MPEG2Tool: A Toolkit for the Study of MPEG-2 Video Transport Over ATM based Networks

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Abstract

Providing high bit rate real-time video services has been a major driving factor in the advancement of high speed networking technology such as ATM based BISDN. In this paper, we describe MPEG2Tool, an X-window-based software implementation of the MPEG-2 video compression algorithm with many additional useful functions. The ultimate goal of designing this toolkit was to facilitate the study of MPEG video transmission over ATM-based networks. The toolkit consists of four major modules, which appear as four push-buttons in the main Motif menu: 1) Encoding, 2) Statistical Analysis, 3) Transmission simulation, and 4) Decoding.

1 Introduction

The requirement for bandwidth on demand to support complex services which integrate diverse media such as video, audio and graphics has lead to the introduction of ATM, a packet switched approach based on fixed cell sizes. It has been proposed as the switching and multiplexing scheme that can provide a unified transport structure for services. Among the variety of services that will be supported by ATM, video services will be an important component because of its complex bandwidth requirements and its high sensitivity to cell losses and delay jitter which are common in packet switched networks that use statistical multiplexing.

ATM based networks can support variable bit rate (VBR) video services because of their ability to allocate bandwidth on demand. VBR video is potentially superior to constant bit rate (CBR) video since it can provide constant image quality for all scenes. However, many aspects of the transport of VBR video services over packet switched networks are still open issues.

One potential problem related to ATM based networks, which is directly caused by the bursty nature of the traffic stream and the statistical multiplexing, is cell losses. When several sources transmit at their peak rates simultaneously, the buffers available at some of the switches may be inadequate and hence overflow will occur. The congestion at these switch buffers and the subsequent dropping of cells due to overflow can lead to severe video quality degradation. Proper traffic control mechanisms involving both network control and source rate control are important in these situations as they can be used to reduce the cell loss and/or minimize the impact of cell losses.

In order to study the performance of various traffic control schemes and their impact on the quality of video, we implemented a software-based MPEG-2 codec, of which the versatility and user friendly nature can aid the task of studying issues in video transmission over ATM based networks.

In this paper we describe the design of the MPEG2Tool. We use it extensively for our studies of MPEG video. It consists of 1) an MPEG-2 encoder that encodes digital video data, 2) a statistics package to study the characteristics of the encoded bit stream, 3) a transmission simulation module which simulates the cell losses in ATM networks and 4) a decoder with error concealment and video quality assessment features. The modules appear as push buttons in the main menu (Fig. 1). Our MPEG2Tool is based on the current MPEG-2 standard.

The outline of this paper is as follows: in sections 2,3,4,5, we present the interface and functionalities of each of

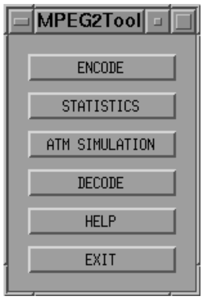


Figure 1. The main Motif window for the toolkit.

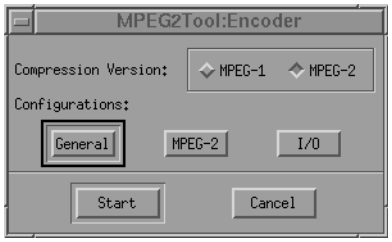


Figure 2. The main Motif window for the encoder module

the modules of the MPEG2Tool. In section 6, we give the summary.

2 Encoding Module

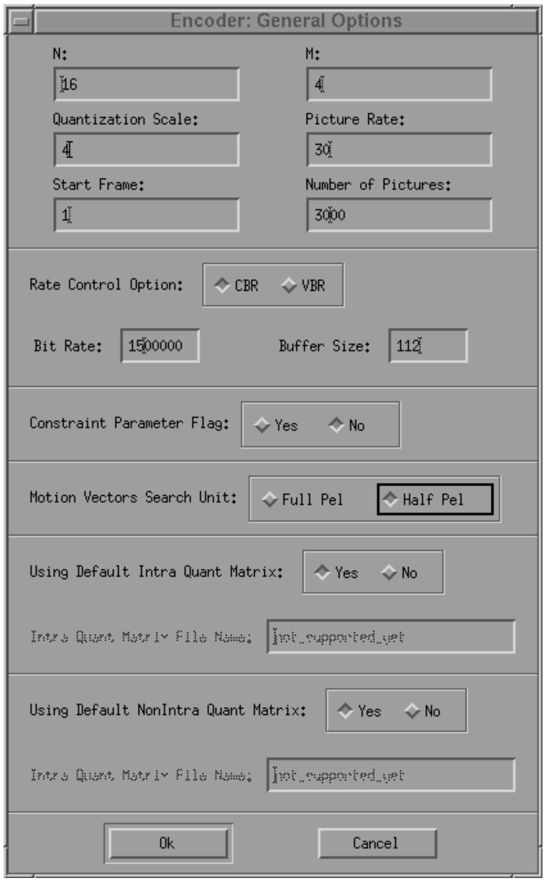
The encoding module as shown in Fig. 2 can compress various formats of raw video sequences according to the MPEG-2 [1] standard. The MPEG-2 standard only specifies the decoding procedure. As a result, we are given quite some flexibility while implementing the encoder. Hence, in the encoder submenu, we make it possible for the user to configure a large subset of the encoding parameters. This can be achieved by 1) simply clicking toggle buttons or filling out the Motif text columns, or 2) directly editing a configuration file ".MPEG2Toolrc". The following configurations are supported:

- Compression version: The user can specify the compression version as MPEG-1 or MPEG-2 by clicking on the toggle buttons.
- General coding parameters (common to both MPEG-1 and 2) as shown Fig. 3: This is obtained by clicking on the "general" button: These parameters include I frame distance, P frame distance, frame rate, quantization scale, start frame index, frame numbers, pel aspect ratio, constant bit rate (CBR)/variable bit rate (VBR) option, CBR target bit rate and encoder buffer size (if CBR is chosen), constrained parameters flag, motion searching scope, motion searching unit, loading user specified quantization matrix, etc.
- MPEG-2 specific coding options: It is active only when the compression version is chosen to be MPEG-2 and obtained by clicking on the "MPEG-2" button. In this submenu as shown in Fig. 4, most of the MPEG-2 coding options are supported, such as layer source coding mode (scalability), concealment motion vectors, chrominance format, alternate scan table, alternate quantization table, intra DC coefficient precision, etc.
- I/O configurations: The user can specify input image format, input/output device name, option to generating statistical results option with corresponding file name as shown in Fig. 5. Currently, the supported input video format are RGB and CCIR. The I/O media can be tape or disk. The details of the statistical functions will be described in the next section.

After specifying the above parameters, the encoding function can be engaged by clicking the start button. Additional information indicating the coding progress will be constantly displayed in a popup window.

3 Statistical Module

The statistical properties of MPEG video bit streams are as yet not well understood in particular for MPEG video. Knowledge of their properties is essential for determining the best traffic management strategies in ATM based networks. Therefore an important component of this toolkit is the statistics package. It is very similar to the



N: 16

M: 4

Quantization Scale: 4

Picture Rate: 30

Start Frame: 1

Number of Pictures: 3000

Rate Control Option: ◇ CBR ◇ VBR

Bit Rate: 1500000

Buffer Size: 112

Constraint Parameter Flag: ◇ Yes ◇ No

Motion Vectors Search Unit: ◇ Full Pel ◇ Half Pel

Using Default Intra Quant Matrix: ◇ Yes ◇ No

Intra Quant Matrix File Name: not_supported_yet

Using Default NonIntra Quant Matrix: ◇ Yes ◇ No

Intra Quant Matrix File Name: not_supported_yet

statistical module of an earlier version of the tool called MPEGTool that was released for the MPEG-1 standard two years ago [3].

If the option of generating statistical data is chosen before the encoding process starts, this package can be used to study the statistical properties of the encoded video sequence. After encoding is finished, various statistical results can be plotted using the graphical tool Gnuplot. All the results can be examined at different granularity, i.e., they can be calculated on the basis of frame, slice or macroblock. Also the user can choose the basic analyzing unit to be either bit or ATM cell (assume 47 byte payload). If layered source coding is chosen, results for both layers can be obtained separately. The submenu for this module is as Fig. 6. The statistical results include:

- General records: The bit/cell rate generated per frame or per slice. This is very useful for trace driven simulations to determine performance of real video sources.
- Rate distribution: Distribution of bit/cell rates at the frame, slice or macroblock level.
- Autocorrelation function: In addition to distribution, the autocorrelation function is another important property of video sources. It is defined as:

where u_x is the mean of the random variable x. Here x refers to the rate per frame, slice or macroblock.