Dynamic Shift of Image Brightness Range

Olena Osharovska
Department of Radioelectronic Systems and Technologies
State University of Intelligent Technologies and Telecommunications
Odesa, Ukraine
osharovskaya@gmail.com

Mikola Patlayenko
Department of Radioelectronic Systems and Technologies
State University of Intelligent Technologies and Telecommunications
Odesa, Ukraine
nick_msa@ukr.net

Динамічний Зсув Діапазону Яскравості Зображення

Олена Ошаровська
кафедра радіоелектронних систем та технологій
Державний університет інтелектуальних технологій і зв'язку
Одеса, Україна
osharovskaya@gmail.com

Микола Патлаєнко
кафедра радіоелектронних систем та технологій
Державний університет інтелектуальних технологій і зв'язку
Одеса, Україна
nick_msa@ukr.net

***Abstract*— The paper presents the results of a study on equalizing the contrast of small details and textures in images created with insufficient lighting or overexposed. It is proposed to use methods for creating images with a high range. The brightness signal of the original image is divided into subranges according to the brightness signal levels. In each subrange, a linear or nonlinear brightness shift occurs with upper and lower limits. The resulting image is reassembled. As a result, the contrast of fine details is locally increased. The original and improved images and their corresponding histograms of the distribution of brightness signal levels are shown.**

***Анотація*— У роботі представлені результати дослідження з вирівнювання різноманітності контрастів дрібних деталей та текстур у зображеннях, створених при малому освітленні або засвічених. Пропонується використовувати методи створення зображень із розширеним діапазоном. Сигнал яскравості вихідного зображення поділяється на піддіапазони за рівнями сигналу яскравості. У кожному піддіапазоні відбувається лінійне або нелінійне зміщення яскравостей з верхнім та нижнім обмеженням. Результативне зображення знову збирається. Внаслідок цього контраст дрібних деталей локально збільшується. Наведено вихідне та покращене зображення та відповідні їм гістограми розподілу рівнів сигналу яскравості.**

Keywords— image; texture; dynamic range; brightness signal; contrast

Ключові слова— зображення; текстура; динамічний діапазон; сигнал яскравості; контраст

I. INTRODUCTION

High dynamic range (HDR) images provide viewers with a more vibrant visual experience. Recommendation ITU-R BT.2100-2 [1] defines HDR-TV image parameters for use in production and international program exchange using soft quantization (PQ) and logarithmic signal transformation (HLG) techniques. ITU R in Recommendations ITU-R BT.709 [2] and ITU-R BT.2020 [3] defined these digital television picture formats for HDTV and UHDTV. HDR-TV provides an "incremental" improvement in viewing experience by significantly increasing the brightness range. This paper proposes to apply the idea of gradual image enhancement, which is formed from intermediate images. Each intermediate image has its own contrast correction law.

II. THE DESCRIPTION OF THE ORIGINAL IMAGE

As the source image, we use the still image "Drama Sunset" (Fig. 1) of high definition 2K, corresponding to the parameters presented in Recommendation ITU-R BT.709 [2]. The image is represented by three RGB primary color matrices of the same size, which corresponds to the 4:4:4 sampling format. The bit depth of each of the primary colors is eight. Thus, the signal levels of the primary colors can vary from 0 to 255. [4, 5, 6]

Рис. 1.The original Image “Drama sunset”

For subsequent processing, we convert the RGB colour space into the signal space Y, CR, CB in accordance with formula (1) for the brightness component E'Y

$$E'Y = 0.2126\ E'R + 0.2126\ E'G + 0.0722\ E'B, \quad (1)$$

The image "Drama of Sunset" is low-contrast, ripples on the water and other small details are almost indistinguishable. Fig. 2 shows histogram of the distribution of brightness signal values.

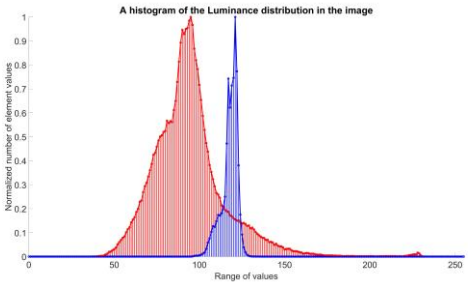

Рис. 2. The histogram of brightness signal original Image

The total number of pixels corresponding to potential 2K image clarity is presented on the vertical axis in relative units.

III. Experiment Results

In this study, we used the idea of adding several images obtained from the original, but with shifted brightness ranges. The brightness range in this study shifted stepwise, both down and up [7, 8]. However, such shifts were carried out only for selected small parts that fell within the ranges specified by the threshold values. Modelling of intermediate images with shifted brightness ranges was carried out in the Matlab environment. Figure 3 shows a planar map for the smallest details when shifted down by 220 levels.

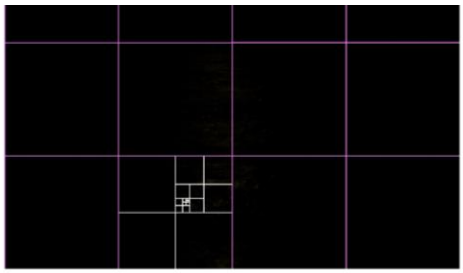

Рис. 3. The planar map for shifted doun Image

Double precision was used to calculate signal values. To output images, the signal values were converted to eight-bit integers. As a result of such shifting and cutting off the thresholds from above and below, we achieve an increase in the ratio of the maximum brightness of the fragment to the minimum, which corresponds to the improvement of local contrasts. Five subranges were selected: -100%, -80%, -40%, +40%, +80%, +100%. A histogram of the summary image with a high range is shown in Fig. 4.

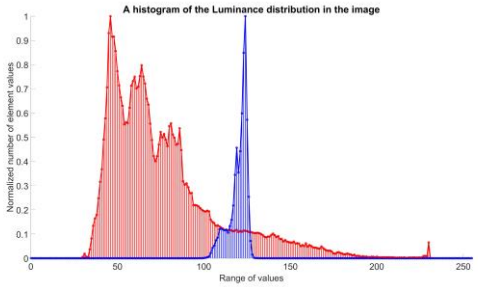

Рис. 4.The histogram of HDR image

When analyzing a histogram, you can pay attention to the variety of representation of small details. The resulting image is shown in Fig. 5.

Рис. 5.The histogram of HDR image

We do not reduce the spatial frequencies.

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