DEMONSTRATION OF RAPID FREQUENCY SELECTIVE RECONSTRUCTION FOR IMAGE RESOLUTION ENHANCEMENT

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1. STATEMENT OF THE PROBLEM

Most algorithms for processing, transmitting, or displaying images require the samples being placed on a regular grid. However, there exist imaging scenarios where the samples to be processed are located on a mesh with non-integer positions. This happens for example in image super-resolution, image warping, image registration, or image acquisition using random sampling sensors. In addition, sampling an image at non-regular sensor positions offers several advantages, as the effective spatial resolution of an imaging sensor can be increased as shown in [1].

In all cases, a suitable reconstruction method is required for resampling the pixels from the given mesh with non-integer positions onto a regular grid. An algorithm that achieves a very high reconstruction quality is the block-based Frequency Selective Reconstruction (FSR) proposed recently in [2]. As shown there, it outperforms state-of-the-art reconstruction algorithms and achieves PSNR gains of more than 1 dB compared to the competing methods. However, the reconstruction is computational expensive as the whole image has to be processed extensively.

Therefore, we propose to adapt the local statistics estimation from [3], which has been designed for rapid error concealment originally. By merging the approaches from [2] and [3], the reconstruction of images is fastened significantly. We will show in this demonstration that several frames per second (fps) can be processed using conventional computers and HD sized image data.

2. PROPOSED METHOD AND SET-UP

The FSR divides the incomplete image in fixed size blocks at first. Subsequently, for every block the distorted signal is recovered from known values by generating a model of superimposed and weighted Fourier basis functions. Thereby, the complete algorithm can be carried out in the Fourier domain and only one transform of the input signal and one inverse transform of the generated model have to be performed. In [3], a novel approach is presented to fasten this algorithm by estimating the local statistics of the neighboring pixels. As a consequence, it is possible to determine the best parameters for the algorithm dynamically per block. Here, the normalized standard deviation is calculated for each block and used as an estimation for the required amount of iterations and the needed frequency bins for a high quality reconstruction.

Regarding the demonstration set-up, we connect a high quality camera to an off-the-shelf computer, discard $3/4$ of the pixels randomly and reconstruct the image using the proposed Rapid FSR. Afterwards, the outcome is displayed and the reconstruction qualities and times are measured (see Fig. 1). Moreover, the interactive set-up allows the operator to change the FSR parameters via buttons and sliders on the fly. For a meaningful comparison of the algorithms, two different computers have been selected. Firstly, test-system 'Notebook' has been chosen, which can be purchased from stock and encloses an i7-6700HQ CPU @ 2.60 GHz and 8 GB RAM. Secondly, the faster computer 'Xeon', which contains two Xeon E5-2630v4 CPUs @ 2.20 GHz and 32 GB memory, shall demonstrate the possible performance of the novel approach.

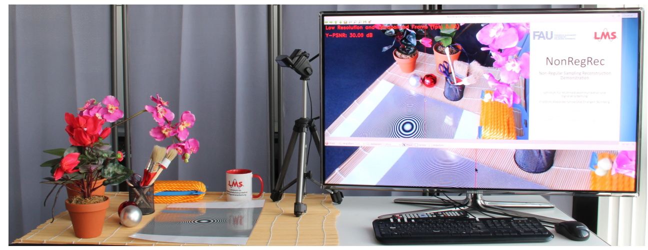

Fig. 1. The proposed set-up showing the interactive, real-time reconstruction demonstration. On the flat screen, a typically used pixel averaging method on the left side is compared to the proposed, highly-accelerated algorithm on the right side. The lower half shows a magnified section of the competing procedures. Using the test system 'Xeon', a frame rate of 5 to 11 fps is obtained.

The Rapid Frequency Selective Reconstruction has been implemented in C and parallelized using OpenMP. As a consequence, every processor core gets a set of image blocks assigned, which are processed independently. Thus, the full power of the CPUs can be utilized, which leads to a higher frame rate. Regarding the test systems, we achieve at least 2 fps using 'Notebook' and at minimum 5 fps using 'Xeon'. Moreover, for homogeneous image content up to 5 and 11 fps are achievable for the two test-systems as the approach from [3] has more influence on the processing time then.

3. BENEFIT AND OUTLOOK

Making use of High Definition image data, the state-of-the-art FSR algorithm achieves less than 1 frame per second using conventional computers, e.g., test-system 'Notebook'. Compared to this, the proposed method reconstructs about 2 fps, while achieving the same reconstruction quality. Moreover, video frame rates from 5 to 11 fps can be obtained, when using appropriate computers, e.g., test-system 'Xeon'. As a consequence, we are able to show that video data can be reconstructed in near real-time, while the same high reconstruction quality of the original method from [2] is achieved.

4. REFERENCES

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[3] N. Genser, J. Seiler, and A. Kaup, "Local statistics estimation for rapid frequency selective extrapolation," in *International Conference on Systems, Signals and Image Processing*, Poznań, May 2017.