

MATLAB-based Applications for Image Processing and Image Quality Assessment Part II: Experimental Results

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Abstract. *The paper provides an overview of some possible usage of the software described in the Part I. It contains the real examples of image quality improvement, distortion simulations, objective and subjective quality assessment and other ways of image processing that can be obtained by the individual applications.*

Keywords

Image quality evaluation, image processing, quality metrics, QoE.

1. Introduction

In the first part of this paper [1] the authors presented a set of MATLAB-based applications useful for image processing and image quality assessment developed at the Multimedia Technology Group (MMTG), Faculty of Electrical Engineering (FEE), Czech Technical University (CTU) in Prague. These are the Image Processing Application, the Image Quality Adjustment Application, the Image Quality Assessment Application, the Image Quality Evaluation Applications and the Results Processing Application. All of them contain user-friendly interface which make the usage intuitive and easy even for the users not particularly educated in the field of image processing. Related works to the applications were referenced also in the Part I [2] – [12].

The purpose of this paper is to show some typical examples from this field where the applications can be useful. It means that the experimental results in this paper are just a selection from the wide range of possible use.

The paper is organized as follows. Section 2 contains the examples obtained from the Image Processing Application. Section 3 shows the possible use of Image Quality Adjustment Application. The illustration of subjective quality assessment using the Image Quality Evaluation Applications and following processing of its results with

Results Processing Application is in sections 4 and 5. Section 6 is about Image Quality Assessment Application and section 7 concludes the paper and discusses the future work.

2. Image Processing Application

The Image Processing Application is the largest one and therefore offers the greatest number of image modifications. It is divided into five subunits.

The first subunit is called Intensity Transformations. It enables to simulate intensity distortions on one hand and to increase the contrast and with that also the image quality on the other. The examples of use are in Fig. 1. Fig. 1a) is the original image, Fig. 1b) is the distorted version when the low (high) output intensity thresholds were set higher (lower) than low (high) input intensity thresholds (input thresholds: low intensity – 0, high intensity – 1, output thresholds: low intensity – 0.3, high intensity – 0.7). That means that the dynamic range of the image was decreased. Fig. 1c) represents the opposite case (input thresholds: LI – 0.15, HI – 0.85, output thresholds: LI – 0, HI – 1) where the dynamic range was increased. Another important characteristic of the picture that can be adjusted is the gamma parameter. Fig. 1d) shows the impact on the original image when the gamma parameter is set to be the half of its original value. Fig. 1e) is the picture with gamma equaled 1.5 times original value. This subunit also enables to adjust the histogram of the image. It can either be replaced by the histogram of the image uploaded by user or modeled by bimodal gaussian function. An example of modeled histogram is in Fig. 2. The picture with this histogram is in Fig. 1f).

The second subunit of IP Application is the Spatial Domain Filtering. It offers two main options – Linear and Non-linear filtering. Linear filtering section contains number of linear filters (complete list can be found in Part I of this paper) based on *fspecial()* and *imfilter()* functions in MATLAB. Results of this filtering are well known and need no introduction.

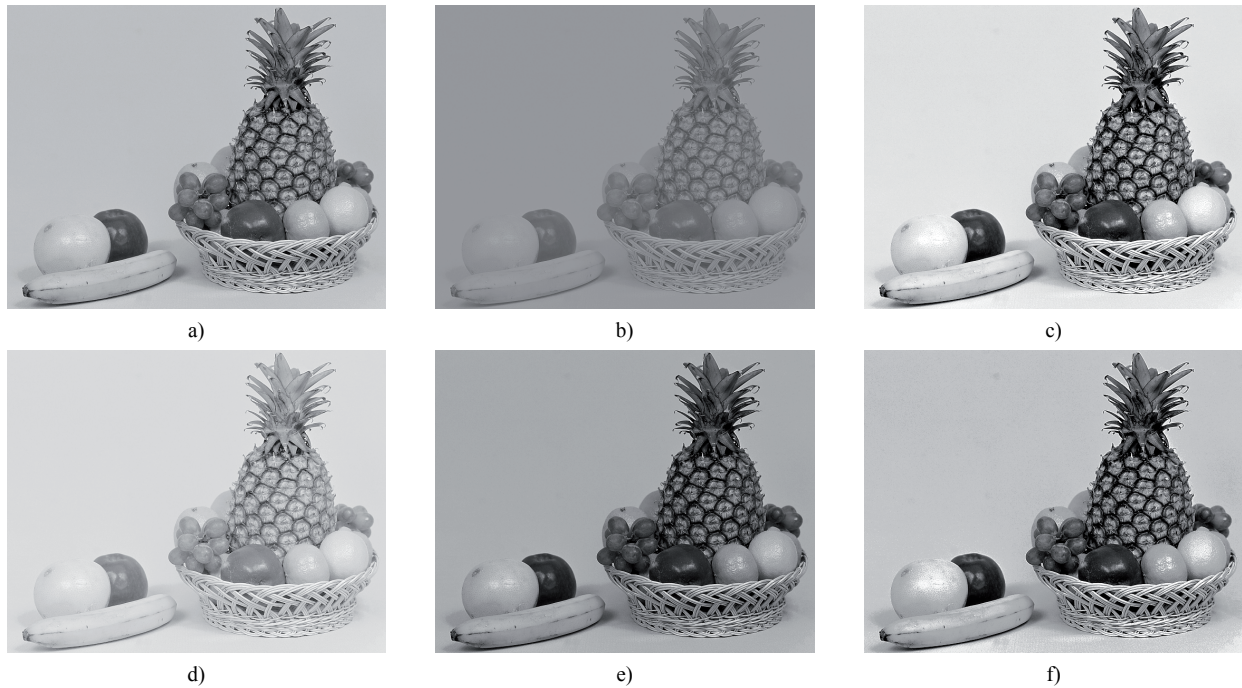


Fig. 1. Image Processing Application – Intensity Transformations results.

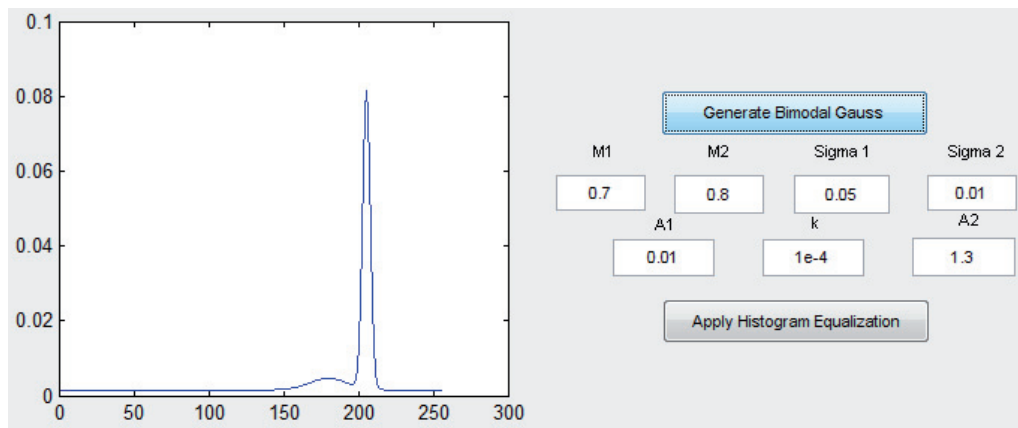


Fig. 2. Histogram modeled by bimodal gaussian function.

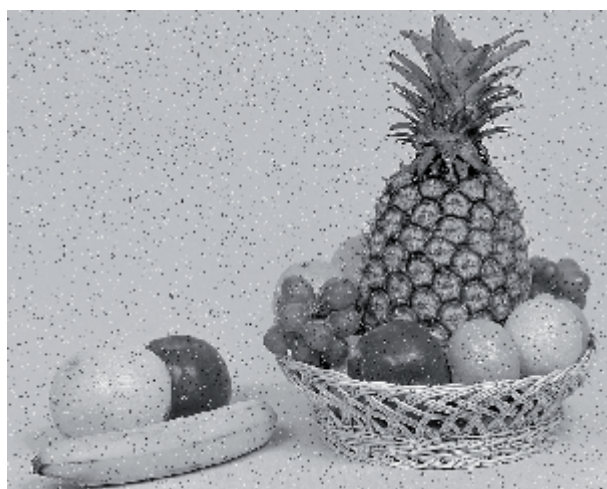
Non-linear filters are especially useful when applied on the images distorted by “salt&pepper“ noise field (Fig. 3a). Figs 3b), 3c) and 3d) show the results after filtering by median filter. The size of the neighborhood for the median filter in 3b) is 3 x 3 pixels, 6 x 6 pixels for 3c) and 10 x 10 pixels for 3d). As can be seen the median filter suppresses the noise but slightly blurs the image (the larger the neighborhood is, the more blurred is the output).

Figs. 3e) and 3f) are the results of filtering with adaptive median filter. The suppression of the noise is not as good as by median filtering but the output images are not blurred at all. Moreover the results are almost the same for the size of neighborhood 3 x 3 (Fig. 3e) and 10 x 10 pixels (Fig. 3f).

The third subunit is the Frequency Domain Filtering. Again two possibilities are available. Either filtering with

frequency filters defined in the spatial domain and then transferred to the frequency domain by FFT (demonstration of the Prewitt frequency filter is in Fig. 4a) or filters defined directly in the frequency domain. Filtering in frequency domain is useful for example when the original image has a line-structure. That means that every even (or every odd) line of the picture is missing (all pixels of the line are black – Fig. 4b). Image like that can be obtained by taking a picture of the CRT screen. The result of filtering with gaussian frequency filter from Fig. 4c) is in Fig. 4d). The line-structure is corrected but the output image is slightly blurred.

The Image Processing Application’s fourth subunit is the Noise Addition. The list of available noise fields and their parameters with the description can be found in the first part of this paper.



a)



b)



c)



d)



e)



f)

Fig. 3. Image Processing Application – Spatial Domain Filtering – Non-linear filtering results.

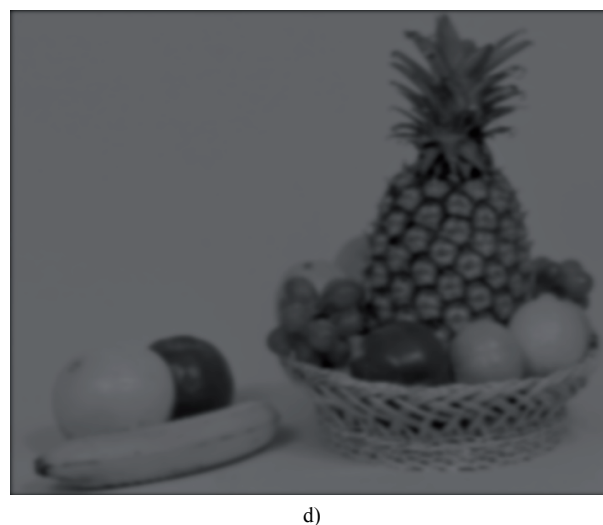
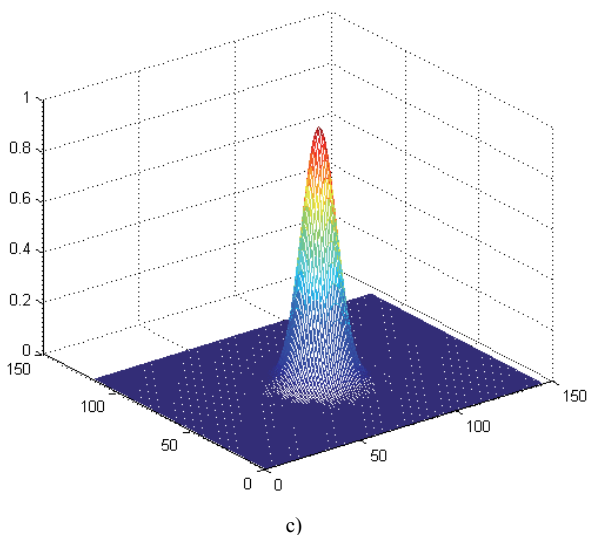
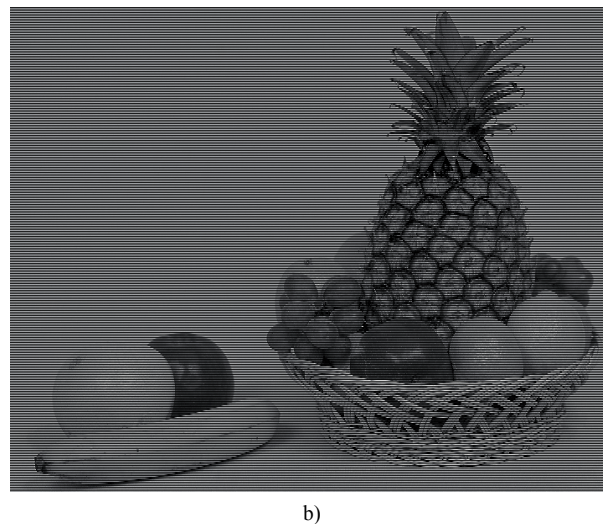
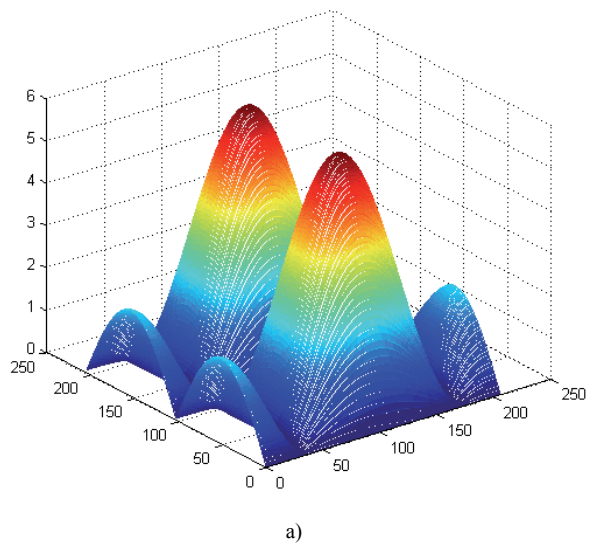


Fig. 4. Image Processing Application – Frequency Domain Filtering results.

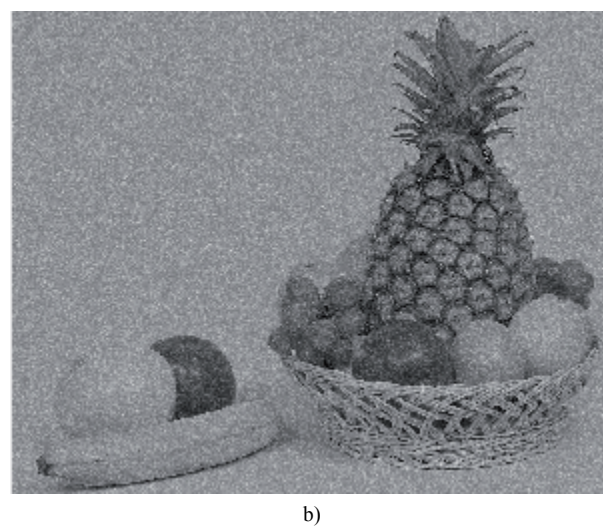
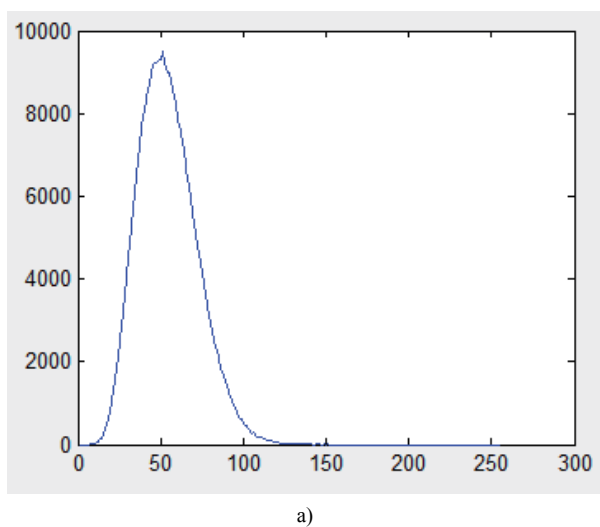


Fig. 5. Image Processing Application – Noise Addition – Rayleigh's noise.

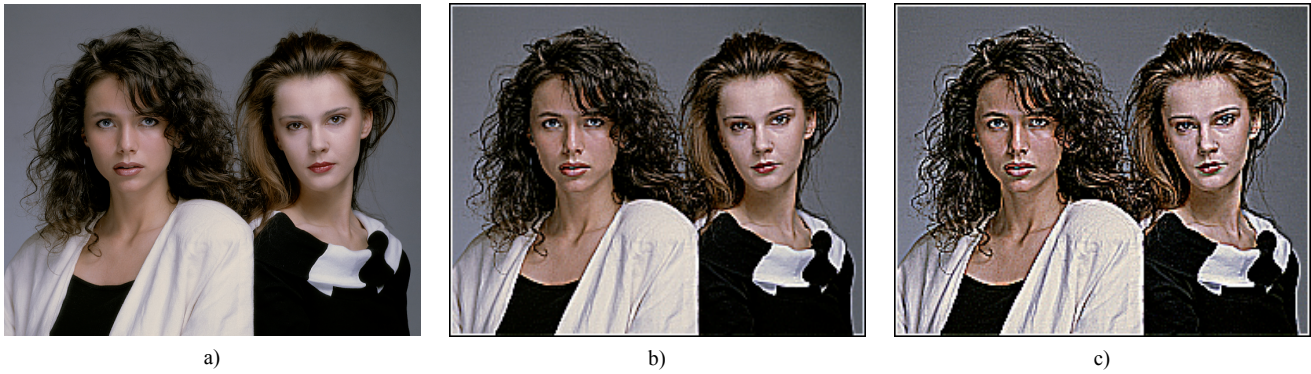


Fig. 6. Image Adjustment Application – 2D High Pass Filter.

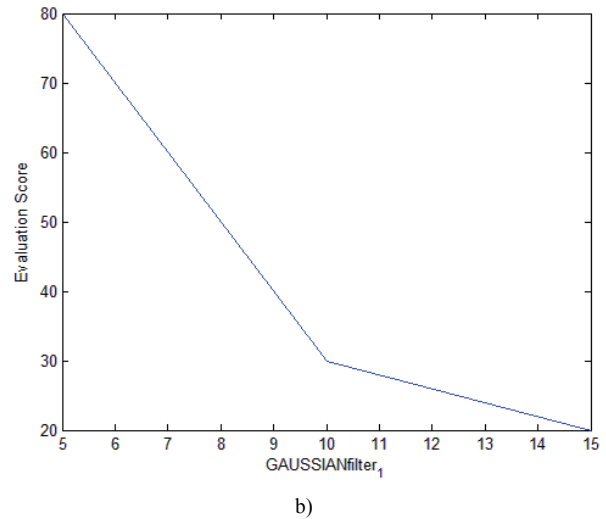
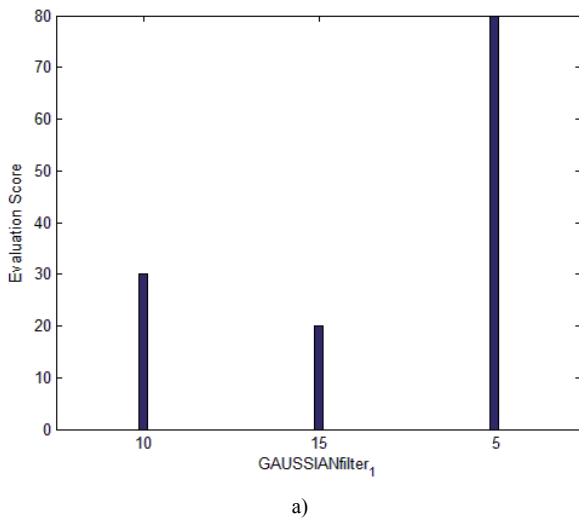


Fig. 7. Image Quality Evaluation Applications results.

As an example of use the Rayleigh’s noise field with parameters $A = 0.01$ and $B = 0.05$ was chosen. In Fig. 5a) the probability density function of the noise field is shown and in Fig. 5b) there is the noisy output image.

The last division contains basic objective image quality metrics MSE, SNR and PSNR.

3. Image Quality Adjustment Application

The second application proposed in the Part I was the Image Quality Adjustment Application. It is able to create series of pictures with increasing degree of applied method. Available methods and adjustable parameters are discussed in the first part. One of them is 2D high pass filtering which is widely used for “sharpening” the image. For the purpose of this paper a series of 20 pictures was created by this application from the original image in Fig. 6a). The coefficient was set to be 1. Fig. 6b) and 6c) shows the 10th and 20th picture of the series respectively. The sharpening is clearly visible in both of the images but the degree of sharpening of the

Fig. 6c) is too high and the picture is therefore qualitatively worse.

4. Image Quality Evaluation Applications

Another important part of image processing is subjective quality assessment. Image Quality Evaluation Applications can be very useful in this area. They represent a simple tool for creating and performing subjective quality tests. As described in the first part of this paper there are two applications available. The main difference between them is the representation of the results. After finishing the evaluation the results are shown as a graph. The first application generates the bar graph (Fig. 7a) and the other one creates the curve of the evaluation values depended on the values of parameter (Fig. 7b). Subjective quality tests whose results are in Fig. 7 were performed for 3 pictures distorted by gaussian filter using Image Quality Adjustment Application. The coefficient was set to be 1. The pictures were 5th, 10th and 15th respectively from the generated series. The scale was from 0 to 100.

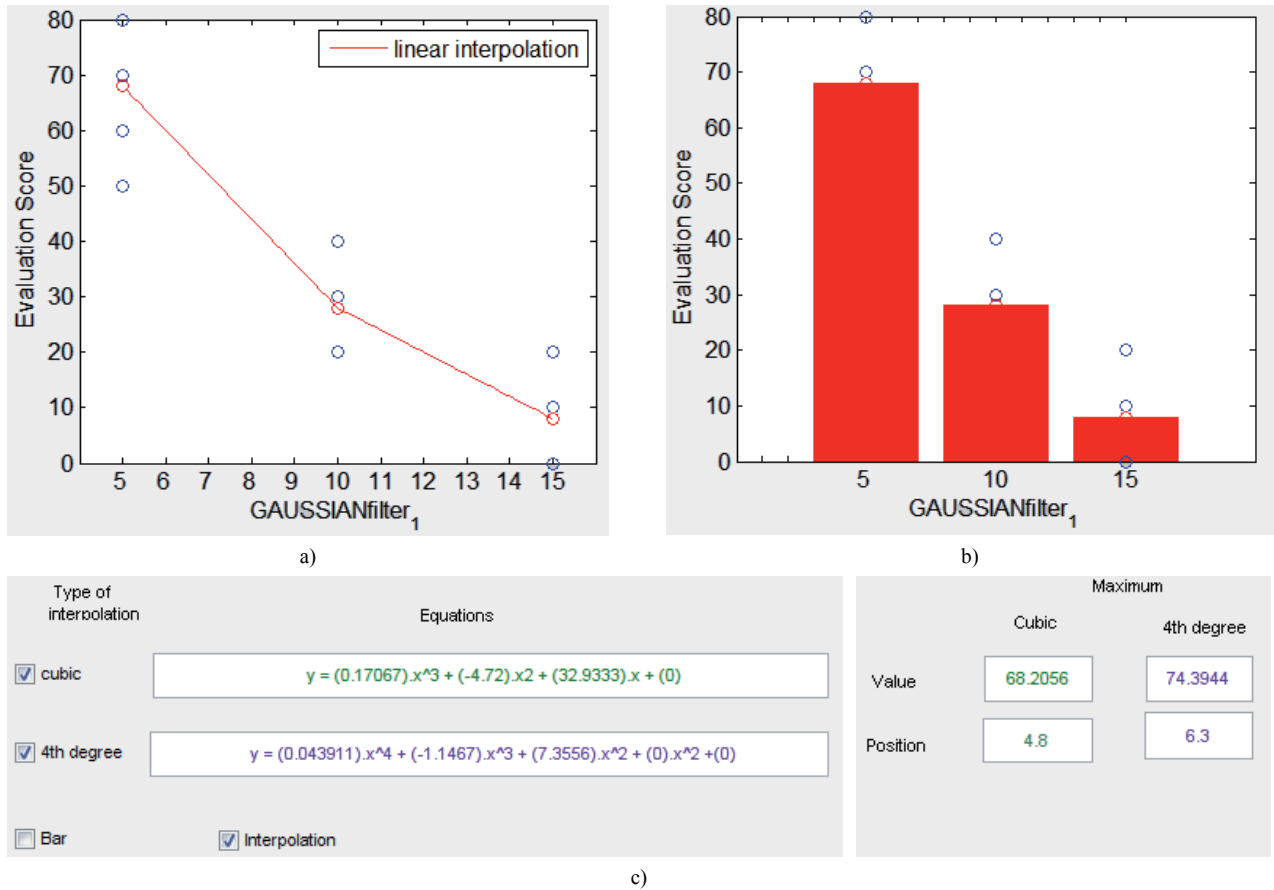


Fig. 8. Results Processing Application.

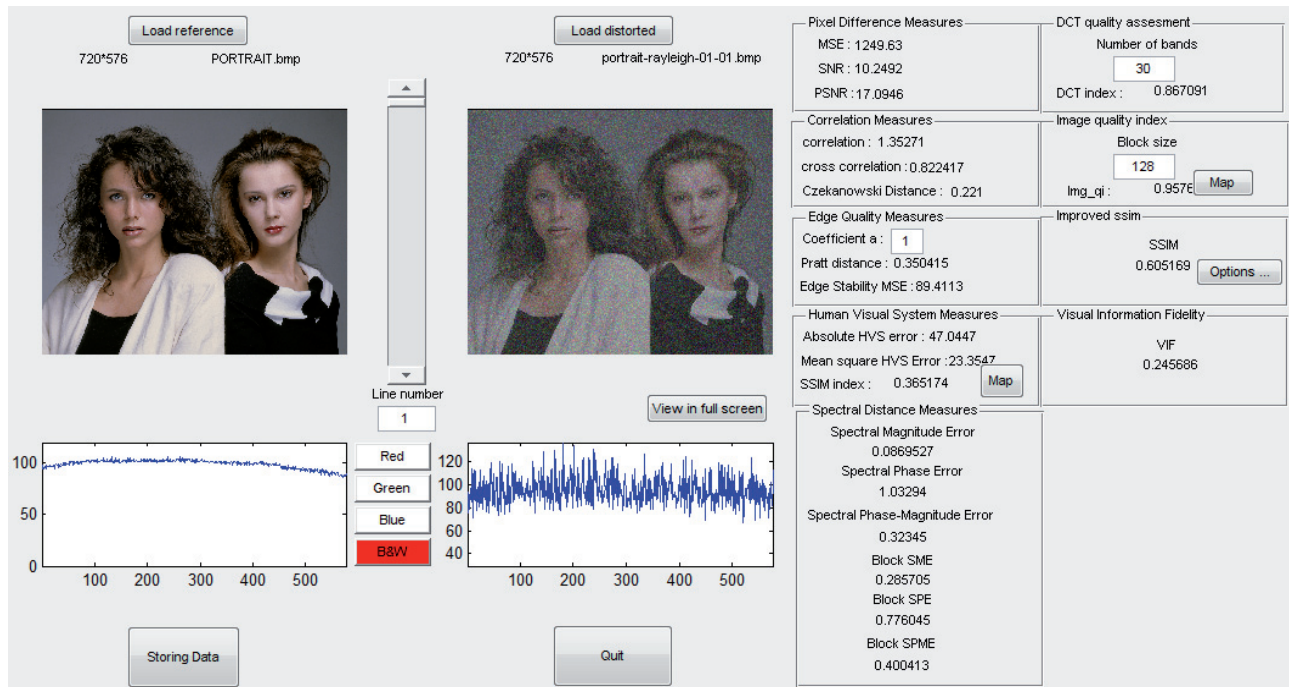


Fig. 9. Image Quality Assessment Application.

5. Results Processing Application

The results obtained from the subjective tests can be processed by the Results Processing Application. If Image Quality Evaluation Applications were used the text files with results are already in the form necessary for the processing. When the folder with these text files is uploaded the application automatically creates the graphical representation of all data. These data can be either interpolated (Fig. 8a) or the bar graph of average values can be created (Fig. 8b). Blue circles represent the evaluation values of particular observers. In this case 5 observers participated in the test but only 3 or 4 circles can be seen per every image. That means that some observers evaluated some pictures with the same score. The application enables also cubic and 4th degree interpolation of data but it is useless without further data analysis. In case it is appropriate to use these interpolation methods the equations of interpolation functions and maximum values of this functions will be visualized by the application in the form shown in Fig. 8c).

6. Image Quality Assessment Application

The last application that was described is called Image Quality Assessment Application. It contains objective full reference image quality metrics. After uploading the original and distorted image main menu containing all the metrics sorted out to the sections is shown. When the user opens the section all metric values of the section are calculated. In Fig. 9 all the sections are opened and all the indexes are calculated. This application represents an easy and intuitive way to objectively evaluate images.

7. Conclusion

This paper completes the description of the MATLAB-based applications for image processing and image quality assessment developed at MMTG, FEE, CTU in Prague started in the first part with the description of their function. In this part some concrete examples of use were shown and every application was practically presented.

The future work could be aimed to extend the set of applications to cover even more areas of image and video processing. Authors are currently working on development of new applications for quality assessment of video sequences and stereoscopic images.

In case of interest about the test use of presented applications please contact the main authors at CTU in Prague.

Acknowledgements

This work has been supported by the project of the Czech Grant Agency No. P102/10/1320 "Research and modeling of advanced methods of image quality evaluation" and the research project MSM 6840770014 "Research of perspective information and communication technologies" of MSMT of the Czech Republic.

Authors would also like to thank Alexandre Vivier, Matthieu Bleichner and Eva Fenclová for their help with implementation and debugging.

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