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Fu
Jianxiang

**ALGORITHMS FOR DYNAMIC RANGE TRANSFORMING OF
MULTICHANNEL IMAGES**

Abstract
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Supervisor
Tsviatkou Viktor
Doctor of Science, Full professor
Head of the Department of
Infocommunication technologies

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INTRODUCTION

Images can act on the human eye directly or indirectly to produce visual entities. As the most accessible medium for human beings to receive information, images have become an important channel and source for human daily life to obtain information in the information age by virtue of its rich information, intuitive expression, fast transmission speed, and long-distance effect. Images can describe many scenes and things clearly at a glance.

A multi-channel image refers to an image in which each pixel contains information of multiple channels in image processing. In a color image, three channels of RGB (red, green, blue) are usually used to represent the color of each pixel, so an RGB image is a common three-channel image. The title of this article is Algorithms for dynamic range transforming of multichannel images, so we mainly study the dynamic range conversion algorithm of RGB color images in this article. The pixel value of each channel in a multi-channel image represents the intensity or color information of the channel, and the final color information can be obtained by weighting and combining the pixel values of different channels. In image processing, the operation of multi-channel images can better reflect the information of different channels, so as to better meet the needs of different applications.

In our daily life, most of the images we come into contact with are color images, but grayscale images are still used in many fields due to their small data volume and simple calculation. In order to reduce the amount of input and output information and reduce information redundancy, the primary task is to grayscale the color image to be processed to ensure the efficiency of subsequent work. Grayscale images permeate almost every field related to image processing, and have great practical value in various application markets.

According to the characteristics of night scene images and foggy images, this paper proposes a saliency-preserving grayscale algorithm for night scene images and foggy images. According to the characteristics of night scene images and foggy images, the saliency map of the original color image is obtained by using frequency-tuned saliency detection technology, the target area of interest is found, and the brightness channel of the saliency map is extracted to obtain the guide map. A polynomial parameter model is constructed by using the saliency of the pixel in the guide image and the RGB three-channel value of the pixel in the original color image. Then use the reference contrast value in the energy optimization function constructed by saliency scaling in the guide map to enhance the local contrast of the target area in the obtained grayscale result, and obtain the grayscale of night scene images and foggy images with saliency preservation result.

The experimental results in this paper have achieved good results under both subjective and objective evaluation methods.

GENERAL DESCRIPTION OF WORK

Relevance of the subject

The work corresponds to paragraph 1 «Digital information and communication and interdisciplinary technologies, production based on them» of the State Program of innovative development of the Republic of Belarus for 2021–2025.

The work was carried out in the educational institution Belarusian State University of Informatics and Radioelectronics within the framework of research work 21-2033 "Processing, coding and transmission of information in network-centric systems".

The aim and tasks of the work

The aim of the work is to complete Algorithms for dynamic range transforming of multichannel images. In this regard, for multi-channel images such as night scene images and foggy images, this paper proposes a grayscale algorithm for night scene images and foggy images that maintains saliency according to their own characteristics.

To achieve this aim, the following tasks were solved in the dissertation:

1 Introduce the basic theory of digital image, including the type of digital image, color space, principle and evaluation method of grayscale color image, etc.

2 Analyze the existing grayscale methods, according to whether the main mapping function acts on the whole image, they are divided into global mapping method and local mapping method, and their main contents are introduced respectively.

3 Introduce the saliency-preserving night scene image and fog image grayscale algorithm proposed in this paper, and describe the steps, models, formulas, etc. of the algorithm in detail.

4 Subjective evaluation and objective evaluation of the experimental results of the algorithm. Experimental results show that this algorithm achieves good results while maintaining image saliency.

Personal contribution of the author

The Algorithms for dynamic range transforming of multichannel images proposed in this paper is a night scene image and foggy image grayscale algorithm

that maintains saliency. The experiment of the algorithm is implemented by matlab, and the simulation experiment is carried out on six pictures to study the characteristics. The E-score value of the obtained grayscale image is calculated, and the effect of the developed algorithm is evaluated by combining subjective evaluation and objective evaluation of the experimental results. The results prove that this algorithm can effectively improve the contrast of important information in the grayscale image, and the algorithm has achieved good results.

Testing and implementation of results

The main provisions and results of the dissertation work were reported and discussed at: High dynamic range image processing technology (Minsk, March 2023), Research on texture image feature extraction method (Minsk, March 2023) and Synthesis algorithm of multi-exposure images (Minsk, April 2022).

Author's publications

According to the results of the research presented in the dissertation, 3 author's works was published, including: 3 articles and abstracts in conference and seminar proceeding.

Structure and size of the work

The dissertation work consists of introduction, general description of the work, four chapters with conclusions for each chapter, conclusion, bibliography, eight appendixes.

The total amount of the thesis is 70 pages, of which 42 pages of text, 16 figures on 9 pages, 5 tables on 3 pages, a list of used bibliographic sources (57 titles on 3 pages), a list of the author's publications on the subject of the thesis (3 titles on 1 pages), graphic material on 9 pages.

Plagiarism

An examination of the dissertation «Algorithms for dynamic range transforming of multichannel images» by Fu Jianxiang was carried out for the correctness of the use of borrowed materials using the network resource «Antiplagiat» (access address: <https://antiplagiat.ru>) in the on-line mode 25.05.2023. As a result of the verification, the correctness of the use of borrowed materials was established (the originality of the thesis is 91.20 %).

SUMMARY OF WORK

In the first chapter, the basic theory of digital image and related algorithms are introduced, which provide a theoretical basis for subsequent algorithms and experiments.

In Section 1.1, the basic types of digital images are introduced, and binary images, grayscale images, indexed images and true color images are introduced in detail. In Section 1.2, common color spaces are introduced, mainly RGB color space and CIE lab color space. The RGB color space is a color space based on the principle of three primary colors. The CIE lab color space expresses colors with three values: L represents perceived brightness, and a and b represent four unique colors of human vision: red, green, blue, and yellow. In Section 1.3, the principle of color image grayscale is introduced, and the principles of color transformation and dimension transformation in the grayscale process are briefly introduced. The concept of visual saliency is introduced in Section 1.4. This section introduces several classic saliency detection algorithms. After analysis, this paper chooses a saliency detection algorithm that is more suitable for the next working frequency tuning. In Section 1.5, the evaluation methods of the grayscale effect of color images are introduced, which are subjective evaluation relying on the visual characteristics of the human eye and objective quantitative evaluation based on mathematical models. These evaluation methods will be used to calculate and analyze the experimental results in subsequent chapters.

In Section 1.6, the existing color image grayscale related algorithms are introduced. These algorithms can be divided into global mapping methods and local mapping methods according to the characteristics of whether their main mapping functions act on the entire image. The global mapping method introduces the RGB channel average method, RGB channel weighting method, etc. Local Mapping Methods provides a brief introduction to the algorithm of Bala, Smith et al. Both the global mapping method and the local mapping method have their own advantages and disadvantages.

In the second chapter, the grayscale algorithm of night scene image and foggy image which maintains saliency is introduced. The algorithm proposed in this paper is introduced and explained in detail.

In Section 2.1, a saliency-preserving image grayscale algorithm is introduced. Saliency is a biologically based concept. The researchers found that for the same picture, most people have roughly the same attention area. Therefore, according to this characteristic, this paper introduces it into the grayscale process of the image, and proposes a method that is more suitable for night scene images and foggy days. The grayscale method of the image aims at "maintaining saliency",

improves the local contrast of the image, and obtains a better grayscale result.

The algorithm of this chapter is introduced in section 2.2, and the detailed formulas are listed. First, the saliency map of the original image is obtained through saliency detection, and the saliency coefficient within a certain range is determined according to the saliency map. Then, construct a grayscale parameter model, the pixel grayscale value is the power series combination of the vector subspace composed of the RGB three-channel value of the original color image corresponding to the pixel point and the four channels of salience, and then multiplied by their respective weights . Scale the contrast value in the energy optimization function according to the saliency value obtained above and solve the grayscale parameter model to finally obtain the grayscale value of the pixel. After such processing, regions with different saliency values will have different final gray values even if the colors are the same.

In the third chapter, the experimental results and analysis of the algorithm are introduced. The experimental results are evaluated objectively and subjectively through simulation experiments, and the effectiveness of the algorithm is verified.

In Section 3.1, two test images and two additional night scene images and two foggy images are used as the experimental objects. Observe the grayscale result, and compare it with the result map obtained by using the `rgb2gray` function in the MATLAB library and the result map obtained by using the Lu algorithm.

The experimental results are evaluated in Section 3.2. The evaluation of the above experimental results includes subjective evaluation and objective evaluation. The subjective evaluation was done by ten students randomly selected by the author, and the grayscale images obtained by different algorithms were scored. Most of the students gave higher scores to the algorithms in this chapter than the other two methods. The objective evaluation uses the E-Score model to analyze and compare the above grayscale results. The results fully prove the superiority of the algorithm in this chapter when dealing with night scene images and foggy images.

CONCLUSION

Grayscale images are used in almost every image-related field, and have very strong practical value. Whether it is now or in the future, color image grayscale technology will be an indispensable key technology in the field of image processing. But there is no algorithm that can be perfectly applied to any application scenario, so this paper designs an effective color image grayscale algorithm based on the characteristics of night scene images and foggy images. Next, make a detailed summary of the work done in this paper.

Firstly, the background and research status of color image grayscale are introduced, and the two categories of color image grayscale technology are analyzed in detail, as well as the advantages and disadvantages of each specific method. Then it introduces various image processing related knowledge involved in the algorithm of this chapter, emphatically introduces the concept of visual saliency, and common methods to obtain image visual saliency. Next is the specific work done in this paper.

Aiming at the shortcomings of most existing algorithms that only do automatic and unified grayscale mapping for images in the grayscale process, this paper proposes a saliency-preserving color image grayscale algorithm based on the image saliency theory. Before the grayscale processing, the frequency-tuned saliency detection algorithm is used to obtain the saliency map of the original color image, and the regions with different saliency in the result are processed accordingly to obtain the guide map, and the guide map is used to intervene in the next grayscale process. Firstly, the significance factor is added to the established grayscale parameter model. Then, the guide map is used to change the reference contrast value in the energy optimization function to enhance the local contrast of the target area in the final grayscale result. Finally, the grayscale results processed by the algorithm in this paper have achieved good results in both subjective evaluation and objective evaluation methods, which proves that the algorithm has a very high practical value.

LIST OF AUTHOR'S PUBLICATIONS

1–А. Fu J.X. High dynamic range image processing technology / J.X. Fu, J.K. Chen // Технологии передачи и обработки информации (Technologies of information transmission and processing): материалы Международного научно-технического семинара, Минск, март – апрель 2023 г. – Minsk : BSUIR, 2023. – С. 163–166.

2–А. Fu J.X. Research on texture image feature extraction method / J.K. Chen, J.X. Fu, V.yu. Tsviatkou // Технологии передачи и обработки информации (Technologies of information transmission and processing): материалы Международного научно-технического семинара, Минск, март – апрель 2023 г. – Minsk : BSUIR, 2023. – С. 149–153.

3–А. Fu J.X. Synthesis algorithm of multi-exposure images / J.X. Fu // Инфокоммуникации : сборник тезисов докладов 59-ой научной конференции аспирантов, магистрантов и студентов, Минск, 18–22 апреля 2023 г. – Minsk : BSUIR, 2023. – С. 163–164.