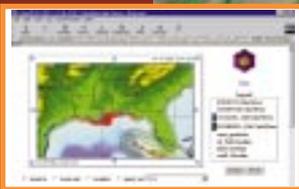




ECW: Wavelet Compression Beyond Limits?



High-resolution Imagery of the Earth's Surface
How to Extract, Analyse and Display a Wealth of Information



Combining Maps on the Web
The OpenGIS Web Mapping Testbed Explained



UK's Largest Aerial Photographic Survey Project
80,000 Ortho-rectified Images for Professional and Home Use



Creating Synergy
The Integration of ERP and GIS



ECW: Wavelet Compression Beyond Limits?

Image compression techniques were introduced in our magazine with a long article last summer. The new discrete wavelet transform compression was also presented in details. Then we predicted that harvesting fruits growing on this new technology will begin immediately, bringing our geoinformatics business in a whole new perspective. This article brings you undoubtedly one of the juiciest fruits from the wavelets' tree so far, the ECW wavelet compression from Earth Resource Mapping company. Knowing that wavelets as a commercial image compression technique are actually newcomers on the market, one obvious question comes into my mind - where are the limits of wavelet image compression...? Until the reasonable answer to this question is found, read on the following lines and you will discover that already the present wavelets capabilities are at the verge of believable.

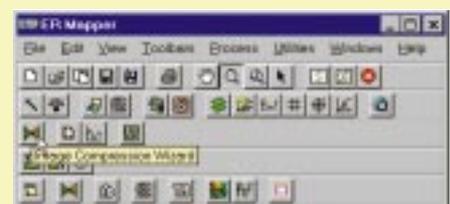
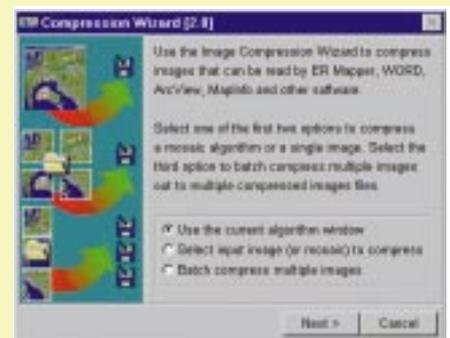
By Joc Triglav, Technical Editor Geoinformatics

If you ever used or generated raster imagery you probably found out that file size is often an important issue as digital raster images are usually large. In some cases these images are even so huge that they exceed your available physical computing resources at least in terms of disc storage, processing capability and image generation or manipulation time. Even if you are among those few in the business that do not encounter these problems in

their own companies, the problems immediately arise in the moment when such massive imagery needs to be distributed to your partners or customers. Then CD-s get too small and suddenly you are caught in the middle of storage and distribution nightmare. Well, compression comes as a natural choice to shrink raster imagery down to a manageable size and let's take a look how Earth Resource Mapping wavelets' based solutions can ease this and other raster image generated burdens.

ECW - Enhanced Compression Wavelet

The image processing expertise Earth Resource Mapping developed in processing large amounts of digital imagery with the ER Mapper product has somehow naturally lead to the development of ECW compression. ECW stands for Enhanced Compression Wavelet raster image compression software that has been designed



ECW compression inside ER Mapper is done with a few simple steps in Compression wizard

to compress, display, Internet serve and distribute imagery. To cover each of these tasks separate software packages were developed and their short introduction follows.

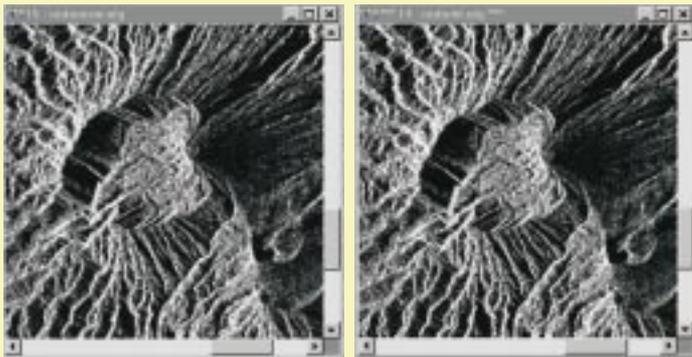
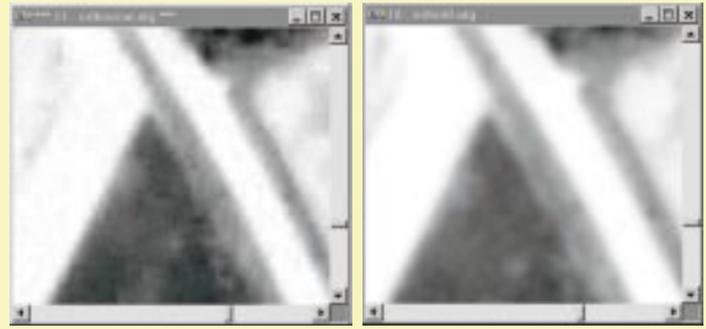
- ECW 2.0

ECW compresses by transforming images into wavelet space using multi-level Discrete Wavelet Transformations (DWT).

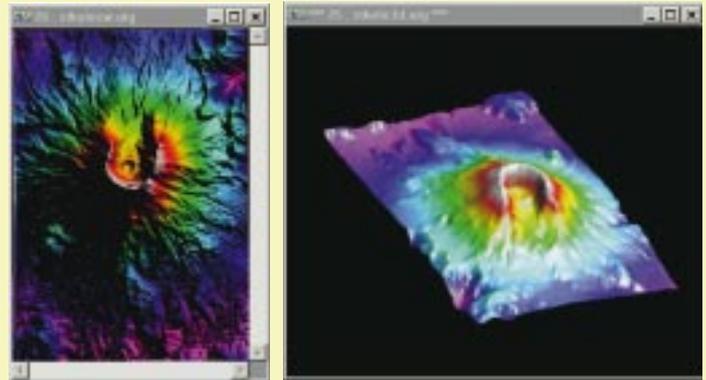
ECW compression functionality is included in growing number of different software



A detail from grayscale digital orthophoto image viewed at two different zoom levels - ECW compressed image is on the left and the original TIFF image on the right. Compression ratio 20:1.



A detail from Radarsat radar grayscale image of a volcano shows actually no difference between the original and the compressed image. Compression ratio 20:1.



Compressing a 3D view algorithm in ER Mapper gives a "normal" compressed image.

The next step is quantization, which reduces image information content, followed by the encoding phase, which actually compresses the wavelet space images. The ECW compressed image is processed line after line directly from the original image. Therefore the ECW compression technique can process images of any size, using relatively small amounts of RAM, making it extremely useful at compressing very large images. The ECW uses a patent pending recursive algorithm pipeline technique which does not require the use of disc storage while performing the DWT.

- ECW Compression Wizard

I had the opportunity to use the ECW 2.0 Image Compression Wizard inside ER Mapper software as well as a free ECW Compress software that allows compression of single raster images up to 500 MB in size and is downloadable from <http://www.ermapper.com>. Compressing unlimited size images and/or compressing image mosaics is available with an ECW 2.0 Compression Enhancement Pack that is built in the latest version 6 of ER Mapper software, where it is tightly integrated with other image preparation functionality (image processing, orthorectification, colour balancing, contouring, surface gridding, vector rasterization, map production, etc.). Using the image compression wizard in ER

Mapper we can choose whether the compressed image is grayscale or RGB (colour), and then we select the compression ratio. Actually, the wizard suggests the best compression ratio for the chosen image type, not limiting the user to select any required compression ratio. The wizard follows the user's selection showing in advance the resulting compressed image size. When all our requirements are met we start the ECW compression process and store the result as an ECW image file. As a sample set of imagery for compression I took my usual set of images and as the rest of samples I have picked up various images from the image examples packed on the ER Mapper 6.0 CEP CD-ROM. Some examples of ECW compression are shown in the pictures with adjacent captions.

- Quality Matters!

My general impression of ECW compression is very good. The compressing procedure is simple and fast, though the wizard didn't usually compress at the desired rate. I expected the actual compression ratio to be at least the same or higher as the set target ratio, but sometimes it was also lower. This was happening regardless of the type of source image, i.e. grayscale or RGB. When compression calculates size, it works off the original size of the input image and not off the current size using

your current compression method, like for example RLE encoding or LZW compression. I am not writing this to discourage you from using wavelet compression but on the contrary to show you the intelligence built in the software. When a discrete wavelet transform is performed inside an image and afterwards the result is quantized and encoded to make a compressed image, the software could choose between two strategies, i.e. either to pre-

ECW compresses to a certain quality, not to a certain size. This way user gets constant quality with varying file size rather than a constant file size with varying quality.

serve the user set target ratio or to preserve the quality. You must know that you can't have them both! ECW compresses to a certain quality, not to a certain size. This way user gets constant quality with varying file size rather than a constant file size with varying quality. When you think a little, you will recognise this is the only sen-



Some Useful Hints on Wavelet Compression

- The key characteristic of the wavelet based compressions is that they are able to preserve a very good quality of the image - not showing artefacts or making the image blurred - with high compression ratios.
- An increase in the compression ratio at the wavelet image compression will lead to less quality of the compressed image. Generally it is more useful for the user to keep the quality than the target compression ratio. This is very important in the case of geographically referenced photographs, scanned to high resolutions in which the quality is the main target.
- The compression ratio depends a lot on the dispersion of the values inside the image. For example, uniform areas as deserts, water and similar compress very well, while complex coverage like urban areas are more difficult to compress.
- Wavelet compression and lossy compression in general achieves better results for photo style imagery (airphotos, etc.) than for line-art style images (scanned maps, etc.)
- The free downloadable ECW v2.0 software never applies automatic 99% clipping. That is true also for ECW inside ER Mapper, but ER Mapper 6.0 itself applies 99% clipping automatically as most of the image processing software do. Depending on user's ECW compression goals, user should consider deleting 99% clipping transforms prior to compression from an image window or use compression directly from a file instead. The new ER Mapper 6.1 applies 99% clipping in a smarter way only when needed.
- Even with low compression ratio the user gets multi-level wavelet file, making it fast to access off slow media such as CD-ROM and fast to serve over the Internet.
- Image Web Server (<http://www.earthetc.com>), ER Mapper product to serve large compressed images in the Internet and intranets, shows in practice that the speed of displaying the images is almost independent of the size of the compressed images as the engine only decompresses the area of a current zoom.

sible way to do any compression. So, when using wavelet compression don't just go hunting for brainless high squeezing ratios while the quality of the compressed image is what should be considered in the first place. It's nice to know that at least software takes care of this if you don't.

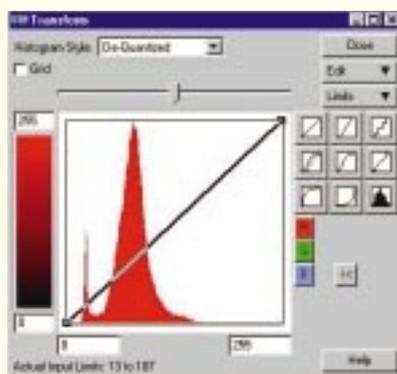
Taking into account the above explanation the quality of compressed images was above expectations, considering applied compression ratios. However, the user should be aware that compressed imagery should not be used in applications, where important information is hidden in very small image details or in subtle variations

of the data. The only possible solution in such cases is to use a much lower compression ratio, which gives a compressed image very close to the original image. Again, don't get too greedy for those high compression ratios.

- ECW Preserves Georeference

ECW compressed images have a standard .ers header file with information about the image file, therefore the full georeference and projection/datum information about the file is maintained, i.e. the compressed images will be automatically registered with other raster or vector data in the same way as an uncompressed file. However, it is

A Few Worthy Words on 99% Clipping



A "normal" RGB satellite image with its adjacent histogram

The image shown above corresponds to one of the examples from the ER Mapper 6.0 CEP CD-ROM and perfectly meets the criteria for this example of explaining 99% clipping. It is a false colour composition of a Landsat TM RGB (red-green-blue bands) satellite image, in which the areas with high vegetation activity can be seen in red while in the left side of the image there is a lake in dark tones and the clouds in white tones. Considering the total amount of pixels of the image, the amount of pixels of these two kinds of coverage is very small. The rest of the colours in the image are intermediate colours between the dark lake and the bright clouds.

- Image to Histogram Translation

When you load any image inside an image processing system, usually that image has no colour enhancement. The colours in the image are a translation of a range of numbers, usually from 0 to 255 (8 bit range). The cloud pixels will have a number assigned in the top of the range (near 255), while the lake pixels will have numbers near to 0. So, the 0 is the minimum

brightness and 255 is the maximum brightness for each band. Translating the image shown above into a histogram of frequencies to represent the amount of pixels of each value, you get (for each one of the bands that compose the image) a histogram like the one shown above. In there, most of the histogram corresponds to intermediate values, although there is a peak in the lower part of the histogram representing the water with lower values, and there are a few pixels in the higher values of the histogram, which represent the clouds.

The histogram has two scales - one horizontal, in which the values of each pixel of the image are represented, and another vertical one, that gives the colour value assigned to each pixel in the horizontal scale. In the above histogram, that corresponds to the red band of an image, there is a line that relates each value in the horizontal scale with each value of the vertical scale. In that figure, you can see how the relationship is the normal one, with the 0 value in the image (horizontal scale) relat-



A Hint for TIFF/GEOTIFF Users

When ECW compressor (standalone or in ER Mapper) opens a TIFF file, it searches for georeference information in the following order:

1. If there is an .ERS file present for the TIFF file it is used in preference to all other header info.
2. If there is no .ERS file present, the software checks for GeoTIFF headers in the TIFF file.
3. If there is no .ERS or GeoTIFF header information, the software looks for .TFW file.
4. If there is no header data available, the software sets cell size to 1 meter with units equal to image size and performs the compression.

important to know, that you must use an uncompressed image when using image rectification tools and you should therefore

georeference any selected image to the desired map projection prior to compressing it.

ed to 0 display value (vertical scale), and the same effect applied to the 255 value and therefore extended to all values of the band. So, with this relationship, the pixel value 25 in the image will be seen with a red tone of 25 in the vertical scale, and so on.

Usually, the values of a coverage in the image are not a fixed value (for instance, all the cloud pixels don't have the value of 255), and they usually cover a small range of values as for instance, the cloud is seen in this band with pixel values from 131 to 187, while the water is seen in values from 13 to 35. The effect of these "hot and dark spots" in the image is that they reduce the amount of tones we can use to represent the main part of the image (with pixel values in the middle of the range, that represent the part of the image that is not covered with clouds or water). The histogram main part is displaced to the left - therefore the linear relationship assigns then the lower colours in the vertical scale to most of the pixels in the image, and the image is dark.

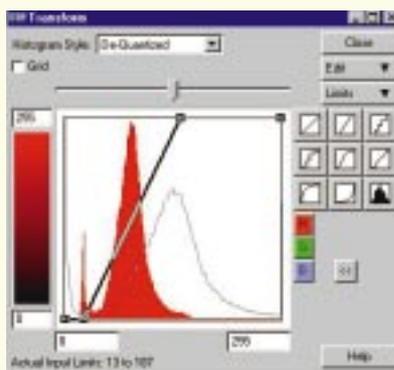
This is a typical effect in all images, even if they haven't got clouds or water as this happens also because of some atmospheric effects, like Raleigh dispersion in the blue bands on colour photos, the presence of shadows in the terrain, etc. The 99% clipping effect is applied to avoid this effect and make the image brighter. That is useful for most of the users, especially if they don't have experience in image processing.

- Explanation of 99% Clipping Effect with a Histogram

Now, look at the histogram shown below.

In there, a transformation has been applied with the default 99% clipping. What the default 99% clipping does is to cut the edges of the histogram, in a way that keeps the 99% of the pixels inside the limits, and assign fixed values to all the pixels outside the new limits. This technique assumes that the extreme values in an image, that are less than 1% of the total amount of pixels, correspond to information that can be assigned to a unique value because they are not representative of the whole information of the image.

Look again at the histogram and you see the line that crosses the histogram begins in the value 23 and ends in the value 135 (instead of the previous 0 and 255). But the vertical scale remains constant, from 0 to 255. Now, the value 23 and all the values below that one in the image are assigned to 0 in the display colour scale, and the value 135 and all the values higher than this one in the image are assigned to 255 in the display colour scale. The result of this operation is to displace the histogram body to the right, and therefore brighter colours in the vertical scale are assigned to the main pixels in the image.



- Mosaic Wizard and Balance Wizard

An extremely useful option, available only in ER Mapper and not in the free standalone ECW Compressor, is to use mosaicing and colour balancing of the imagery, and then save the resulted mosaic of multiple images directly as a single georeferenced ECW compressed image. ECW process can also be used to merge images of different spatial resolution. I used mosaicing of 35 digital orthophoto grayscale georeferenced TIFF/TFW files (1 gigabyte input size) and compressed the mosaic into a single ECW file (40 MB resulting size) with the Mosaic Wizard and Balance Wizard in ER Mapper. The mosaicing is a straightfor-

The wavy polyline that you can see represents the histogram as it is after the 99% clipping.

- The Image with Applied 99% Clipping

The result of this can be seen on the image shown below. The 99% clipping has been applied to the three bands on this image, and the result is a more bright image, with most of the high values in the clouds set to 255 - so the clouds can be seen in a brighter white colour, and the low values of the water set to 0 - so the water is very dark). The rest of the range of visualisation colours covers then all the intermediate pixels, and you can see how the image is in general brighter.

This is more or less what happens with the 99% clipping, explained with an example image. Though 99% clipping has nothing directly to do with compression, awareness and understanding of this function is needed for a proper work as it is an important and indeed essential function for many types of imagery.



The same image as above with applied 99% clipping has a different histogram, i.e. a brighter image



ward procedure in a few simple steps after which the selected image mosaic is set up according to georeference data adjacent to images or built into the images. The best practice is to store all images of the mosaic with their adjacent georeference data in a single directory. I did so and there were no problems in compressing a mosaic into a single georeferenced ECW file. Before compressing a mosaic user can run the Balance Wizard to radiometrically balance the images and this way reduce the usual 'chessboard' effect in mosaics of different images. Though experimenting with balance options can give excellent results, the user should not expect miracles. Usually radiometric differences can not be removed completely as for example images that form a mosaic can be from different seasons of the year. However, when balancing is used with some brains and sense, the results can be astounding.

ER Viewer 1.2

The ECW viewer (ER Viewer) is a freely available viewer than can be shipped with any imagery compressed with ECW format, at no charge. The viewer is downloadable free from <http://www.ermapper.com>. It is a simple compact software for viewing the following image formats:

- alg ER Mapper algorithm file
- ers ER Mapper dataset file
- ecw ER Mapper wavelet compressed image
- tif RGB tiff or geotiff image. Most of the common tiff formats are supported
- bmp 24-bit Windows RGB uncompressed bitmap file
- hdr ESRI BIL or GeoSPOT raster image file
- jpg JPEG compressed image
- doq USGS DOQQ image in BIL format (grayscale only)
- dat CEOS variant used by RESTEC in Japan

- A Simple and Effective Viewer

The software has a few simple tools that user can learn in seconds. For example, besides the usual zoom and pan functions duplicating the currently active image window allows you to create an independent copy of an image to look at multiple views of the same image. A very useful option. A measure tool can be used to view coordinates of a point and the shortest distance from a chosen start point. A tool for displaying general and georeference image data like the projection name, datum, units, the coordinate type and the rotation of the image, is also included. The smoothing function for the image in the current window can be toggled on or off. When smoothing is on, blocky or pixelated images are smoothed out. Smoothing is for example useful for geophysical type images, which often have poor resolution and applied smoothing can give them a more eye-pleasing look.

It's also useful to know that ER Viewer is implemented as an OLE server. This means that you can insert ECW compressed image or any other ER Viewer supported file formats into other applications that support containment of OLE objects. For example, you can place such a file into Microsoft Word or PowerPoint and make dazzling documents. In short, the combination of using ECW compressed imagery distributed along with the free ER Viewer gives geoinformatics' users a useful and (hassle-) free solution. And that is actually everything that is to tell about this free software.

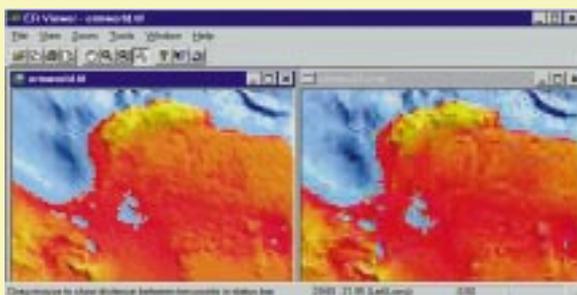
Automatically Adjusted Contrast in ER Viewer

When opening an ECW compressed image in ER Viewer the user has two options. The usual double-clicking of an image file from the File open list or using the option to 'drag-n-drop' the file into ER Viewer window automatically triggers 99% clipping (look at explanation on this term in another frame) before displaying the image. Comparison of the ECW image with the original image file shows ECW image much brighter, in more vivid colours.

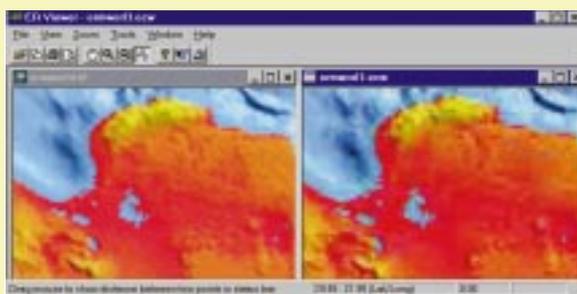
Sometimes, this is not what you wanted or expected to see. To avoid this, use the File Open icon in ER Viewer and make sure that "Automatically adjust contrast" button at the bottom of the File open menu is not ticked. This way the 'normal' ECW image without colour shift is displayed.



The free ER viewer reads ECW compressed images and other image formats



A detail from an original and compressed RGB image with smoothing option switched off - individual pixels are seen



A detail from an original and compressed RGB image with smoothing option switched on - pixels are smoothed

ECW Compression/Decompression Libraries

As declared from Earth Resource Mapping the ECW technology is an open standard, with both Decompression and Compression Software Development Kits (SDK) application integrate libraries available at no cost, enabling application developers free and unrestricted reading and creating compressed imagery to a maximum of 500MB input images inside their own applications. The ECW decompression libraries enable any application to use imagery via the Internet. At a first sight this is quite an unusual market philosophy. On the other hand, nowadays it's almost a necessity for



a software company in order to spread the usage of a certain type of software. Many software companies offer free downsized but fully functional versions of their flagship programmes or a time limited full versions of software. This way the user has an opportunity to test the suitability of such a programme for his specific needs. In our case the software is very good, so it is obvious that sooner or later a serious user will want to jump over the free 500 MB barrier, where the real business begins.

Free ECW Plug-ins

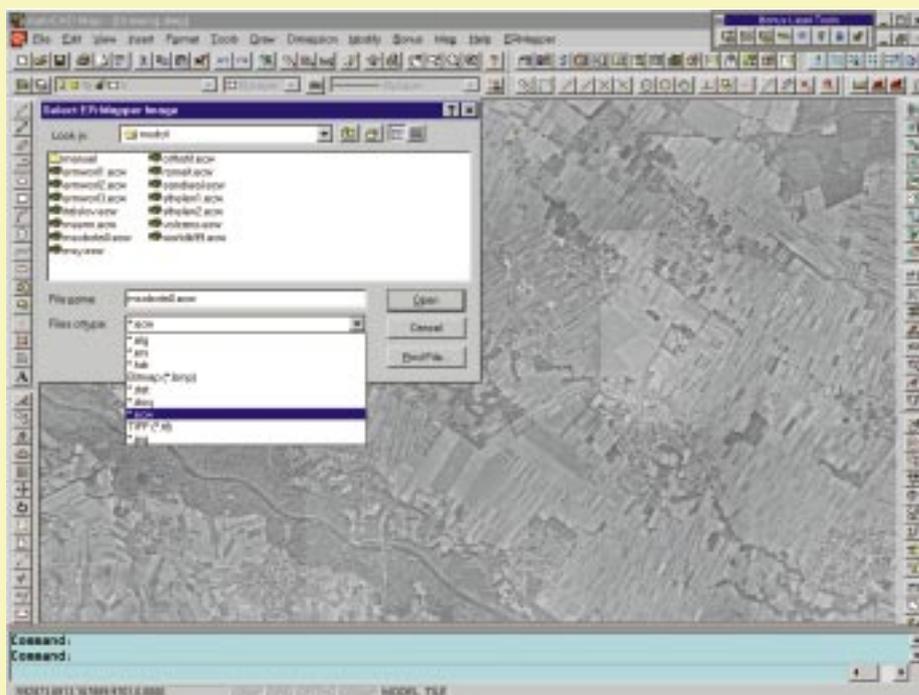
Free imagery plugin extensions for GIS, CAD and Office applications are downloadable from <http://www.ermapper.com>. They enable reading of ECW compressed data inside a wide range of software applications such as AutoCAD MAP, ArcView, MapInfo, Microsoft Office, Photoshop, etc.

- AutoCAD MAP 3 ECW Plug-in

As a daily AutoCAD Map user I didn't hesitate to download the free beta version of the ECW plug-in for this software. After installation of plug-in an ER Mapper menu is added at the end of standard AutoCAD Map main menu. The ECW compressed images are opened with Image Attach function allowing users to use very large images of actually any size inside AutoCAD Map. If images were compressed with georeference data, the image is correctly positioned in AutoCAD Map and allows normal combined use with other vector or raster graphics. ER Mapper decompression engine, which manages the display of the imagery within AutoCAD Map, continually re-defines the ECW image object, specifying an updated extents and sample factor based on user's current zoom. This procedure is performed whenever the user exits Real-time Zoom mode. This trade-off comes a little bit awkward at first, but considering the huge, previously unimaginable sizes of images, that can be viewed inside AutoCAD Map, it can be forgiven. Remember, it's still a beta version with new improved free releases for AutoCAD Map 3 and AutoCAD Map 2000 already announced.

- Using the New ECWP:// Transfer Protocol Inside Your Applications

In the last hours before finishing this review, I found out that the new ER Mapper beta products allow "remote-viewing" of huge images over the Internet inside applications (using the new ecwp://



A part of a colour balanced 1 GB mosaic of 35 digital orthophoto grayscale images compressed into a single 40 MB ECW image, shown within AutoCAD Map using free ECW plug-in

transfer protocol) without physically transferring the entire massive images to your hard disc. For now, I am talking about ArcView ECW URL plugin and ER Mapper 6.1 with ECW URL functionality, but similar plugins for AutoCAD Map and other software will follow this year.

I am sure you will agree with me, if I say with appreciation: it was about time the market of the 'normal' GIS, CAD and Office users is offered the possibility to view huge images, available on some distant

An extremely useful option, available only in ER Mapper and not in the free standalone ECW Compressor, is to use mosaicing and colour balancing of the imagery, and then save the resulted mosaic of multiple images directly as a single georeferenced ECW compressed image.

image server, inside their everyday applications. This way many geoinformatics users will be able to use imagery in a totally new

approach. Definitely a giant leap for geoinformatics science!

Image Web Server (www.earthetc.com)

If you ever tried to view very large images over Internet, your main impression in spite of all the beautiful images was probably the slow speed. The large size of image data and network bandwidth limitations are two main obstacles making availability of imagery over the Internet usually a painful experience. For on-line viewing users are usually given an option to view thumbnail compressed images (JPEG, GIF, etc.). This becomes extremely awkward for images from the geoinformatics arena, where cutting beard is a usual task while waiting for such an image to display. If the user then wants to have the actual image, there is no practical way he/she could get it over the Internet. Well, at least until the wavelet compression stepped in and showed us how to serve large gigabyte or even terabyte sized images via the Internet or intranets even to users with usual speed modem links.

- Viewing and Using Huge Images over the Internet

The Image Web Server using ECW technology with its progressive image transmission is an excellent example of this technology and supports the ability to serve images

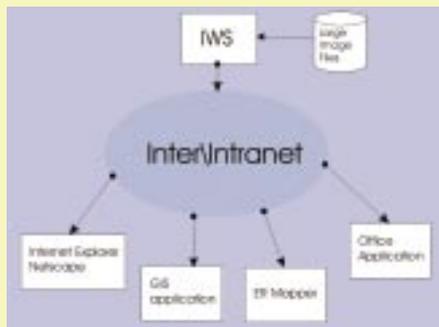
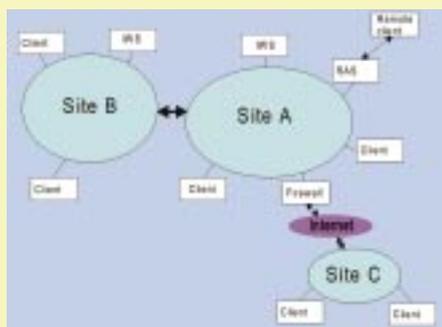
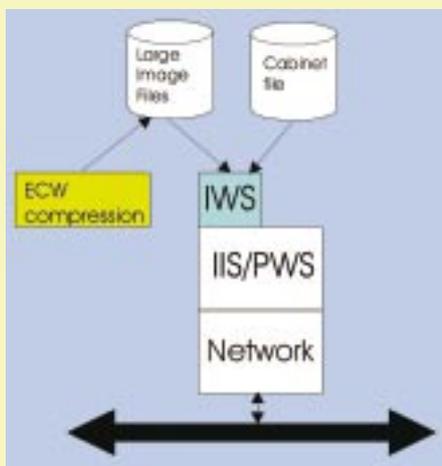


Image Web server offers remote viewing of huge images from a distant image server over Internet using a special ECWP:// transfer protocol



The diagram shows a possible intranet for a large corporation. This corporation has two large sites, A and B, and one smaller one, C. Each of the three sites has its own LAN (Local Area Network). The LANs of the sites A and B are interconnected by a leased broadband network. Site C accesses the site A network via the Internet. The site A network also has a RAS (Remote Access Server) to enable remote users to dial in. An Image Web Server could be located at either site A or B, or both site A and Site B. The RAS and the Firewall are also set up to combat the threat of unauthorized access. The NT server RAS requires a User Name and Password, and the NT Firewall has a number of filtering options.



The Image Web Server is installed as an add-on to the Microsoft IIS (Internet Information Server). For small numbers of clients (less than 10) or evaluation purposes, the Microsoft PWS (Personal Web Server) can be used.



Image URL: ecwp://www.earthetc.com/images/uk/london.ecw. One of the images available for testing the Image Web Server capabilities. The image shows part of London (UK) and is created from a mosaic of orthophotos, balanced and compressed using ER Mapper. Image size is 16000*12000 pixels RGB, each pixel covers 25cm x 25 cm on the ground. Uncompressed image size of 576 MB is ECW compressed with ratio 20:1 to 29MB size.

via the Internet or intranets using all common application interfaces: OLE, ActiveX and ATL. It can serve many different types of imagery including airphotos, high resolution satellite images, digital terrain models, radar images, etc. These images can be accessed from within web browsers or soon using CAD, GIS and MS Office application software as mentioned above. For potential Internet image providers it is useful to know that Image Web Server is E-commerce ready and supports charging access subscription fees or charging downloaded image sub-sets. A tight integration of imagery with user's existing web based HTML and database applications is another

good news from Image Web server. And, though I have repeated this a few times already, the fully functional beta version is downloadable free from <http://www.ermapper.com>.

- Seeing Is Believing, so Check It by Yourself

I advise you to visit the <http://www.earthetc.com> Internet site, where you can test Image Web Server capabilities in practice. A list of large size, or considering the Internet environment I should say huge, images is available for viewing. Do not hesitate to choose for viewing any of those images, even the largest ones. I am posi-

Do You Want To Know More on Wavelets?

For those of you readers who think that in spite of this long article it wasn't said enough on wavelet compression, for a start of web surfing here are some interesting URL addresses to enlarge your knowledge on the subject:

- <http://www.programmersheaven.com/links/link11.htm>
- <http://www.wavelet.org/wavelet/index.html>
- <http://www.mathsoft.com/wavelets.html>
- http://www.zdwebopedia.com/TERM/d/data_compression.html
- <http://www-stat.stanford.edu/wavelets.html>
- <http://www.cs.ubc.ca/nest/imager/contributions/bobl/wvlt/top.html>
- <http://www-dsp.rice.edu/software/>
- <http://www.aware.com/products/compression/compression.html>
- <http://www.amara.com/IEEWave/IEEWavelet.html>
- <http://www.amara.com/current/wavelet.html>
- <http://www.crc.ricoh.com/CREW/>
- <http://www.isds.duke.edu/~brani/wavelet.html>
- <http://www.mat.sbg.ac.at/~uhl/wav.html>



ECW compressed Resurs-01 satellite image of Northern Adriatic and Alpine region

tive that once you see the Image Web Server in action it will turn upside down your perception of what is huge and what is tiny, especially in the Internet. Any additional words are useless here, just go and check it for yourself.

Instead of a Summary

I don't know what is happening to me, but when I begin to write on wavelet compression I just can't force myself to end. I ask myself if I am too enthusiastic about these wavelets? While searching for possible confirmation to this answer, the reality in the last year is always quicker with new wavelet based software from different vendors, from the big ones to a bunch of

The wavelet compression has stepped in and showed us how to serve gigabyte or even terabyte sized images via the Internet or intranets

smaller wavelet based products. We described two major wavelet players in the geoinformatics field so far, but we are still far from saying the last word on it. The development here is so hot, that a constant close look is barely enough to follow all the novelties. While doing this and previous review on wavelets I checked the world wide web to get some additional theoretical and practical background on wavelet compression. I guess I could read on wavelets a whole year or more and I still wouldn't swallow all the web resources on this subject. And the number of the URLs is rapidly growing. This fact itself is a guarantee that more

astounding software solutions will hatch from this nest soon.

- Do Not Hesitate and Enjoy the Ride!

This review presented as detailed as possible an excellent example of wavelet based software suite. It is of unusual length only because in combination with July/August 1999 issue our magazine wants to give you readers the necessary minimal background on the wavelet compression to be able to follow the developments in the near future. If you still don't use efficient image compression at your everyday work, this has to change and will change!

Therefore let me finish this story with a question and an invitation: Don't you think the time has come for you to join this wavelet compression caravan? Do not hesitate too long, as you will definitely enjoy the ride!

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