

INCREASE THE CLARITY OF DIGITAL IMAGE

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Photos are an integral and certainly an important part of our lives. Often we are faced with a need to increase the clarity of digital image, for example, solving pattern recognition problems, or for other reasons. Methods of increasing the clarity of digital images are very diverse, each has its own range of applicability. However, there may be often artifacts by processing of digital image. The aim of this paper is to increase clarity of digital image with the possibility of avoiding artifacts. To achieve this aim the researchers used digital image processing algorithms, based on using different convolution matrix types. There are shown in typical images with increasing clarity of digital image what advantages is the use of combinations of these algorithms in a specific sequence. A comparative analysis of the impact of different filters to increase the clarity of digital images was conducted and gives recommendations by using them.

Keywords: digital image, clarity image, matrix of filter, the convolution, image processing

Introduction

Photos taken by most digital cameras, are not sufficiently clear (may have low sharpness). This happens even with the images created by high-end cameras with high resolution display. Increased clarity - a highlight and underline the contours of objects, lines and borders to make them more distinct and noticeable. Improve the clarity of digital images - is to make sharper the edges of objects.

Clarity - is one of the main parameters that characterize the quality of the image and shows the completeness playing small objects on it. Clarity also characterizes the degree of blurring boundaries around image objects [1]. Setting clarity (sharpness) is getting by increasing the contrast on the image contours to improve detail.

However, the application field of sharpness filters is to avoid redundancy. Excessive sharpening create a very "rough" texture of the image, and "torn" outlines and shadows. That may be artifacts of sharpness field [2]. Artifacts are a wide range of micro-defects on the image. Noise can also be attributed to artifacts. Usually artifacts appear in tricky situations or with incorrect camera settings. Number artifacts significantly increases with the wrong or excessive computer processing.

The aim of this scientific work is to improve clarity of digital images with the ability to avoid artifacts.

Main part

Modern graphics editors provide a wide range of filters to increase the clarity (sharpness) of digital images. But sometimes increase the clarity can cause to artifacts.

The basis of most known methods of digital images sharpening is the use of spatial filters. The core or matrix filter – a coefficient matrix of 3×3 , 5×5 , 7×7 , etc., which identified certain function [3]. The core filter used for the image using convolution operations. Convolution – a linear combination of elements values of the image (1).

$$\begin{bmatrix} p_1 & p_2 & p_3 \\ p_4 & p_5 & p_6 \\ p_7 & p_8 & p_9 \end{bmatrix} \begin{bmatrix} k_1 & k_2 & k_3 \\ k_4 & k_5 & k_6 \\ k_7 & k_8 & k_9 \end{bmatrix} = \sum_{i=1}^9 p_i k_i = p'_5 \quad (1)$$

p_i – elements of the image area; k_i – core filter; p'_5 – new pixel value.

Most use a matrix of 3×3 , allowing for more image processing [2]. During brightness filtration pixels of the original image are processed one after other and is determined by the color of the pixel through its values and pixel values that surround it. The core filter shows which value extends to each of the surrounding pixels and affect to the final result. [3] Filtration filter made moving windows on the image.

The core filter to increase the clarity formed as follows: the central rate should be greater than 1, and surround it with not positive numbers whose sum in absolute is less than the central one, for example: next we will use in our experiments the following core filter (2), as the experiments have shown that it works very well with images made by shallow depth of represented space field.

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix}, \quad (2)$$

Experimentally, it was found that increase the clarity leads to many artifacts when the image is made of shallow depth of represented space field (Fig. 1).



Fig. 1. Example of images with shallow depth of represented space field

These images have as clear and blurred areas. If the object on the image is sharp (is in focus), the increase of its sharp causes to artifacts on it. At the same time, the blurred areas of the digital image are more clearer. That’s why it would be advisable to slightly reduce the sharpness of your own digital image that is to say blur it.

The assumption that the previous blurred digital image (when the clear objects will become more blurred) further sharpening filter application will give the best results without artifacts, was confirmed in experiments, a typical example of which is shown on Fig. 2.



а



б



в

Fig. 2. Application of increase the clarity algorithm: a – original image; b – without preliminary blurring; c – after blurring

Fig. 2 shows an example of using the increase the clarity filter without preliminary blurring. As we can see in the area, which was clear, there were artifacts. Blurry area became clearer. Fig. 2,c shows the result of using the increase the clarity filter to image that was previously blurred.

Even the subjective ranking shows that the area that was in focus, almost no sharpness artifacts, and the area that is out of focus, has also become clearer. However, conduct a quantitative assessment of improved clarity of digital images.

Reliability perceptions will evaluate the classic way with a typical signal to noise ratio (PSNR), as measured by a scale in decibels (dB). The easiest way to define it by the standard deviation (SCR or MSE), for two monochrome or color images I and K size $m \times n$, one of which is original and the processed one, calculated using the formula:

$$MSE = \frac{2}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} |I(i, j) - K(i, j)|^2$$

PSNR is defined as:

$$PSNR = 10 \log_{10} \left(\frac{MAX_I^2}{MSE} \right) = 20 \log_{10} \left(\frac{MAX_I}{\sqrt{MSE}} \right)$$

MAX_I – a maximum value that is accepted image pixel; MSE – standard deviation; I, K – monochrome image; i, j – pixels.

The experiment we will use a variety of matrix filters (3) - (5) for blur digital image and define the use of which matrix is the most successful in terms of increasing PSNR compared

with the case where the image before increase the clarity not blurred. Matrix filters to blur images taken with a digital resource [2].

$$\frac{1}{8} \times \begin{bmatrix} 0 & 1 & 0 \\ 1 & 4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \tag{3}$$

$$\begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix} \tag{4}$$

$$\frac{1}{6} \times \begin{bmatrix} 0.5 & 0.75 & 0.5 \\ 0.75 & 1 & 0.75 \\ 0.5 & 0.75 & 0.5 \end{bmatrix} \tag{5}$$

The experiment is as follows. We have the original image I_1 and get the following image:

- image $I_2 - I_1$ processed by increase the clarity filter (2);
- image $I_3 - I_1$ blurred by Gauss window of 5×5 filter and blur radius 2 with further application of increase the clarity filter (2);
- image $I_4 - I_1$ blurred using a filter matrix (3) with further application of increase the clarity filter (2);
- image $I_5 - I_1$ blurred using a filter matrix of 5×5 ($1/25 \times E$, where E - the identity matrix) with further application of increase the clarity filter (2);
- image $I_6 - I_1$ blurred using a filter matrix (4) of 3×3 with further application of increase the clarity filter (2);
- image $I_7 - I_1$ blurred using a filter matrix (5) of 3×3 with further application of increase the clarity filter (2);

Compare the original image with each of the received tested images are presented in Table 1.

Table 1.

Result of comparison definition digital images after processing

Pairs of images	PSNR, dB	Improved results compared to PSNR(I1,I2), %
(I1, I2)	19.6470	—
(I1, I3)	9.0490	54%
(I1, I4)	37.0109	88%
(I1, I5)	30.7402	56%
(I1, I6)	34.2050	74%
(I1, I7)	34.6821	77%

As we can see from the table 1, the best results were obtained with matrix filter to blur, represented by (3).

Based on the experiments, the authors of this scientific work give next recommendations. If the aim of image processing is to improve clarity of details that are out of focus, and does not matter possibility of artifacts to clear objects, it is best not to use the previous blur, so not clear elements become more expressive. But if you want all the image details become clearer, and they were no visible artifacts on it, it should be used blur with the filter above to the digital image before increase its sharpness.

Conclusions

It was proposed in this paper, the way of increase of clarity the digital images, which avoids the sharpness artifacts by blurring previous processed file. It was conducted a comparative analysis of the impact of different filters for blur to improve the clarity of digital images and recommendations to use them.

Further work the authors focused on a detailed study of the process sharpening a digital image. The results will be used to create a method of increase the clarity of digital image.

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ПІДВИЩЕННЯ ЧІТКОСТІ ЦИФРОВОГО ЗОБРАЖЕННЯ

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Фотографії є невід'ємною і, безумовно, важливою складовою нашого життя. Часто ми стикаємось з необхідністю підвищити чіткість цифрового зображення, наприклад, під час вирішення задач розпізнавання образів або з інших причин. Методи підвищення чіткості цифрових зображень дуже різноманітні, кожен має свою область застосування. Проте часто при обробці цифрового зображення тим чи іншим методом можуть виникати артефакти. Метою даної роботи є підвищення чіткості цифрового зображення з урахуванням необхідності уникнення артефактів. Для досягнення даної мети в роботі застосовано алгоритми обробки цифрового зображення, засновані на використанні матриць згортки різних типів. На прикладі типових зображень показано, які переваги при підвищенні чіткості цифрового зображення дає використання комбінації цих алгоритмів у певній послідовності. Проведено порівняльний аналіз впливу різних фільтрів на покращення чіткості цифрового зображення та дано рекомендації щодо їх використання.

Ключові слова: цифрове зображення, чіткість зображення, матриця фільтра, згортка, обробка зображень.

ПОВЫШЕНИЕ ЧЕТКОСТИ ЦИФРОВОГО ИЗОБРАЖЕНИЯ

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Фотографии являются неотъемлемой и, безусловно, важной составляющей нашей жизни. Часто мы сталкиваемся с необходимостью повысить четкость цифрового изображения, например, при решении задач распознавания образов или по другим причинам. Методы повышения четкости цифровых изображений очень разнообразны, каждый имеет свою область применимости. Однако часто при обработке цифрового изображения тем или иным методом могут возникать артефакты. Целью данной работы является повышение четкости цифрового изображения с учетом необходимости избежать артефактов. Для достижения данной цели в работе использованы алгоритмы обработки цифрового изображения, основанные на использовании матриц свертки разных типов. На примере типичных изображений показано, какие преимущества при повышении четкости цифрового изображения дает использование комбинации этих алгоритмов в определенной последовательности. Проведен сравнительный анализ влияния различных фильтров на улучшение четкости цифрового изображения и даны рекомендации относительно их использования.

Ключевые слова: цифровое изображение, четкость изображения, матрица фильтра, свертка, обработка изображений.