

Web Image Processing Technology based on Wavelet Formatted Images

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Abstract

Processing of digital colour images becomes more and more important as respective markets like digital photography and digital document managing grow exponentially. Resolution, quality and file size of digital images generated by digital cameras increased tremendously over the last years, pushing the development of complex data archiving solutions for web based applications, allowing users to host their digital images.

Downloading of images for processing purposes requires fast data transfer in order to reduce waiting times. As the available bandwidth mostly is not sufficient, only new image compressing formats based on wavelet technology offer a satisfying solution: images may be processed only on a quicklook, generated out of the high resolution image. A protocol of the changes will be transferred to the back-end server, starting the changing processes on the original high resolution image hosted on the back-end server.

The paper presents the online image processing technology in detail based on a reference application used in the digital photoservice. That includes demonstration of the online image processing features like image optimisation (cutting, rotation, mirroring, colour changes etc.), image effects (Pop Art, passepartout, solarisation etc.), text functioning etc.

In addition the paper will explain the wavelet compression technology, which becomes part within the new standardised image format "JPEG2000".

Introduction – The Problem

Since the scanning of the traditionally processed films is often directly done by the photo-finisher, high-resolution images are archived at the photo-finisher's server architecture. Also, to determine whether the quality, resolution and proportion digital image is suitable to perform a digital printing, the images should be located at the servers of the photo-finisher.

Usually the photo-finisher helps the customer with customized access-software to upload optimized images. Once uploaded – or scanned by the photo-finisher, a manipulation of the images directly at the server is not possible. Correcting the images means not only the upload of a better image, but also the cancellation of previous

printing order and the deletion of already uploaded, bad-quality images.

Even more, if a customer orders different products with the same image, like a cup-print and a larger sized poster, different digital images are needed to process these orders – which sometimes have to be separately uploaded by the customer.

Online processing of the images reduces not only possible round-trips to prepare a printable image, it also reduces transmission costs and is optimizing the server-overhead caused by cancelled preprint orders.

The Idea

An image, once uploaded by the customer or directly scanned by the photo-finisher, is manipulated directly at the server using a web-based front-end. Since only small images can be displayed at the clients screen, either low-resolution images or zoomed portions of the images may be transmitted to the clients machine. A flexible image format with random-tile and random-resolution access as well as efficient wavelet based image compression may be used to additionally reduce the transmission effort and the server loading.

Subsequent image manipulation is directly performed and recorded at the clients machine using these smaller and compressed images. The user may interactively vary different parameters, can undo some operations and checks the quality of the "virtually" processed image. The client software may also check whether the image manipulation would cause problems printing problems and can warn the user before applying the manipulation to the image.

Once finished, the recorded image manipulation is transmitted to the server and all steps are executed according the client machine. Since the server architecture is different from the client machine, a thin client like a java applet may be used for the web-based client and powerful workstations may be used to process the high-resolution images.

The Solution

A running software solution, according the ideas outlined before is running at Refs. 0 and 0. This software solution consists of the following components:

- Wavelet based image compression
- http – compliant transmission of the recorded manipulation steps
- Java based, platform independent client-side image manipulation modules
- Applet based, browser-enabled user front end
- Linux based server-side image manipulation modules
- Java-server based server integration of the server-side modules

Figure 1 outlines the general architecture of the user front end software.

The following image manipulation tools are already implemented and can be extended by other modules:

- Image optimisation, including rotation, cropping, mirror, contrast and brightness enhancement and automatic level adjustment
- Filtering effects like picture ageing, pop-art, passé-partout and solarisation effects
- Text insertion including colour, font and size selection

All of these image manipulation tools have to be programmed either for the client-side as well as for the server-side modules. The usage of the java programming language for the client-side and the C/C++ language for the server-side ensures the platform-independency of the client software and the optimized performance on the server-side while keeping the portation overhead as small as possible because of the similarities between Java and C/C++.

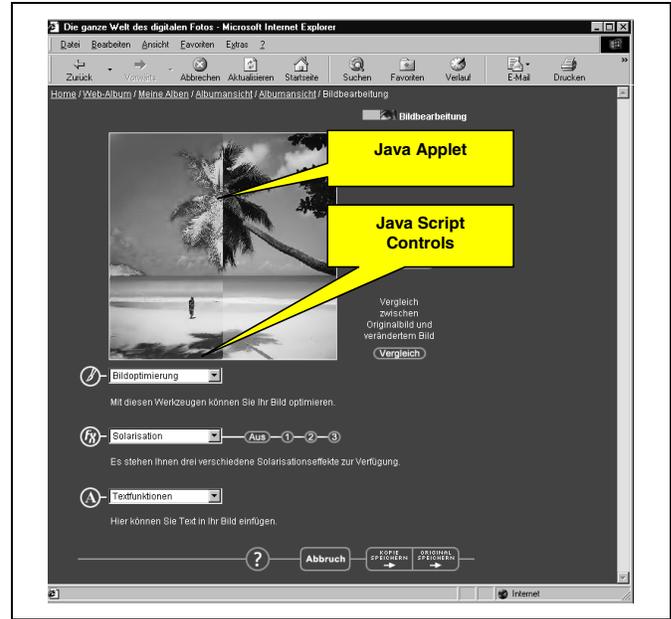


Figure 1. User front end of the image editing tool

Figure 2 depicts the graphical user-interface of the image manipulation tools. The platform-independent java applet contains the wavelet-decoding software and the image manipulation algorithms. The java applet interacts with the web-application via java-script interface methods.

Since the transmission of the images and image portions causes a high-load on the internet, an effective image compression which is natively supporting tiling and scaling features is essential. JPEG2000, the new wavelet based image compression standard is used as a transmission standard.

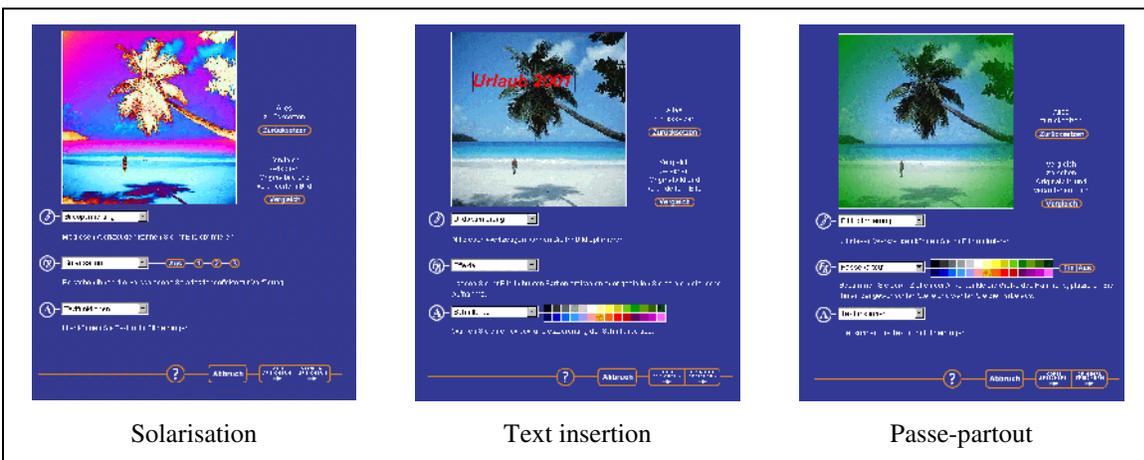


Figure 2. Image editing functions

The Backbone-Technology – JPEG2000

JPEG2000, the new wavelet based image compression standard may be used as a transmission format for the web-based image processing technology. The following features are part of the JPEG2000 standardization and are natively supported by any JPEG2000 compliant software:

- lossless and lossy image compression
- better image quality for high compression ratios
- tiled image format – supporting random access to different image regions
- resolution progressive image format, the access to low resolution images is very simple
- regions of interest, the compression quality may vary between different image regions

The following paragraphs are describing the JPEG2000 format more detailed.

Lossless to Lossy Compression

Due to the choice of variations of the compression steps, a fully reversible, or lossless compression is possible. By enabling quantization, a lossy compression is performed without affecting the other compression steps. With wavelet based compression methods, it is possible to combine both, a lossy and a lossless transform coding method in one coding algorithm.

Superior Image Quality

The efficiency of the wavelet-transformation in affecting the correlation of the image, outperforms the Discrete Cosine Transformation of the common JPEG format. This is represented by the superior image quality of a wavelet compressed image especially at high compression ratios. Figure 3 depicts the compression image quality of a highly (192:1) compressed image with JPEG2000 and the common JPEG format.

The quantization artifacts of the JPEG2000 compressed image are represented by smoothed image regions and blurring edges, whereas the compression artifacts of common JPEG are represented by significant blockiness and color distortions.

Zooming, Panning, Tiling

JPEG2000 offers a very flexible architecture for accessing the compressed image content. It is possible to decompress individual portions (tiles) of the image, if the whole image is too large to fit into the memory of the decompression workstation.

JPEG2000 allows the decompression of the individual tiles at different resolution levels. (Please refer to resolution progression for details). This enables the zooming out, zooming in and panning of the image with reduced computational resources.

Progressive Image Decoding

The order, the encoded data is arranged in the file-format is defined by the progression order. The following different progression orders are defined:

- Progression by quality
- Progression by resolution
- Progression by position

In the progression by quality order, the representation of the quantized image becomes more and more detailed, the more data is decoded. A better representation of the coefficients is resulting in a more detailed image. If all coefficients are exactly represented, the decoded image becomes lossless.

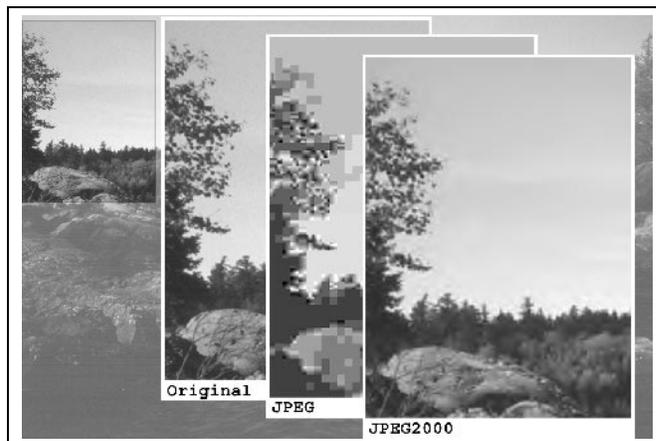


Figure 3. JPEG2000 compression quality at 192:1 compression

Figure 4 depicts the image representation of a decoding process in progression by quality – order.

If all coefficients representing a subsampled version of the original image are fully represented before the coefficients of the next subsampled version are decoded, the decoding process is resolution-progressive. The beginning of the file is representing a whole subsampled version of the original image which can be decoded even lossless. The more data is loaded, the more coefficients needed to represent the next resolution level are reconstructed. Figure 5 depicts a resolution progressive decoding process.

If the fully-detailed coefficients needed to represent the original resolution of the image are ordered in a top-down-left-right order, the image is decoded in a progression by position manner.

This method is very similar to the progression order of most of the general – purpose image formats like TIFF or GIF.

Figure 6 shows the progressive by position – decoding.

Random Access

The organization of the JPEG2000 compression scheme supports individual decoding of any progression order due to the users needs. If an image is stored in a

quality-progression way, it can be accessed resolution progressive and vice-versa.

The Random-Access information of the JPEG2000 compressed file together with an application supporting random access into the compressed data, is managing this flexible access to the image information in a very efficient way.

Region of Interest Encoding

If the level-of-detail of the coefficient representation during decoding varies for different image regions, some image regions appear at a better quality than others. This feature is called region-of-interest-coding (ROI-coding).

Figure 7 is showing the details of a region-of-interest. This region appears more detailed than the rest of the image at a given compression ratio. The region-of-interest is defined during the encoding process and allows the variation of the level-of-detail of the decoded image in addition to the quality-progression feature.

Conclusion

The new JPEG2000 image compression, together with innovative services like on-line image processing, is best suited to be used in image-based web applications like digital photo-services and web-archives. LuraTech has developed both technologies which are running in several applications.

These new services and the compression technology are the backbone of innovative solutions for digital imaging –

not only for digital cameras and web-based archives – but also for traditional photo-finishing companies on the step to the new digital world.

References

1. Pixelnet Image Archive including Online Image Processing, <http://www.pixelnet.de>
2. Photo-Porst Web-Album incl. Online Image Processing, <http://www.photo-porst.de>

Biography

Dr. Michael Thierschmann was born in Berlin on August 9th, 1961. He studied Aeronautics and Space Technology at the Technical University of Berlin and he studied Economics at the University Hagen. From 1988 to 1993 he was Assistant Professor at the Berlin Aerospace Institute doing research in the area of space transportation, satellite systems and data handling systems and where e made his Ph.D.. In 1993 he founded LuraTech GmbH, an enterprise focussing on the development of wavelet-based compression software codecs for satellite imagery, document management systems and digital imaging. In 1999 he founded LuraTech Inc. in California, US, where he is CEO & President. Dr. Michael Thierschmann is shareholder of two patents and got three awards in his career.

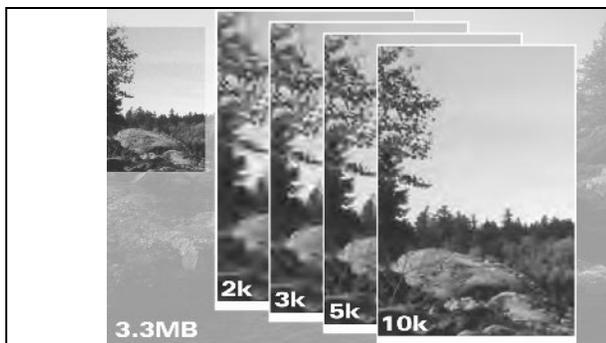


Figure 4. Quality progressive decoding



Figure 5. Resolution progressive decoding

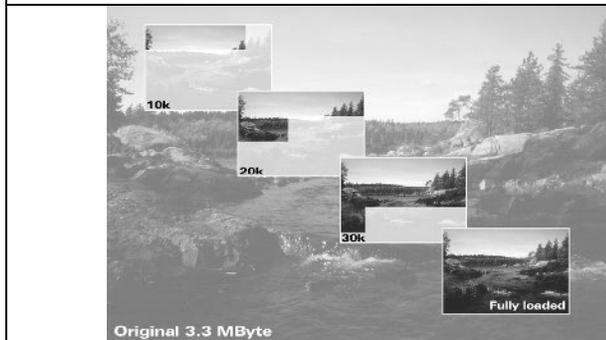


Figure 6. Position progressive decoding

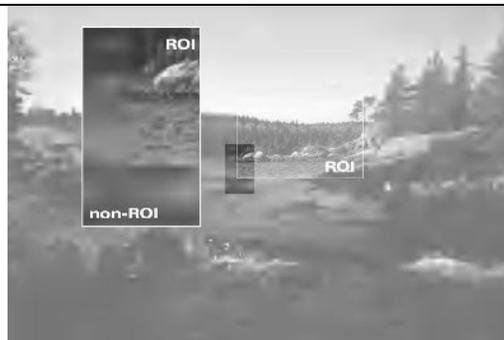


Figure 7. Region of Interest encoding