and www servers. It adapt the web data like images, video, text etc dynamically according for the available bandwidth and the display size of the client device.

Let Rp be the Response time at the Proxy and Ro be the Response time at the output then the object download time is the sum of the transfer time over the server proxy and proxy client links and thus transcoding will reduce response time if Rp<Ro.

A Block Diagram for Transcoding Decision is given in Figure 1.6 which shows that how the Web Proxy (Transcoder) adopts the hyperspectral video input which is captured from source dynamically with respect to the various types of devices such as small screen devices etc., and these video data is processed between the client devices and www servers.

![Block Diagram for Transcoding Decision](image)

Figure 1.6 Video Data Processing in Web Browsing through Transcoding Proxies

A proxy server is a server that acts as a go between for requests from clients seeking resources from other servers. A client connects to the proxy server requesting some service such as file, connection, web page or other resource available from a different server.
The proxy server evaluates the request according to its filtering rules. For example, it may filter traffic by IP address or protocol. If the request is validated by the filter, the proxy provides the resource by connecting to the relevant server and requesting the service an response, and sometimes it may serve the request without contacting the specified server.

Two major purposes of a proxy server is given below:

- To keep machine behind it anonymous (mainly for security)
- To speed up access to a resource commonly used to cache web pages from a web server.

Finally, A proxy server that passes requests and replies without modifications is known as gateway.

**Some Benefits of Transcoding Proxy:**

- It is capable of tailoring text and images for multitude of small, weakly connected but web enabled mobile devices that are now available.
- The capabilities of these mobile devices to receive, process, store and display web content varies widely.

![Diagram](image)

**Figure 1.7 Internal Architecture of Hyperspectral Data Transcoding Proxy**
Figure 1.7 shows that the Internal Architecture of Hyperspectral Data Transcoding Proxy. It explains clearly how the Hyper Spectral Web Server and Hyperspectral Web Browser performs the transcoding through Internet. It is well known to everyone that transfer of large files across the Internet is done through FTP (File Transfer Protocol). The proposed research requires FTP servers called special servers which is used to store hyperspectral information and then transfer it back to FTP clients as needed. The special FTP servers have to be secured with a username and password to prevent unauthorized downloading of a hyperspectral file from the server or uploading of a hyperspectral file on the server. This architecture illustrates clearly about the ability to transmit and receive on the same channel at the same time which known as full duplex transmissions between (Hyper-Spectral) Web server and (Hyper-Spectral) Web Browser. This is known as asynchronous transmissions. If only half duplex transmissions available then one can either perform only job or receive only job. For example most dial up services available to PC users employs full duplex capabilities.

1.6 Understanding Digital Video Compression in Reviewing of Proposed Research

![Diagram of Digital Video Compression](image)

Figure 1.8 Structure of Hyperspectral Video Encoder in Digital Processing
The Structure of Hyperspectral Video Encoder in digital processing in Figure 1.6 describes the technical basis for digital video compression and how the quality versus costs of video based services are directly affected by the practical performance of video compression technologies.

The performance of video compression encoders are characterized by two main curves such as quality versus bit rate on different types of video content. This is suitable to linear TV, VOD as well as video download services.

1.7 Dynamic Hyperspectral Data in Decoding Stage through Intraframe Prediction

Hyperspectral Data are in a way similar to video data, where wavelength corresponds to time, but their statistical properties are different: there is no motion between Hyperspectral Spectral planes but changes in color as illustrated in figure 1.2.

HSI Advantages

It can take the spatial relationships among the different spectral in a neighbourhood allowing more elaborate spectral spatial models for a more accurate segmentation and classification of the image.

If Hyper Spectral Image are received as number of sequential frames. Each frames are divided into number of blocks 8X8 or 16X16 image blocks. The colors(cb,cr) and Luminance(y) are separated and converted using integer transformation or DCT to stored Zigzag format.

YCbCr

The human visual system (HVS) is less sensitive to colour than to luminance (brightness). In the RGB colour space the three colours are equally important and so are usually all stored at the same resolution but it is possible to represent a colour image
more efficiently by separating the luminance from the colour information and representing luma with a higher resolution than colour. The YCbCr colour space and its variations (sometimes referred to as YUV) is a popular way of efficiently representing colour images. Y is the luminance (luma) component and can be calculated as a weighted average of R, G and B:

\[ Y = kr \cdot R + kg \cdot G + kb \cdot B \]  

(1.2)

where k are weighting factors. The colour information can be represented as colour difference (chrominance or chroma) components, where each chrominance component is the difference between R, G or B and the luminance Y:

\[ Cb = B - Y \]  

(1.3)

\[ Cr = R - Y \]  

(1.4)

\[ Cg = G - Y \]  

(1.5)

The complete description of a colour image is given by Y (the luminance component) and three colour differences Cb, Cr and Cg that represent the difference between the colour intensity and the mean luminance of each image sample. The chroma components (red, green and blue) corresponding to the RGB components. Here, mid-grey is zero difference, light grey is a positive difference and dark grey is a negative difference. The chroma components only have significant values where there is a large.

H.264 (and MPEG4) uses the YCbCr color space to represent the data values instead of RGB, where Y is the luminance signal, Cb is the blue color difference signal, and Cr is the red color difference signal.
Figure 1.9 Luminance and Chrominance components for Hyperspectral Color Images

The following steps are to be taken out in decoding stage through intraframe prediction

**Spectral Reflectance**

It is the ratio of reflected energy to incident energy as a function of wavelength. Reflectance varies with wavelength for most materials because energy at certain wavelengths is scattered or observed to different degrees.

**Spectral Radiance**

Using hyperspectral sensor who has simply measured the amount of reflected light reaching it in each wavelength band.

1.8 **Organization of the Thesis:**

**Chapter I -** Introduction to HyperSpectral Video Data Processing in Web Browsing describes how hyperspectral video signal is processed in the proposed encoder and how the video data is compressed in a form and how the compressed video signal is transmitted or stored in a manner and these can be decoded for reception to various types of devices with respect to desired output is needed for receiver who want to receive the hyperspectral data.
Chapter II - Overview of Video Data on HyperSpectral Imaging and High Resolution Imaging through Web Browsing elaborates how the HSI and HRI desired informations are co registered by the process of getting the Sharpened HSI data with the help of these methods such as background classification and anomaly detection. After that, Extracting Edge detection in Spatial manner with HRI data which implies Enhanced HSI and HRI target data is achieved for Target detection and identification with specified spectral matching filtering process. It describes how people make simulated data generation by the process of band integration in HRI Simulated data and spatial degradation in HSI data. Finally HSI and HRI fusion data is to be produced by the way of spatial and spectral analysis through transcoding process in web browsing.

Chapter III - Survey On Hyper Spectral Technologies investigated how to classify the region in the hyperspectral imaging incorporates to classify the region such as structural region, gradated region and textural region based on parameter assistant inpainting. Some applications are discussed in the process of mosaicing such as effective information exchange through the internet by making creating immersive environments and also various analysis methods are explained so on.

Chapter IV - Temporal HyperSpectral Video Transcoding for Web Browsing - Problems and Proposed Solutions demonstrates about the hyperspectral video data can be downloaded from server to a variety of client devices in order to adapt the various bandwidths of different client communication links through transcoder (Proxy). When downloading a video data from server, so many problems are created based on the desired connection is set up, from that one has to face out solution for transferring video data to possibly small screen devices through heterogeneous transcoding by means of different coding and decoding methods such as MPEG4 or H 264 AVC.
**Chapter V** - Experimental Results on HS and HR Imaging Technologies illustrates that how do you track the compressed video frames in different wavelet methods such as haar wavelet transform, 5/3 wavelet transform and how to you recover the original frame through Hyperspectral technologies are employed.

**Chapter VI** - Concluding Remarks and Future Enhancements states that the proposed research solves the problem of downloading time delay when transferring the Hyperspectral video data is required between client and server. When Temporal compression is achieved only if the reduced complexity and running time and enabling the interoperability between multimedia networks are employed. By developing the ultra spectral frequencies related to speed of light is increased then the new technology will be introduced in the future. That new technology is known as Ultra Spectral Technology.