International Journal of Information Technology and Management

Vol. VII, Issue No. X, November-2014, ISSN 2249-4510

AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

OBJECTIVE QUALITY METRIC DESIGN FOR WIRELESS IMAGE AND VIDEO COMMUNICATION

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Objective Quality Metric Design for Wireless Image and Video Communication

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Abstract – Lossless image compression is needed for applications that cannot tolerate any degradation of original imagery data, e.g., medical applications such as mammography, angiography, and x-rays. It is essential that the decompressed image does not contain any degradation in quality, since it could lead to misdiagnosis and health injury. Satellite or geographical map images are another case where distortion caused by compression cannot be tolerated.

Keywords - Image, Storage, Pixels

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1. INTRODUCTION

The storage of pixel counters in CT is organized in a tree structure. The nodes of the tree represent the contexts appearing in the image. Symbol '×' denotes the unknown pixel within the particular context. The statistics i.e. the counters represent how many times the unknown pixel appeared as a particular color. In case of binary image, two counters are needed: NW represents the number of white pixels which appeared, and NB represents the number of black pixels. The positions of the context pixels in the context template are arranged in a predefined order; that is, the construction of the tree starts from the root. For every pixel of the image, the algorithm sequentially examines its neighbors according to the defined context template. If the first pixel of the template appears as white, the transition to the left child node is made; otherwise the right transition is made. The process continues recursively: the algorithm examines the second neighbor position in a template and makes the transition to the next level of the tree corresponding to the value of the next context pixel. With every transition from node to node, the algorithm updates the pixel counters according to the value of the current (unknown) pixel. In cases where the current transition does not exist, the necessary node of the tree is created dynamically. Accordingly, only nodes corresponding to existing contexts are created in the tree and no memory is wasted for non-existing pixel combinations. In order to prevent a context dilution problem the size of the model used must be restricted. In context modeling this is usually done by using a context quantization approach, which is referred as tree pruning. The simplest way is to require that every node has children only if the code size provided by the children is less than the one provided by their parent. This guarantees that all surplus nodes of the tree will be pruned and the undesired increase of the context model will be prevented. However, this greedy-style approach does not provide the optimal performance and more sophisticated pruning algorithms can be found in literature (Weinberger, *et. al.,* 2000).]. Although context tree modeling is not restricted to binary images, resource allocation problems limit the use of a more general approach for more than two colors. The principle of constructing a generalized context tree (GCT) as proposed in (Golomb, 1966) is illustrated in Figure 6. In contrast to the binary case, the nodes of the tree have more than two children. Potentially there are as many children as there are colors in the image. Every node must track the appearance counters for all possible colors. Pruning is also more complicated in the generalized case. For K children, there are 2K pruning configurations and each can provide different code size. The selection of the optimal combination by a full search is extremely slow and therefore impractical. In GCT, sub-optimal pruning by a steepest descent search algorithm was considered for solving the pruning problem in a reasonable time, and still providing performance close to the optimum. The order of pixel positions in a context template is also essential and can be a subject of optimization. A solution for the CT model is called Free Tree (Rice, 1979) and it has been considered both for binary images and for gray-scale (Ausbeck, 2000. Yoo, *et. al.,* 1999. Pennebaker, Mitchell, 1993. Taubman, Marcellin, 2001). It provides better compression performance in comparing to a static order CT (Clarke, 1985). Sample contexts optimized by free tree are illustrated.

2. REVIEW OF LITERATURE

These technologies now strongly influence our everyday work and private life. Hence, we are not only used to just looking at the natural environment anymore but rather at artificial reproductions of it in terms of digital images and videos. Since we are accustomed to impeccable quality of the real world environment, we are biased to expect also a certain degree of quality from its digital representations. However, the quality is often reduced due to many inuencing factors such as capture, source coding, or transmission of the image or video. The induced artifacts that are responsible for the reduction of visual quality often distort the naturalness of the image or video, meaning, that structures are changed or introduced that are not observed when looking at a real world environment. The degradation in quality depends highly on the type and severeness of the artifact. Considering the artificial nature of most artifacts though, it is generally no problem for a human observer to quantify the visual quality degradations when looking at an image or video. This is enabled by the complex processing in the human visual system (HVS) and higher cognitive levels which allow to easily identify distortions in an image or video and to make a judgment about the visual quality. Considering the easiness of artifact detection by a human observer, it is therefore highly desirable to achieve high quality representations of the ubiquitous image and video applications. Map images are typically highly structured. The patterns are usually clearly defined and commonly repeated in the image. This makes context tree modeling an effective tool for statistical analysis and processing. Consider a map image, which is slightly corrupted by impulsive or content-dependent noise. By content-dependent noise, we assume that the corruption occurs at the borders of the objects. The presence of noise corrupts the statistical consistency of the image and, therefore, statistical analysis is an appropriate tool for noise detection and removal. In P4, we propose a statistical context tree based filter for map images basing this on the preliminary works published earlier (Ueffing, 2001. Lizard). The filter analyzes the 17 statistical distributions of the colors within a local neighborhood using a generalized context tree model. Pixels are considered as noisy if their conditional probability falls below a predefined threshold. The size of the neighborhood is dynamically adapted using a tree pruning technique. The principle of the algorithm is illustrated in Figure 12, where two 3×3 contexts A and B are presented. One can see that black is much less probable than white in the context A, and vice versa; white is less probable than black in the context B. By replacing noisy pixels by the most probable ones, the filter is able to reconstruct the initial structure of the image. The proposed filtering is very sensitive to the original structure of the image and the amount of the corruption imposed is rather small. Sample corrupted and reconstructed images are presented.

3. MORPHOLOGICAL RECONSTRUCTION OF SEMANTIC LAYERS

When producing a raster map image, map layers of different semantic nature are combined together overlapping each other in a predefined order. This image is well suited for user observation but less appropriate for further processing since the layer structure has been corrupted as the raster map image was produced. The problem is 19 that the overlapping introduces severe artifacts in places where the information on different layers overlap each other. The holes on the face of the lake left by the overlapping letters are typical examples of the artifacts. The presence of these artifacts degrades the compressibility of the color map image, in comparison to the situation when the original semantic layers were available. This problem led us to develop an algorithm for the reconstruction of the corrupted layers of map images. The algorithm proposed in P1 approximates the original layer structure existing before the color combination by repairing the corrupted layers as close as possible to the original ones. Since the converted raster map images are usually compressed by a lossless algorithm, we require that the color combination of the reconstructed layers must be equal to the originally received raster map image. The results of the proposed reconstruction technique are presented. The removal of overlapping artifacts provides 30-50% better compression on standalone layers, and 5-10% better compressibility for 4-layer map images without any loss of quality.

Other types of images can also be treated as layered images via the use of bit plane separation. This assigns one bit from the binary representation of the pixel value into 20 each bi-level layer, thus loss Lesley separating any gray scale image into eight layers. The overall scheme of this approach is shown in Figure 6. In the case where there is a correlation between the bit layers, it is possible to utilize this to gain better compression efficiency. For example, in context modeling, involving neighboring pixels from already processed binary images can improve the probability estimation and, therefore, the compression. Among existing implementations we can mention the EIDAC lossless compression algorithm, which uses a binary multi-layer context model that operates on bit-layers of the image using both the actual bit values and their differential characteristics as context information. Two-layer context modeling with optimization of the order of layer processing was considered in (Bottou, *et. al.,* 1998).

In P2, we study how well the bit-plane-based approach can work on natural and palette images. We consider four different bit plane separation schemes: straightforward bit plane separation, Gray-coded bit plane separation, bit plane separation of prediction errors and separation of Gray coded prediction errors. We use the highly optimized MCT context modeling method for lossless compression and, furthermore, extend the two-layer MCT model to a multi-layer context model for better utilization of cross-layer dependencies. In general, any previously compressed layer can be used to provide the contextual information for the next layer being compressed. An example of a multi-layer neighborhood used in P2 is presented in Figure 6. We extensively evaluate the proposed combinations of the different bit plane separation and context modeling schemes, by applying them to natural and palette images. The efficiency of the bit-plane-based compression is compared to the existing compressors. Moreover, the dependency of the compression on the image content is studied by modeling the transition between natural and palette image classes.

4. OBJECTIVE QUALITY METRIC DESIGN FOR WIRELESS IMAGE AND VIDEO COMMUNICATION

We will focus on the design of objective metrics for visual quality assessment in wireless image and video communication. The aim is to quantify the end-to-end distortions induced during transmission and relates them to quality degradations as perceived by the end-user. These metrics may then replace the conventional link layer metrics to allow for precise perceptual quality monitoring. The application of perceptual image and video quality assessment in a communication context, as we consider it throughout this study, is illustrated. Here, the integral parts of a wireless link are shown including source encoder, channel encoder, modulator, and the wireless channel. In this scenario, the received image or video may from artifacts, and consequently quality degradations, from both the source encoder and the error-prone wire-less channel. The impact of the source coding artifacts is somewhat easier to predict since for deferent codecs certain artifacts can be expected. On the other hand, the time variant nature of the fading channel makes the range of artifacts in the received signal much more unpredictable. With JPEG source encoding and a Rayleigh °at fading wireless channel with additive white Gaussian noise (AWGN). The symbiosis of this setup resulted in a wide range of deferent artifacts, hence, substantially complicating the assessment of the artifacts and the related visual quality. The particulars of the system under test, the set of test images, and the artifacts observed in the images will be discussed in Part 2 of this study. The additional shaded boxes in comprise of the necessary components to facilitate perceptual quality assessment, as we propose it in this study. The blocks surrounded by dashed lines indicate optional parts of the quality assessment which are applied when reference features are extracted from the transmitted image to support the quality assessment, hence, facilitating RR quality assessment. On the other hand, if these blocks are omitted then quality assessment is performed solely on the received image, thus, following the NR approach. However, as we aim to quantify quality degradations induced during transmission, we need some reference information from the transmitted image or video frame. Therefore, we incorporate the reference feature extraction into our metric design to establish RR objective quality metrics. In this case, the reference features may be concatenated to the transmitted image or video frame to be available at the receiver for quality assessment. The number of bits associated with the reference features the overhead for each of the images it is concatenated with and accordingly it is desired to be kept small. In particular the NHIQM metric, as discussed earlier, comprises of only one single value as additional overhead. Extensions and variations to this metric, as proposed in this study, may have slightly larger overhead but allow for tracking of each of the single features included in the metric. This may provide further insights into the cause of induced artifacts during transmission. In order to avoid additional overhead one may alternatively embed the reference features into the image or video frame using data hiding techniques (Gersho, Gray, 1992). Due to the limited capacity of these techniques, however, too large reference information may cause visible distortions in the image. Consequently, the aim to keep the number of reference features small remains also when applying these techniques. The metrics developed in this study are designed with respect to two goals. Firstly, the extracted features need to cover the broad range and precisely quantify the appearance of artifacts as induced in the images by both the lossy source encoding and the error prone channel.

5. CONCLUSION

It is hence crucial to classify these methods in order the favorable approach for an intended application. In this paper a survey and classification of contemporary image and video quality metrics is therefore presented along with the favorable quality assessment methodologies. Emphasis is given to those metrics that can be related to the quality as perceived by the end-user. As such, these perceptual-based image and video quality metrics may build a bridge between the assessment of quality as experienced by the end-user and the quality of service parameters that are usually deployed to quantify service integrity.

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