DOCUMENT RESUME

ED 411 844 IR 056 671

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TITLE	Solving the Imaging Dilemma for Internet and Intranet Applications.
PUB DATE	1996-00-00
NOTE	6p.; In: Online Information 96. Proceedings of the International Online Information Meeting (20th, Olympia 2, London, England, United Kingdom, December 3-5, 1996); see IR 056 631.
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Computer Graphics; Computer Software Development; *Computer System Design; Information Management; Information Technology; *Online Systems; Video Equipment; *World Wide Web
IDENTIFIERS	Bandwidth; Digital Technology; *Fractals; Graphing Utilities; *Imaging; Resolution Requirements (Imaging); Video Audio Compressed

ABSTRACT

Providers of online information with a high visual content face an uncompromising dilemma--how to achieve fast delivery while maintaining good picture quality. As storage space or bandwidth increases, the demands placed on it by the user are always two steps ahead. Since limited bandwidth for communicating images looks like it may remain a problem for some time, the biggest issue facing graphics developers is how to create a Web site, using today's technology, which remains attractive to all users regardless of their access speed. Their site must be accessible to both ends of the speed spectrum and still be video and image rich for each user. Since its founding in 1987, Iterated Systems, specialist in imaging solutions, has pioneered the application of fractal mathematics for the management of digital images. A fractal image is an infinitely magnifialbe picture that can be produced by a set of instructions and data. Advantages of fractal mathematics include: resolution independence; content addressability; fast, software-only decompression; and progressive decompression. Fractal video compression is optimized for low bit rate video delivery in online applications and addresses the issues that existing video compression schemes hadn't even considered. It enables the publisher to deliver a message more clearly and to a wider audience in less time. Iterated Systems has recently launched a new product range for both still images and video, based on its patented Fractal Image Transform to give surfers, software developers and content providers for the Internet/Intranet a solution to the Web managing dilemma. (AEF)

Solving the Imaging Dilemma for Internet and Intranet Applications

By:

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Solving the imaging dilemma for Internet and intranet applications

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Abstract: *Providers of online information with a high visual content face an uncompromising dilemma — how to achieve fast delivery whilst maintaining good picture quality. As storage space or bandwidth increases, the demands placed on it by the user are always two steps ahead. Since limited bandwidth for communicating images looks set to remain a problem for some time, the biggest issue facing graphics developers is how to create a Web site, using today's technology, which remains attractive to all users regardless of their access speed. Their site must be accessible to both ends of the speed spectrum and still be video and image rich for each user.*

Keywords: fractal, image, video, compression, Internet, bandwidth, broadband, narrowband

1. Introduction

It has been said that a picture, with its complex mix of shape, form, contrast and colour can paint a thousand words; a belief widely upheld in the multimedia industry. The explosive growth in this area in recent years coupled with the incredible advancements in multimedia technology means that users now expect, and receive, quality imaging on their desktop. But with the incredible shift towards a networked society in the past few years, how then does this translate for online applications? We are living in a networked society and the phenomenal growth of the Internet and the intranet, along with client server and groupware technology, means that most organisations and many individuals receive incredible amounts of information from networks. The dilemma facing application developers in the graphics field therefore is how to recreate the same high quality image level for online applications as they are able to provide on the desktop.

2. Current limitations

As the Internet has grown, the weakness in the network as a delivery mechanism for pixel-based information has become clear to even the most casual network user. The World Wide Web has become the World Wide Wait. Technology developed for the personal computer and its small bandwidths doesn't translate well for imaging in Web sites; it was, after all, not originally developed for this unique environment.

Yesterday's, and to a large extent today's compression technologies have all evolved with an eye toward storage optimisation. They were designed with a mind set that storage was at a premium and bandwidth was unlimited. With the advancement of technologies, it is becoming apparent that the reality is just the opposite. Storage is relatively inexpensive and bandwidth is at a premium and, as storage space or bandwidth increases, the demands placed on it by the user are always two steps ahead. Since limited bandwidth for communicating images looks set to remain a big problem for some time yet, the biggest issue facing graphics developers is how to create Web sites that are attractive to all users regardless of their access speed. Sites must cater for both ends of the speed spectrum and still be video and image rich for each user. Hence the need for data compression to maximise the usage of the existing infrastructure.

3. Data compression technologies

Data compression can be categorised into three groups: 'lossless', 'lossy' and 'visually lossless' technologies.

3.1. Lossless technologies

Lossless compression allows you to retrieve the information that you put into the compressor in exactly the original format. Examples of lossless compression include huffman or arithmetic-based encoding schemes found in products and technologies like PKZIP, Fax Group 4 or LHARC. In addition the GIF format predominant on the Web uses a similar lossless approach. This sort of compression yields fairly shallow compression ratios: up to about 4:1 depending upon your source material.

3.2. Lossy and visually lossless technologies

By contrast, lossy compression achieves much higher compression ratios by permanently discarding certain information from the original image. Obviously, for ASCII text this can be a quite inappropriate method but when manipulating image data it proves to be extremely effective, since uncompressed digital images contain redundant data that is not necessary in order for the image to be recognisable: take, as an example, a photographic print which is a 'lossy' representation of a real world view. So, clearly there are degrees of 'lossyness' that we are prepared to accept.

Examples of lossy compression techniques include discrete cosine transformation (the maths used for JPEG images), Wavelet and Fractal. With lossy compression technologies, the user chooses the compression ratio based on the amount of data loss that the image will tolerate. This is obviously a totally subjective issue and the nature of the loss varies according to the different algorithms used. At high compression ratios, JPEG and Wavelet tend to produce a more blocky resulting image with pseudo colour being introduced, and these artefacts are exaggerated in printed versions of the image. Because the nature of the fractal mathematical process means that it operates outside of the pixel-based world, highly compressed fractal images degrade more gracefully and print out quite smoothly.

The term 'visually lossless' is used to describe an image compressed using a lossy technique but to a shallow enough compression ratio for the user to be unable to recognise a difference between the compressed and original versions. Again, this is a subjective issue and varies depending on the project for which the images are to be used.

4. The advantages of fractal mathematics

Since its founding in 1987, Iterated Systems, specialist in imaging solutions, has pioneered the application of fractal mathematics for the management of digital images, seeing benefit not just in the high compression ratios achievable but also in the other inherent advantages of turning an image into a fractal format. In 1987 Michael Barnsley, co-founder and now Chief Scientist and Technology Officer at Iterated, discovered the mathematics behind the fractal transform process opening up a whole new era in digital image representation

A fractal image is an infinitely magnifiable picture that can be produced by a set of instructions and data. Iterated Systems' fractal technology compresses images as recursive images: that is, the fractally compressed images are stored as recursive algorithms — sets of equations with instructions as to how they should be reiterated in order to reproduce the image. The equations describe the image in terms of internal relationships between its components, rather than pixel-by-pixel descriptions of its qualities. The tighter compression rate is possible because only these algorithms are stored, rather than a pixel representation of the image.

4.1. Resolution independence

Because the fractal maths formula seeks out shapes, patterns and colours (not pixels) within the larger picture and how they relate to other images within the picture, the formula for creating a particular graphic always remains the same, regardless of the resolution of the image. Think about it for a moment — an infinitely zoomable image. Applications are truly scaleable to the colour and size resolution of the display device (or printer) being used. Images can be scaled to full screen or zoomed to locate finer detail, while still retaining image quality. Fractal images can also be decompressed to colour depths both higher and lower than the original. This resolution independence ensures that pictorial content displays well on a wide range of hardware and protects the time the developer invested in its creation. By contrast, JPEG compressed images are resolution dependent. Users cannot display the original decompressed image at a higher resolution without pixelation and blockiness. The implications to developers or publishers are that multiple digital images may have to be managed concurrently; and potentially, with electronic imaging input and output technology resolution increasing at a breakneck speed, these resolution dependent images must be rescanned and recompressed to keep up with the changes.

4.2. Content addressability

The set of 'equations' that make up a fractal image describe the relationships between the components of the image, rather than the individual pixels that make up the bitmapped representation. This property makes it possible to search a fractal image (or even a collection of images) for near matches with other visual patterns, i.e. images with similar fractal components, even if the content is rotated, scaled, skewed and coloured. This makes the fractal approach suitable as the basis for identification purposes in applications that require fast searching and image comparison for security, image management, database systems and so on. The implications of such technology are astounding.

4.3. Fast, software-only decompression

Fractal images render to on-screen pictures very quickly. The computationally intensive operations in the compression process do not need to be repeated. The instructions governing the shape and positioning of objects within the image can be performed efficiently and in software alone. In comparison to a JPEG image, the FIF will decode and display faster: across a low bandwidth network connection the disparity is even more discernible.

4.4. Progressive decompression

One could say that the real value of compression technology is in the delivery of the image. The methods of progressive and controllable decompression of fractal images mean that online developers and their eager viewers can experience a visual display vastly superior to what conventional techniques allow. A 'thumbnail' image appears almost instantly at full quality, which proceeds to grow before the user's eyes into a full resolution image as data is transferred across the network. The surfer can now enjoy full-focus images almost immediately, and is able to continue traversing the Web at maximum speed without waiting for the image to complete its download process.

5. Video compression for online applications

We have already discussed the new genre of online applications appearing on our networks today (World Wide Web or otherwise) embracing commercial business applications, entertainment and information delivery. The primary focus of the paper thus far has been how to provide a solution for the delivery of *images* within this new online environment. But what happens when you introduce video into the equation?

Consider for a moment the number of frames required to transmit just one second of video and it quickly becomes apparent that the issues associated with the transmission of video over the online networks are quite literally 25 times (or 30 times for our transatlantic colleagues) more severe.

5.1. Video compression technologies available today

A whole plethora of video compression techniques are available, each optimised for a wide range of diverse applications. People wanting to achieve video delivery over broadband network connections (typically between 10 and 50 times ISDN) are well served by the MPEG-1 and MPEG-2 techniques that carry high-quality compressed datastreams to the desktop, and potentially the home.

But what about the growing number of people needing a solution for narrowband connections? Using MPEG-1 technology, a minute of video would require a 50 minute download wait via a modem connection. The new MPEG standard for narrowband delivery, MPEG-4, will use quarter common interchange format (QCIF) resolution and low bit rates for teleconferencing applications. Ratification is expected for 1998. But with ISDN connections a luxury to the majority of Internet users today, a video compression solution is needed now that will operate in the narrowband arena on connections ranging from 14.4 kilobits per second up to 128 kilobits per second.

5.2. Realistic expectations of online video

When considering a solution, we must not be too quick to criticise the playback speed and image quality of multimedia video clips without considering the technical side. We must face up to what are achievable goals for the delivery of video over low bandwidth networks and acknowledge that, at present, we are constrained by the network infrastructure and the issues surrounding this. Although higher bandwidth is an emerging reality it is not, in isolation, the solution to our problems.

The immediate goal is not to deliver TV pictures to a network computer or home browser. We all consider ourselves experts in watching TV and, to even an unsophisticated eye, a quarter screen movie playing back at 15fps is not what we are used to seeing. Broadcast quality video is not the goal. What the technology will do, however, is bring a whole new level of interactivity and user choice to online applications. Remote banking and distance learning will be taken to new levels and emerging applications such as home shopping, narrowcasting, news-as-it-breaks and interactive tourist kiosks will all be brought one step closer to achieving their original design and commercial goals.

5.3. Fractal video compression

Fractal video compression is optimised for low bit rate video delivery in online applications and addresses the issues that existing video compression schemes hadn't even considered. It enables you, the publisher, to deliver your message the way you want it to appear, more clearly, and to a wider audience in less time.

If your video message is low-action as with a talking-head clip, filmed in front of a static background with minimal movement, then a compressed video data rate of around 10 kilobits per second may provide perfectly acceptable quality. Take, on the other hand, a high-action video message. Obviously the more action, the more data you require in the compressed video stream to deliver the message clearly — a rock music video, for example, may require over 100 kilobits of data per second to have the desired impact.

Clearly then we need a scaleable technology: one that will work well at both ends of the spectrum. Fractal technology gives us this scaleability with a unique video compression method that exceeds our expectations by providing surprisingly good results at very low data rates, and increasingly higher quality results as more data is allocated to each second of video: ranging from about 14.4 kilobits per second (standard modem), all the way up to 128 kilobits per second (dual ISDN).

6. The products

It is, and has been, Iterated's belief that the delivery of information is key in today's networked world. To support this belief, the company has recently launched a new product range for both still images and video, based on its patented Fractal Image Transform to give surfers, software developers and content providers for the Internet/intranet a solution to the Web imaging dilemma — providing high-quality at low data rates.

These new products are part of a new business strategy, 'fame and fortune'. The aim is to establish fractal technology as the *de facto* standard for images on the Internet/intranet. To assure service and content providers that their fractal images will be widely accessible and viewable, Iterated is aiming for the mass proliferation of fractal technology with free stills and video decoders downloadable from its Internet home page on the World Wide Web. The focus is to provide software-only fractal encoding and decoding products to the mass-market so that the use of fractal technology is as simple and inexpensive as possible.

Iterated has torn down the 'barriers to entry' for the wannabe Web publisher and professional corporate Webmaster alike. Generation of fractal content is executed by shareware products, and delivery uses standard frameworks like Video for Windows and QuickTime. In addition, by embracing emerging Web technologies like ActiveX, Java and LiveMedia your content can be delivered without the additional expense and implications of proprietary Web server software.

7. The technology in use

Developers have long since realised the benefits of using fractal technology to achieve fast delivery and good picture quality for CD-ROM-based applications. It was fractal technology that allowed Microsoft to incorporate 7000 images into its *Encarta* CD-ROM encyclopaedia, and Hutchinson and Grolier soon followed suit for similar projects.

In today's rapidly expanding online world, the potential for fractal technology is limitless. Smartcard developers, desperate to squeeze the highest amount of information into a limited amount of space, are already making good use of fractal technology to store highly-compressed, high-quality images on smartcards which can then be taken online for a variety of security based applications.

The World Wide Web itself is already playing host to a vast number of diverse fractal-enabled sites, and numbers are increasing on an almost daily basis. Fractal compression is also proving itself to be a major force in intranet-type environments, enhancing functionality and increasing data throughput across local and wide area networks.

8. A customisable technology

Iterated will continue to develop the core mathematics to enhance the possible applications of the technology, and will carry on with the customisation and optimisation of its products to sharpen any specific features required by applications in vertical markets such as medical imaging, security, high finance, entertainment and Web broadcasting. Projects are already underway for security cameras and network computers, for example.

As online graphics technology improves, fractal compression technology continues to undergo significant changes. It is worth noting that since the technology was first introduced, compression times have been reduced by more than 90%. This staggering improvement, coupled with industry advances within the online services sector that provide tremendous opportunities in networked information flow and communication, and future discoveries and improvements can only advance fractal technology beyond its current superior performance level and give value to developers and users alike. Value that is measured, not by the illusion of multimedia lavishness, but by how well it helps you the publishers to sell, educate and entertain.

The next time you run across a site that is fractal-powered, remember, your expectations will be exceeded, clearly.

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