Resource-saving image browsing based on JPEG2000, blurring, and progression

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ABSTRACT

Due to resource limitations, the handling of large imagery in mobile environments is still problematic. This applies especially for browsing and navigation tasks. As existing technology fails to adapt to restrictions, new ideas for appropriate image handling are required.

This publication proposes a new approach for image browsing based on JPEG2000, blurring, and progressive refinement. Blurring is an effective means for user guidance and thus is selected and combined with progression to increase usability aspects during browsing. The resource-saving implementation of the user interface is founded on the image compression standard JPEG2000. The Discrete Wavelet Transform and options for Random Spatial Access are the main features we take advantage of in order to extract the user interface directly from the encoded image data. A discussion of the results shows that this approach saves valuable computing power and bandwidth compared to traditional technology, and is an appropriate means to support browsing of large imagery on mobile devices.

Keywords: Raster image browsing, Image streaming, Mobile computing, JPEG2000

1. INTRODUCTION

Due to their form factors and application environment, mobile devices are still limited by different constraints. To overcome the impact of the most influencing limitation – computing power, bandwidth, and screen space – information contents must be adequately processed and adapted. This especially applies for digital imagery. Modern devices allow taking and handling photos, and thus, must provide options to browse local or remote contents. Existing techniques to accomplish this task are often not appropriate to satisfy the demands of mobile computing. During browsing, they often require much computing power, a full processing and transfer of the image, and many user interactions.[1] Thus, novel ideas for resource-saving and appropriate image handling are needed.

This publication proposes a completely novel browsing approach founded on the modern image compression standard JPEG2000, blurring, and progression and thus, continues a series of recent developments for image browsing in mobile environments.[2,3] *Blurring* is an effective means for highlighting important contents and may also be applied for user guidance.[4] Progressive refinement (*progression*) provides previews with small pieces of all available image data and thus support immediate system feedback. This makes both approaches rather suited for the described application scenario. Due to its superb compression performance and numerous features *JPEG2000* is a great foundation for highly interactive and resource-saving image handling and transmission. We take advantage of these features as follows:

Computing power Blurred representations can easily extracted from JPEG2000-encoded images by an appropriate data selection founded on the Discrete Wavelet Transform and options for Random Spatial Access requiring only un-complex operations in compression domain. Progression is an integral part of the codec.

Bandwidth Blurred representations extracted from an JPEG2000-encoded image require significantly less data to be transmitted. Random Spatial Access allows for differentiated handling of high and less interesting contents.

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This publication is structured as follows: To familiarize the reader with the topic of this contribution the State of Art in image browsing is reviewed in Section 2. After motivating the use of blurring (Section 3), relevant properties of the JPEG2000-codec are described in Section 4. A novel browsing approach is introduced in Section 5, and its resource-saving implementation is demonstrated in Section 6. The eligibility of the proposed ideas is discussed in Section 7. Conclusions close this contribution in Section 8.

2. RELATED WORK IN RASTER IMAGE BROWSING

The browsing of images has always been an issue not only on mobile hardware and numerous solutions have been proposed in literature. None of the approaches, however, outperforms all others on all kinds of data,[5,6] device,[7] or application.[8–10] Thus, there is still a need for new developments. Surprisingly, only little work has been done on efficient remote browsing.

In describing image browsing approaches, it is meaningful to separate statements to the respective *content representation* and the provided means for *user interaction*.[1]

Content representation Most of the content representations proposed in literature are rather specific and limited to a certain application domain. A basic approach found in many techniques, however, is to partition the data in a currently most interesting Window of Interest[11] (WoI) usually shown in full detail and remaining background content often omitted or distorted to save screen space. There are three main strategies to present the background.

Zoom&Pan: The image is represented by the current WoI only. Thereby, the WoI may be zoomed-out to provide context and overview. Although simple, Zoom&Pan is still one of the mostly applied representation approaches. It is also well suited for mobile hardware due to its little complexity.[12] However, it is commonly understood that when Zoom&Pan is used to gain detail, memory of the context is quickly lost.[13] This imposes many interactions and usability problems.

Detail&Overview: A logical advancement of ZOOM&PAN are DETAIL&OVERVIEW-techniques. Instead of displaying the WoI only, this approach provides simultaneous context by one or multiple additional image overviews.[1] It has been shown that this well fits to the requirements of mobile hardware.[3] Navigation and exploration are significantly enhanced.[14,15] This approach also requires less interaction, but has other drawbacks: the additional screen space and computing power to provide the overview. The overview also requires users to visually switch back and forth between the two distinct views and to reorient themselves within the representation every time they do so. Furthermore, its highly-scaled content is in certain cases incomprehensible.

Focus&Context: This strategy displays relevant micro and macro information at same time on a single view. To achieve this, the WoI is embedded as focus into surrounding context. The background is distorted to fit into the available screen space by applying the lens metaphor. Thus, browsing can easily be accomplished by dragging the WoI. A typical example is the rectangular FishEye-View.[16] Due to the intuitive representation of the image content, Focus&Context techniques are well accepted by users and outperform the other approaches on many browsing tasks.[10] Nevertheless, to achieve the lens effect the background must be further divided and distorted. This makes this approach inappropriate for tasks where proportions and distances matter and is costly in terms of processing power. The often needed heavy distortion might also render context incomprehensible and can cause problems for some tasks such as targeting.[17]

These statements demonstrate that although more sophisticated in the manner to represent an image, distortion-oriented techniques are not always suitable for small output devices. The introduced content distortion is often too strong to achieve acceptable visual results. Non-distorted representations, however, require more interaction.

User interaction Browsing also means interaction. No representation is able to show all contents in all available detail at the same time. This requires intuitive means for its adaptation to current needs. Interaction can be described in terms of the *balance of control*[18] between user and device. A technique is *intuitive* if the user does not require long practice to understand and use a technique. This is especially given for real-world interactions adapted by the browsing technique. The following list identifies browsing tasks common for imagery.

- **Roaming** means *selection and immediate display of a certain image region.* Roaming interaction is a discrete jump between two distinct regions. It corresponds to the real-world task of looking up a certain content page or section. Roaming zones do often not overlap.
- **Panning** means *slight spatial adjustment of the most interesting region* and is related to the real-world expression of exploring contents on a continuous path. Contrary to roaming, old and new content region strongly overlap.
- **Scaling** means *content presentation at different scales.* Browsing by simply changing the image region is often not sufficient and does not provide the option to show the image at once. As in real life, scaling provides different abstractions of the content and thus gives the user a better understanding of the image. If the content is provided in different scales, its comprehension is enhanced.

The manner in which these tasks are supported plays a crucial role for the evaluation of a certain technique. Thereby, it is desirable to support the information seeking mantra[19] – *Overview first, zoom and filter, then details-on-demand* – without requiring extensive user interaction. This is especially important in mobile environments.

Remote browsing In mobile environments images are often not available at the local device. Thus, a suitable and resource-saving data transmission is mandatory. Since images are mostly stored and transmitted in compressed representation, encoding is of particular interest. However, it has been shown that a well-designed communication strategy combining image compression, transmission, and display even increases the saved amount of data and allows for short response times during browsing.[16] By such a holistic strategy, the need for bandwidth depends only on the user's interests and his interactions and not longer on the original image size. Due to its excellent compression performance and flexibility, the modern JPEG2000-image coding standard is adopted by many image browsing techniques[20–24] regarding efficient compression and transmission of raster image data.

Figure 1. Two examples for Depth-of-Field applied to raster imagery. The representations have been created by the proposed approach based on JPEG2000 and extracted from the modified data-stream by accessing relevant data only.

3. BLURRING AS A MEANS FOR USER GUIDANCE

Intuitive user interfaces significantly increase usability and acceptance of browsing techniques. An intuitive interface is aligned to human capabilities and does not require extensive learning. The appropriate application of blurring is able to provide such an interface: if highly detailed objects are displayed in a blurred context, the viewer is automatically guided to the detailed objects (cf. to Figure 1). This effect is called *Depth of Field*[25] and is a inherent property of the Human Visual System. Like a lens in a camera, the lens in the human eye cannot show all objects in focus at the same time. We are seldom aware of the fact that parts of our field of view are blurred – our visual system simply ignores these areas. The Depth of Field effect has already been successfully used in photography and cinematography over years.[26,27] Kosara[28] enhanced the basic concept and applied the principle to information visualization. He found that to highlight a certain region blurring performs as well as using color or saturation.[4]

A DoF representation is described by the following characteristics:

1. The representation consists of one or multiple focus regions embedded into the background
2. A focus represents interesting information and is shown in full or high detail
3. The background provides context to the foci and is blurred

The most obvious way to create a DoF representation is to blur the regions belonging to the background. Blur is characterized by two effects: less high spatial frequencies and reduced contrast. Thus, it causes a smoothing of edges and a general loss of detail.[29–31] Consequentially, mainly low pass filters are used to introduce blurring in raster imagery. The most popular representatives are *Mean filters*,[32] e.g. the Standard Gaussian filter, and *Order filters*.[33] However, blurring using filters is slow when done in software[4] and requires all available image data.

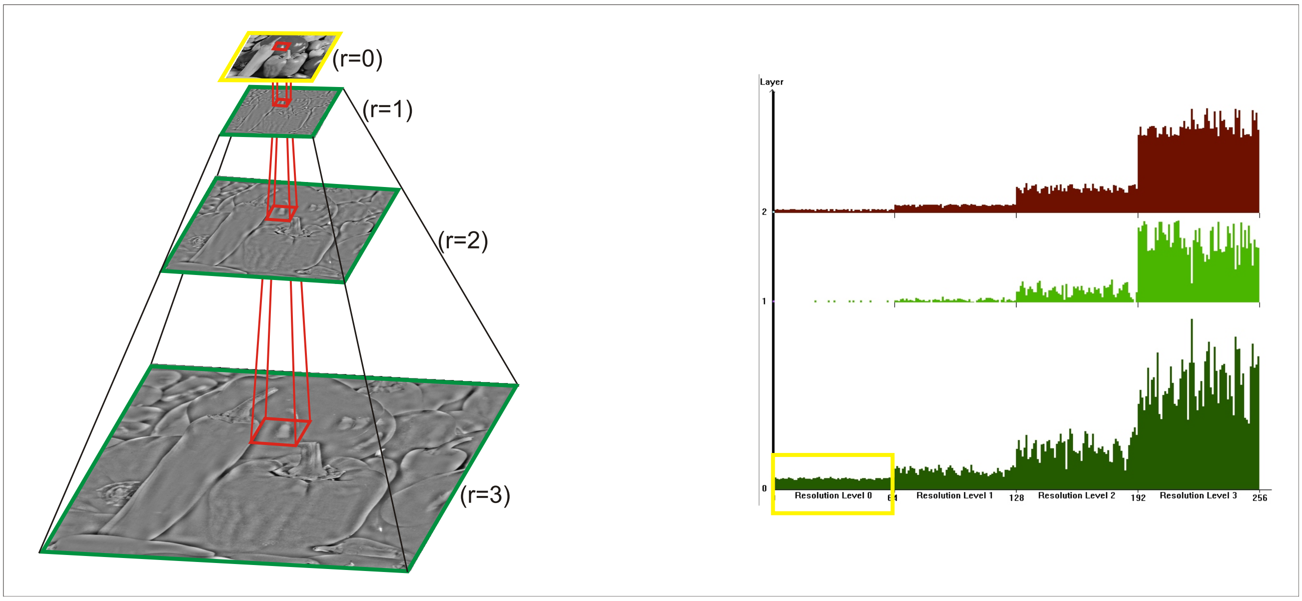

Figure 2. Separation of approximation ($r = 0$) and detail ($r = 1, 2, 3$) within a 3 stage DWT-decomposition (left) and the distribution of the resulting values over 3 quality layers (right). The data used to introduce blurring is marked yellow. The red pyramid indicates all precincts contributing to the full reconstruction of a the belonging image region.

4. IMPORTANT PROPERTIES OF THE JPEG2000-IMAGE CODING STANDARD

JPEG2000 is a modern coding standard for raster imagery and provides beside a superb compression performance a number of very useful features. It is based on the Discrete Wavelet Transform (DWT) and *Embedded Block Coding with Optimized Truncation* (EBCOT).[34] While features of the DWT may be used to impose blur, properties of EBCOT are related to the efficient partition of the encoded image data and distinct handling of focus and context.

Within a DWT of *k-decomposition stages*, labeled $d = 1, 2, \ldots, k$, the image is transformed into $3k + 1$ subbands, LL_k and LH_d, HL_d and HH_d. Due to the underlying dyadic decomposition, subband dimensions at stage d, and thus the belonging image *resolution* $r = k - d$, are half the size of stage $d - 1$ (cf. to Figure 2/left). Each subband consists of wavelet coefficients resulting from the transformation of the source signal by wavelet kernels. The baseline codec supports two different transforms, a reversible transform based on 5/3 kernels and an irreversible transform using CDF 9/7 kernels.

One major property of the DWT is the separation of image details, stored in subbands LH_d, HL_d and HH_d, and the approximation stored in LL_k (Resolution 0 in Figure 2/left). This is of great advantage as it can be exploited to extract the aspired image representation without further processing. As each additional decomposition stage removes more detail from the approximation, the number of decomposition stages and used kernels are of great interest for the quality of the blurring.

During the following EBCOT-encoding, each subband is partitioned into *code-blocks*. As each code-block is associated with a limited spatial region and is coded independently, a certain spatial region can be fully or partially reconstructed by its belonging code-blocks. The bitstreams of all code-blocks of a decomposition stage d contributing to the same pixel region are collected into larger groupings known as *precincts*. Precinct dimensions might be selected in such a way as to contribute with related precincts to a limited spatial region (red pyramid in Figure 2/left). This feature is called *Limited Spatial Access* (LSA)[35] and may be used for an uncomplex separation and independent handling of all encoded data contributing to a given pixel region.

In the final encoded image, each precinct is represented as a collection of *packets* with one packet including an incremental contribution from each of its code-blocks on each of l *quality layers* (cf. Figure 2/right). A JPEG2000 data-stream basically consists of a concatenated list of packets. The packets may be successively decoded in order to add incremental detail to the resulting pixel representation and thus, to allow for *progressive refinement*. Due to the strong relation of precincts and packets, LSA can easily achieved on packet-level.

To allow for resource-saving data transmission, the described properties must also be accessible in remote environments. This is possible by adopting the JPIP-transmission protocol[36] closely related to the baseline standard. One of the main goals of JPIP is to exploit the random spatial access properties of JPEG2000, to standardize a means of interacting with the data in an efficient and effective manner for client-server based applications.[37] Precincts are a foundation for data transmission with JPIP.

5. A NOVEL IMAGE BROWSING APPROACH

This section introduces a novel approach BLURBROWSER for displaying and navigating large raster images on small mobile client devices. Thereby, we focus on usability aspects. Statements to a meaningful implementation are provided within the next section.

5.1. Content representation

The DoF effect of the Human Visual system is a great means for user guidance (cf. Section 3) and within our proposal used as a foundation of an appropriate image representation. Strictly following its requirements, the general layout of the representation consists of two different parts: (1) the WoI by means of a focus region and (2) the blurred background (cf. Figure 3/left). The focus is displayed in full detail in order to emphasize the significance of this region and to allow for its detailed examination. The background is shown in a low detailed representation which appears as it has been blurred. The focus is well embedded into the background, can be easily distinguished, and inherently attracts the attention of the viewer. Due to its layout, the proposed displaying technique belongs to the FOCUS&CONTEXT approaches. In opposite to other techniques of this class, however, the background is not spatially distorted allowing for the provision of comprehensible context information even at devices with small form factor. Although not mandatory, we propose to represent the background in grayscale color in order to further decrease its visual significance and to increase visual discontinuities between WoI and background. To simplify adaptation to current needs, the representation also consists of a rectangle surrounding the focus region in order to provide means for interaction.

Figure 3. The user interface of the proposed image browsing system: In close-ups, the fully-detailed focus allows for an exploration of currently important image content, whereby the blurred representation of the background provides spatially-undistorted context (left). In overviews, the blurring effect is inherently reduced allowing for better orientation and navigation (middle). The means for interaction involve common elements of modern mobile hardware and support typical browsing interactions (right) as panning focus and background (green), focus resize (yellow), and animated zooming (red).

5.2. User interaction

Interaction is an integral part of every browsing interface and a means to adapt the representation to current needs. The proposed approach supports all typical interactions required for image browsing (cf. Section 2). Thereby, the interaction scheme has been designed to require as little user input as needed to achieve these tasks. Fluent animations guide the user to the desired parts of the representation and provide a causal flow within the shown contents for usability reasons.

To navigate and interact, just an arbitrary pointing device for selection and modification is required. This is not a limitation for mobile devices since modern hardware is often equipped with a touch-sensitive screen allowing for pen-based interactions. Furthermore, almost all current devices provide a 2D-rocker for further interaction. They are often used as hot-keys to activate frequent tasks.[12] All of the following browsing interactions have been designed to require only these two kinds of input (cf. Figure 3/right).

Roaming: To select a completely different image part as focus region, the user is just required to tap the center of the new region on the touch-screen display. The focus is immediately set at to new position. In case this region is actually not shown on screen, the user is required to pan the current view or to zoom-out first.

Panning: Traditional pixel-wise *focus panning* is supported by selecting and moving the focus. Its size may also be changed by modifying the associated interaction rectangle. If the focus comes close to screen borders, the current view is panned in order to allow for discovering content previously hidden behind screen borders. This interaction has been implemented by imitating real world behavior. *View panning* only starts if the focus is "pressed" to the respective border. Once activated, the view is successively moved by applying an exponential distance/time function to intuitively combine short and long distance navigation within a single interaction.

Scaling: Browsing an image by continuous panning or roaming is in most cases not sufficient and does not provide options to show the image at once. As in real-world, image content must be provided at different scales to enhance its comprehension. All scaling interactions have been implemented via the 2D-navigation rocker rather than the pen. An animated exponential change of the zoom level similar to the described view panning contributes to an fluent browsing experience.

Based on the simple and fast support for these basic interactions and the respective content representation, a user is well assisted to manage the different tasks appearing during browsing an image on a small display device.

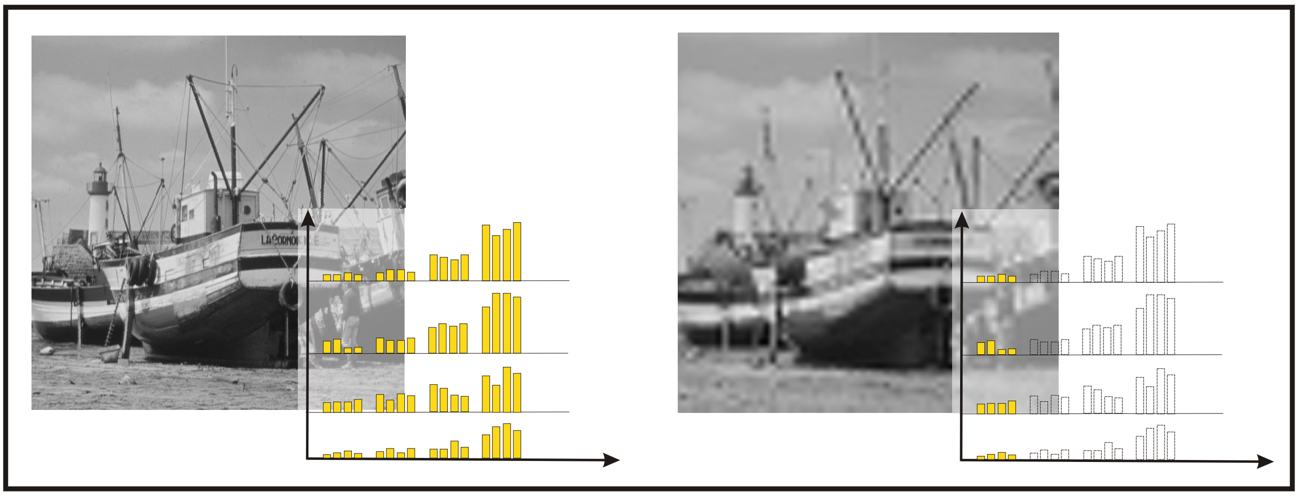

Figure 4. Compared to the use of all available data (left), content reconstructed by using only data belonging to the lowest available resolution appears as it has been blurred (right).

6. RESOURCE-SAVING CREATION AND DEMAND-DRIVEN STREAMING

Beside the availability of appropriate means for representation and interaction, their resource-saving implementation is crucial for mobile computing. For the aspired DoF representations, this can be achieved by taking advantage of inherent properties of JPEG2000. The following statements assume a client/server setup as typical in mobile environments. By fusing server and client, however, the proposed concept can also be applied in stationary environments. The server basically stores a JPEG2000-encoded image and delivers those parts relevant for the currently desired representation. The client just stores the received data, decodes relevant data, and presents the respective representation to the viewer.

6.1. JPEG2000-based creation of the content representation

Image content transformed to JPEG2000-domain is scalable in a variety of dimensions and able to support limited spatial access. We take advantage of these properties and propose to met the characteristics of a DoF representation by a sophisticated but uncomplex selection of data packets. The following list assigns to each property its respective solution in JPEG2000-domain:

Content blurring: the DWT supports the inherent *separation of detail and approximation*, the layer concept allows for *reduction in quality*

Different representation of focus and background: Limited Spatial Access to encoded image data enables *independent access* to image regions

The following statements provide further information to each of these points.

Separation of detail and approximation The DWT is an integral part of JPEG2000. During the decomposition of the image, subsequently details are extracted and separated from a given approximation. As blurring is characterized by a general loss of detail, these parts are neglected for blurred representations. Consequentially, only data belonging to the approximation LL_k is used. This process and its consequences is depicted in Figure 4 for a grey-scale image.

Reduction in quality Decoding of the approximation only leads to a low resolution image shown in its original spatial dimensions. Due to the fact that the content still contains details, the blurring effect might not be as strong as desired. To achieve a stronger blur, ideas from pixel domain are applied. Here, blur can be introduced by averaging adjacent pixel values to remove sharp variances and details. In JPEG2000-domain this can be accomplished by taking advantage of the concept of quality layers. By removing higher quality layers, accuracy of wavelet coefficients is reduced. As each coefficient contributes to multiple pixels, this leads to an averaging of the belonging values and in turn to similar values of adjacent pixels. As shown in Figure 5 for the given example image, this proceeding can heavily increase the strived blur effect.[38]

Independent access An important part of the DoF effect is the highly detailed focus embedded into the blurred background. To achieve this, it is required to combine focus and background, and thus, to access data contributing to either type of region independently. Here, it is proposed to apply the flexible concept of limited spatial access. Founded on this, each precinct belongs to either focus or background. Thus, both types of regions can be simply combined by a region-dependent selection and omission of packets.

Once the respective parts have been selected (cf. Figure 6/left), they are transmitted and decoded at client side. The result is a DoF representation of the original content, whereby the focus is shown with all details and the background is blurred. (cf. Figure 1).

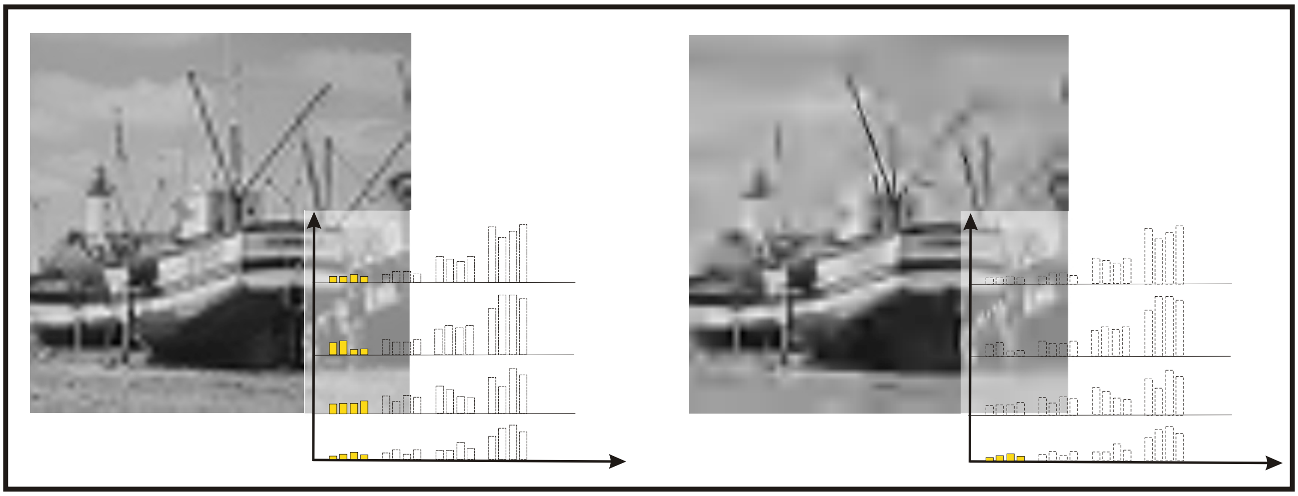

Figure 5. Compared to the use of all data belonging to the approximation (left), the removal of data residing at higher layers intensifies the blurring (right).

6.2. JPEG2000-based data transmission

The application field of mobile devices often demands that imagery must be transmitted. Since bandwidth is limited and the transfer costly, an efficient strategy for image transmission is essential. In previous work it has been shown that this can be achieved by coupling image compression, transmission, and browsing to a holistic image communication system. This section is concerned with the demand-driven streaming of the data. To achieve this, we adopt the JPIP-transmission protocol[36,39] as compliant and flexible basis for image transfer. Using JPIP, the server is fully responsible for the transmitted data. Only simple cache management and a compliant decoder are needed at client side. During interaction, the client signals the desired representation layout to enable the server to calculate and send belonging image data.

Transmission and streaming of the data does not strongly vary from the handling of ordinary JPEG2000-imagery. At the beginning of image transmission, the client cache is successively filled with data. Although different strategies are supported, the server usually streams the data in approximation-to-detail order to allow for traditional progressive refinement. At client side, the data is stored within a cache structure assigning to each precinct and packet a unique position. JPIP ensures for proper identification of each received data chunk even if parts of the encoded image not contributing to the current representation are omitted.

During transfer, the data may be constantly decoded to allow for progressive refinement of the representation. The fact that some cache positions might be empty if the proposed approach is applied does not prevent compliant decoders from processing the remaining packets. However, only pieces relevant for the desired representation layout are handled.

In case the user interactively changes the current representation layout, the server is required to adapt the data streaming. Redundancy-free data transmission can be achieved by keeping track of already transmitted data and streaming remaining pieces only. This increases resource efficiency and response rates at client side.

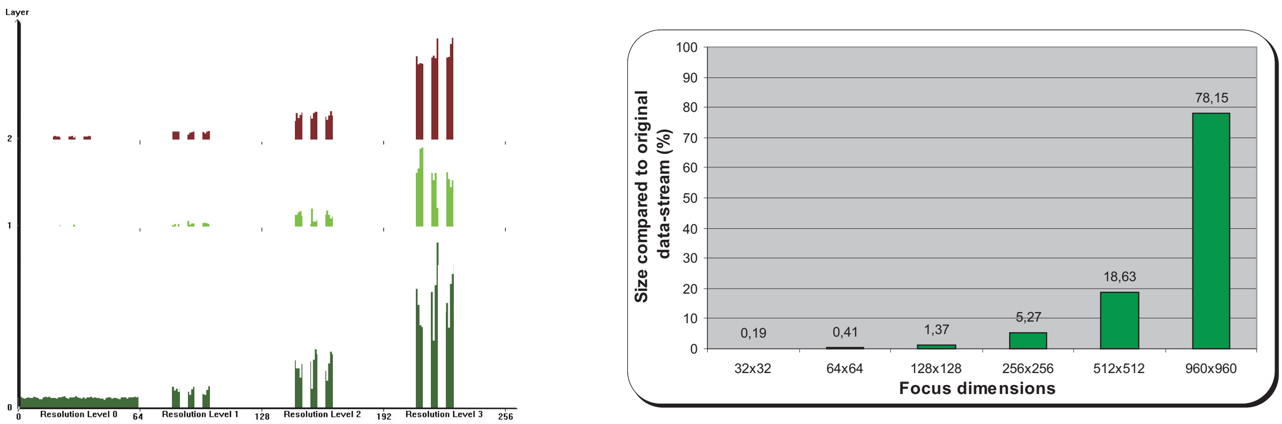

Figure 6. Compared to all available image data (cf. Figure 2/right), only selected data is required to achieve a DoF representation of the content (left). The save in the amount of transmitted data mostly depends on focus dimensions and is usually tremendous (right, image dimensions: 960×1280).

7. DISCUSSION

In this section, the proposed image browsing approach and its resource-saving implementation is evaluated regarding the main limitations of mobile environments – computing power and bandwidth – as well as usability aspects. For fair comparison, we add the resource consumption of our technology at server and client side and match them with traditional approaches.

Little complexity Since the lack of processing power is one of the most critical constraints of modern mobile hardware,[40] an implementation should be as simple as possible in order to allow for acceptable interaction rates.

The procedure to determine all precincts contributing to a desired DoF representation requires only little computing power. The same applies for the access to single packets of a given data-stream. Compared to traditional Gaussian filtering in pixel domain, our approach is on average 5 times faster.[38] This is mostly due to the fact, that pixel-based filtering requires numerous operations to calculate each pixel value contrary to the proposed approach only calculating and accessing a limited number of packets. If one further considers the fact that pixel-based processing requires the decoding of all data, the gain is even bigger. Nevertheless, the introduced transitions and animations between the different interaction steps increase the overall complexity and may be disabled if computing power is strongly limited.

Reduced amount of transmitted data Regarding image transmission, the decision to use JPEG2000 as image compression scheme pays off twice. The standard inherently provides a high compression performance, but also a quit beneficial structure of the encoded data. By taking advantage of these properties, the proposed approach only requires the transmission of those packets contributing to the DoF representation and much bandwidth can be saved. Due to the reason all data available for the focus is transferred, this especially applies for the large background region reconstructed by parts of the approximation only. As they cover the majority of the encoded data, an heavy decrease in the amount of transmitted data can be achieved (cf. Figure 6/right). Thereby, the image must not be decoded and re-encoded to support different layouts of focus and context. This also allows for a non-redundant data transfer.

To give an estimation of the advancement, the general assumption that the amount of encoded data required to restore a certain level of the multiresolution hierarchy increases exponentially with increasing r is applied. If $2^{2 \cdot 0}$ represents the data required to restore the image in lowest inherent resolution, the data needed to reconstruct the original image is 2^{2r}. By assuming equally distributed image data and the focus region to cover $\frac{1}{f}$ of the image, the required amount of data can be stated as:

$$\begin{aligned} \textit{Focus}: &\ \tfrac{1}{f} \cdot 2^{2r} \\ \textit{Background}: &\ \tfrac{f-1}{f} \end{aligned}$$

For typical values $r = 6$ and $f = 10$, this means that only 10.02% of all available image data is needed for a single DoF representation. Removal of data from higher quality layers and from hidden regions further decrease this value. Due to the small amount of data belonging to the blurred background, however, this does not impose significant performance shifts. Figure 6/right depicts the overall gain by a real example considering multiple focus dimensions.

Advanced browsing experience Compared to traditional browsing technology for mobile devices, the proposed approach provides advanced usability due to the following points:

Sophisticated content representation. DoF representations are means for viewer guidance already proven in many application areas. DoF is a low-level effect of the HVS, makes very efficiently use of the provided bandwidth to convey a lot of information in very little time, and does not require learning.

Since simple and intuitive interaction was one of the main goals for the proposed technique, simple perspicuous actions have been designed. Based on this, the information seeking mantra: "Overview first, zoom and filter, then details on demand",[19] is rather easy to achieve. To get an overview the user executes a single zoom-out operation, roams to a desired location and zooms-in to get details. Thus, only 3 interactions fast and easy to accomplish are required to change the current WoI via a temporal overview. Due to the fact image regions may also be hidden, however, roaming may require more than a single interaction.

Higher interaction rates: By sending and displaying small incremental parts instead of the whole image, shorter response times and higher interaction rates can be achieved. Regarding usability, progressive refinement is a great advantage compared to other techniques requiring the availability of all image data before presentation.

Smooth embedding of the focus Compared to pixel based processing, the proposed approach leads to a smoother embedding of the focus into the background. Due to the overlapping property of the wavelet synthesis operations, precincts associated with one image region have a slight influence over neighboring regions. The coarse spatial access to the encoded data, however, only allows for an approximation of a given focus shape. Furthermore, the produced quality of the blur is not as good as by applying a special filter purely designed for this purpose. It is noticeable that the proposed strategy leads to coarser results. Subjective tests have revealed that the best quality of the blur is achieved if approximately 8-12% of all available image data reside at the handled layers. These values, however, can only be a rough guideline and vary depending on image content. Thereby, reducing quality has less impact on blurring than reducing detail. Its influence further decreases with increasing d_{max}. Although the difference is small, quality also depends on the character of the transformed data.[41] Different experiments revealed that CDF 9/7 kernels achieve the best results. Due to their larger influence, they produce smoother blurring than the 5/3 kernels.

8. CONCLUSIONS

Summarizing this contribution, a novel approach for browsing large raster imagery on mobile hardware has been proposed. Compared to existing technology, it is less resource-demanding and provides more usability. This is mostly achieved by combining blurring and progressive refinement with the beneficial properties of JPEG2000. The applied DoF effect of the Human Visual System is an effective means for user guidance. However, often much computing power and bandwidth is required to support this effect in mobile environments. This publication has proposed a strategy to create DoF representations directly from JPEG2000-encoded imagery. It takes advantage of the DWT and the modularity of the encoded image by neglecting data not required for the desired content representation. The procedure is uncomplex and more than *5 times faster* than Gaussian filtering. As based on data reduction, the strategy also increases transmission efficiency. In case of a focus covering 10% of the whole image, approximately *10 times less* data must be transferred. Although, the resulting blur is not as smooth as be using a specific blurring filter, the properties of the transformed data allow a much better integration of the focus into its context.

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