

A Virtual Media (Vmedia) JPEG 2000 Interactive Image Browser

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ABSTRACT

A Vmedia JPEG 2000 interactive image browser is developed. Two key technologies make our system unique: it is the first to implement the decoder ROI access functionality of JPEG 2000, and it uses virtual media (Vmedia) protocol to manage and deliver the ROI bitstream in an efficient fashion. The user browses the image by specifying a region of interest (ROI) with spatial and resolution restriction. Only the portion of the compressed bitstream covering the current ROI is streamed. Moreover, the streaming is performed in a progressive fashion so that a coarse view of the ROI can be rendered very quickly and then gradually refined as more and more bits arrive. Vmedia greatly improves the browsing experience of large images over the slow network.

Keywords: virtual media (Vmedia), JPEG 2000, media access, interactive browsing, streaming, progressive coding, cache

DESCRIPTION

As the Internet becomes popular, more and more high-resolution images are brought online. NASA is putting its collection of space photos online. The Microsoft terra server provides access to high-resolution satellite/aero photographs over the Internet. Museums are digitizing and moving their collectibles online. Even individuals are sharing their personal photos over the web. It is very enjoyable to watch a high-resolution image on the screen; but it is equally painful to download the huge image over the slow Internet. Although the backbone of the Internet keeps improving, the content and the number of users also grow. Efficient delivery of large image is thus crucial to provide enjoyable image browsing experiences on the Internet.

In the early days, compressed images are downloaded entirely from the network before its content is rendered. Delay is inevitable in such a first download and then render model. Newer version of the browser supports progressive JPEG streaming, where views are rendered repeatedly as more and more bitstream arrives. Progressive streaming improves the experience of image browsing. However, for a large image, the size of the compressed bitstream is still too big to be streamed efficiently.

A better way to browse a large image is to use the interactive browsing. Besides reducing the bandwidth requirement, the interactive browsing is also ideal in case the image resolution is higher than the display resolution, such as the handheld device. In interactive browsing, the user interacts with the browser and specifies

the interested region and resolution, which is called a region of interest (ROI). The user may change ROI by panning around (changing the spatial access region), and/or zooming in and out of the image (changing the access resolution). The Live picture viewer [1] has implemented interactive browsing with a multi-resolution JPEG image format called Flashpix. Though enabling better response, Flashpix adds a 33% overhead because multi-resolution compressed bitstreams are stored. In addition, the Live picture browser does not cache the downloaded bitstream. When the ROI is changed, a different compressed bitstream is accessed, which increases the network traffic.

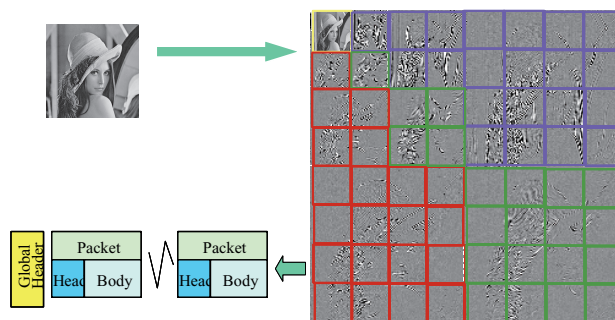


Figure 1 Coding flow of JPEG 2000.

In this work, a network efficient interactive image browser is developed. There are two key technologies that make our system unique. First, we use JPEG 2000, which not only offers a superior compression performance, but also generates a highly structured scalable bitstream that enables ROI access. Second, a virtual media (Vmedia) protocol is developed to efficiently deliver and manage pieces of bitstream related to ROI.

The coding flow of JPEG 2000 is shown in Figure 1. It first transforms an image into the wavelet domain. Each resolution subband is then segmented into fixed size blocks, each of which is encoded by an embedded bitplane coder. The embedded coded block bitstream is chopped into several SNR layers. All chopped bitstreams are then assembled to form the compressed bitstream of JPEG 2000. Such bitstream syntax enables access by region, spatial resolution and quality level.

To access a ROI, we do not need to access the entire JPEG 2000 bitstream. Shown in Figure 2(a), a ROI of size 128x128, with its upper left corner located at (256,256) is accessed. It is easily calculated that a total of 10 wavelet coefficient blocks need to be accessed to decode the ROI¹. At first not all bitstream segments arrive. But we still can decode a coarse quality view of the ROI. We use the Vmedia protocol, a protocol developed by the

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¹ Considering the boundary of the wavelet filter, the accessed region is actually a little larger. Though ignored in the discussion for simplicity, the boundary adjustment is implemented in the actual Vmedia interactive image browser.

author, to manage the delivered bitstream segments and prioritize the delivery task. As more and more bitstream segments arrive, the quality of the ROI improves.

The browsing experience is very pleasing. We show a picture of the running scene in Figure 3. The image is an aerial photography with size 8192x8192. It is compressed to 1.0 bit per pixel, i.e., 8MB, and is put on the server. It is then interactively browsed through a window of size 600x380 with a simulated modem link at 33.6 kbps. If the image is downloaded and then browsed, it will take more than half an hour. Streaming is also too slow for such large images. However, with the Vmedia interactive image browser, the user can freely wander in the image: zoom in/out or pan around. A coarse quality ROI shows up immediately in response to the selection of the user. The quality of the ROI then gradually improves, and a visually lossless ROI is usually shown within 10 seconds.

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- [2] VM adhoc, "JPEG 2000 verification model 5.2 (technical description)", ISO/IEC JTC1/SC29/WG1N1422, Vancouver, BC, Jul. 1999.

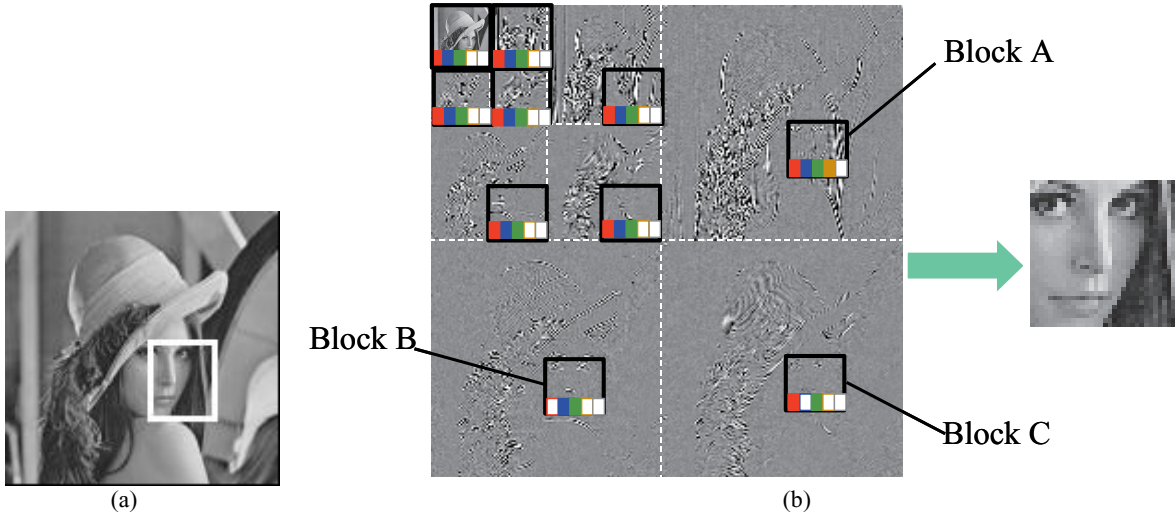


Figure 2 (a) A sample of Vmedia image browsing. The Lena image is of size 512x512. The ROI is at (256,256) with size (128,128). (b) The accessed bitstream segments. The black box identifies the coefficient blocks accessed by the Vmedia. A shaded bar identifies an available bitstream segment, and a white bar identifies an unavailable bitstream segment.



Figure 3 A running scene of the JPEG 2000 interactive image browser.