中原大學電子所博士論文點數審查推薦函

112 年 11 月 15 日

一、事由：推薦電子所博士班研究生 He-Sheng Chou(周和陞)(學號 10776018)進行博士論文點數審查。

二、說明：中原大學電子所博士班學生周和陞投稿論文列表

A. Journal 期刊論文

(J-1) Shih-Lun Chen; He-Sheng Zhou; Tsung-Yi Chen; Tsung-Han Lee; Chiung-An Chen*; Ting-Lan Lin; Nung-Hsiang Lin; Liang-Hung Wang; Szu-Yin Lin; Wei-Yuan Chiang; Patricia Angela R. Abu; and Ming-Yi Lin, "**Dental shade matching method based on hue, saturation, value color model with machine learning and fuzzy decision**", Sens. Mater 32 (2020): 3185-3207. (SCI)

第一學生作者，預估點數：4

(J-2) Yi-Cheng Mao; Tsung-Yi Chen; He-Sheng Chou; Szu-Yin Lin*; Sheng-Yu Liu; Yu-An Chen; Yu-Lin Liu; Chiung-An Chen*; Yen-Cheng Huang; Shih-Lun Chen*; Chun-Wei Li; Patricia Angela R. Abu; Wei-Yuan Chiang , "**Caries and restoration detection using bitewing film based on transfer learning with CNNs**" Sensors 21.13 (2021): 4613. (SCI)

第三學生作者，預估點數：1

(J-3) Chun-Wei Li; Szu-Yin Lin*; He-Sheng Chou; Tsung-Yi Chen; Yu-An Chen; Sheng-Yu Liu; Yu-Lin Liu; Chiung-An Chen 4*; Yen-Cheng Huang; Shih-Lun Chen*; Yi-Cheng Mao; Patricia Angela R. Abu; Wei-Yuan Chiang; Wen-Shen Lo , "**Detection of dental apical lesions using CNNs on periapical radiograph**" Sensors 21.21 (2021): 7049. (SCI)

第三學生作者，預估點數：1

(J-4) Yen-Cheng Huang; Chiung-An Chen 2*; Tsung-Yi Chen; He-Sheng Chou; Wei-Chi Lin; Tzu-Chien Li; Jia-Jun Yuan; Szu-Yin Lin 4*; Chun-Wei Li; Shih-Lun Chen*; Yi-Cheng Mao; Patricia Angela R. Abu; Wei-Yuan Chiang; Wen-Shen Lo , "**Tooth position determination by automatic cutting and marking of dental panoramic X-ray film in medical image processing**" Applied Sciences 11.24 (2021): 11904. (SCI)

第四學生作者，預估點數：0.5

(J-5) Shih-Lun Chen, He-Sheng Chou, Chun-Hsiang Huang, Chih-Yun Chen, Liang-Yu Li, Ching-Hui Huang, Yu-Yu Chen, Jyh-Haw Tang, Wen-Hui Chang, and Je-Sheng Huang, "**An Intelligent Water Monitoring IoT System for Ecological Environment and Smart Cities**" Sensors 23, no. 20 (2023): 8540. (SCI)

第一學生作者，預估點數：4

B. Conference 研討會論文

(C-1) Shih-Yao Ke; He-Sheng Jhou; Chiung-An Chen; Ting-Lan Lin; Patricia Angela R. Abu; Shih-Lun Chen , "**A Hardware-Oriented Image Compression Algorithm Based on BTC and YEF Color Space**" 2021 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2021, pp. 1-5, doi: 10.1109/ICCE50685.2021.9427696.

第二學生作者，預估點數：1

(C-2) Jr-Yu Lin; He-Sheng Chou; Kun-Ze Su; Shih-Yao Ke; Wen-Shen Lo; Chiung-An Chen; Shih-Lun Chen , "**Descriptor Sampling VLSI Design Based on BRIEF Algorithm for Surrounding View Application**" 2021 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), Penghu, Taiwan, 2021, pp. 1-2, doi: 10.1109/ICCE-TW52618.2021.9603183.

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(C-4) He-Sheng Chou, Hsiang-Yun Cheng, Jun-Xiang Qiu, Tsun-Kuang Chi, Tsung-Yi Chen, Shin-Lun Chen , "**Retinex Based on Weaken Factor with Truncated AGCWD for Backlight Image Enhancement**" 2022 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2022, pp. 1-5, doi: 10.1109/ICCE53296.2022.9730202.

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(C-6) Chi-An Li; Tsung-Yi Chen; He-Sheng Chou; Ya-Yun Huang; Chiung-An Chen; Wen-Shen Lo; Tzu-Yu Chen; Ting-Lan Lin; Shih-Lun Chen , "**An Improved Image Feature Detection Algorithm Based on Oriented FAST and Rotated BRIEF for Nighttime Images**" 2022 IEEE International Conference on Consumer Electronics - Taiwan, Taipei, Taiwan, 2022, pp. 289-290, doi: 10.1109/ICCE-Taiwan55306.2022.9869224.

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(C-8) Ming-Zhan Lee, He-Sheng Chou, Yu-Lin Liu, Ting-Lan Lin, Wei-Chen Tu and Shin-Lun Chen, "**3D Point Cloud Denoising Algorithm Based on Two-Stage Filtering**" *2023 International Conference on Consumer Electronics - Taiwan (ICCE-Taiwan)*, PingTung, Taiwan, 2023, pp. 419-420

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(C-9) Cheng-Lin Lu, He-Sheng Chou, Ya-Yun Huang, Mei-Ling Chan, Szu-Yin Lin, Shih Lun Chen, “**High Compression Rate Architecture For Texture Padding Based on V-PCC**” *2023 International Conference on Consumer Electronics - Taiwan (ICCE-Taiwan)*, PingTung, Taiwan, 2023, pp. 413-414. Doi: 10.1109/ICCE-Taiwan58799.2023.10227018.

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第四學生作者，預估點數：0.25

(J-1) Shih-Lun Chen; He-Sheng Zhou; Tsung-Yi Chen; Tsung-Han Lee; Chiung-An Chen*; Ting-Lan Lin; Nung-Hsiang Lin; Liang-Hung Wang; Szu-Yin Lin; Wei-Yuan Chiang; Patricia Angela R. Abu; and Ming-Yi Lin, "**Dental shade matching method based on hue, saturation, value color model with machine learning and fuzzy decision**", Sens. Mater 32 (2020): 3185-3207. (SCI)

Dental Shade Matching Method Based on Hue, Saturation, Value Color Model with Machine Learning and Fuzzy Decision

By Chen, SL (Chen, Shih-Lun) [1] ; Zhou, HS (Zhou, He-Sheng) [1] ; Chen, TY (Chen, Tsung-Yi) [1] ; Lee, TH (Lee, Tsung-Han) [1] ; Chen, CA (Chen, Chiung-An) [2] ; Lin, TL (Lin, Ting-Lan) [3] ; Lin, NH (Lin, Nung-Hsiang) [4] ; Wang, LH (Wang, Liang-Hung) [5] ; Lin, SY (Lin, Szu-Yin) [6] ; Chiang, WY (Chiang, Wei-Yuan) [2] ; Abu, PAR (Abu, Patricia Angela R.) [7] ; Lin, MY (Lin, Ming-Yi) [8] ...Less

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Abstract Color information is an important indicator of color matching. It is recommended to use hue (H) and saturation (S) to improve the accuracy of color analysis. The proposed method for dental shade matching in this study is based on the hue, saturation, value (HSV) color model. To evaluate the performance of the proposed method in matching dental shades, peak signal-to-noise ratio (PSNR), structural similarity index (SSIM), composite peak signal-to-noise ratio (CPSNR), and S-CIELAB (Special International Commission on Illumination, L* for lightness, a* from green to red, and b* from blue to yellow) were utilized. To further improve the performance of the proposed method, dental image samples were multiplied by the weighted coefficients derived by training the model using machine learning to reduce errors. Thus, the PSNR of 97.64% was enhanced to 99.93% when applied with the proposed fuzzy decision model. Results show that the proposed method based on the new fuzzy decision technology is effective and has an accuracy of 99.78%, which is a significant improvement of previous results. The new fuzzy decision is a method that combines the HSV color model, PSNR(H), PSNR(S), and SSIM information, which are used for the first time in research on tooth color matching. Results show that the proposed method performs better than previous methods.

Keywords **Author Keywords:** dental shade matching; new fuzzy decision; chrominance; HSV; PSNR; CPSNR; S-CIELAB; SSIM

Keywords Plus: SYSTEM

Author Information Corresponding Address: Chen, Chiung-An (corresponding author)

Ming Chi Univ Technol, Dept Elect Engn, New Taipei 301, Taiwan

Addresses :

[1] Chung Yuan Christian Univ, Dept Elect Engn, Taoyuan 320, Taiwan

[2] Ming Chi Univ Technol, Dept Elect Engn, New Taipei 301, Taiwan

(J-2) Yi-Cheng Mao; Tsung-Yi Chen; He-Sheng Chou; Szu-Yin Lin*; Sheng-Yu Liu; Yu-An Chen; Yu-Lin Liu; Chiung-An Chen*; Yen-Cheng Huang; Shih-Lun Chen*; Chun-Wei Li; Patricia Angela R. Abu; Wei-Yuan Chiang , "**Caries and restoration detection using bitewing film based on transfer learning with CNNs**" Sensors 21.13 (2021): 4613. (SCI)

Caries and Restoration Detection Using Bitewing Film Based on Transfer Learning with CNNs

By	Mao, YC (Mao, Yi-Cheng) [1] ; Chen, TY (Chen, Tsung-Yi) [2] ; Chou, HS (Chou, He-Sheng) [2] ; Lin, SY (Lin, Szu-Yin) [3] ; Liu, SY (Liu, Sheng-Yu) [2] ; Chen, YA (Chen, Yu-An) [2] ; Liu, YL (Liu, Yu-Lin) [2] ; Chen, CA (Chen, Chiung-An) [4] ; Huang, YC (Huang, Yen-Cheng) [1] ; Chen, SL (Chen, Shih-Lun) [2] ; Li, CW (Li, Chun-Wei) [1] ; Abu, PAR (Abu, Patricia Angela R.) [5] ; Chiang, WY (Chiang, Wei-Yuan) [6] ...Less
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Abstract

Caries is a dental disease caused by bacterial infection. If the cause of the caries is detected early, the treatment will be relatively easy, which in turn prevents caries from spreading. The current common procedure of dentists is to first perform radiographic examination on the patient and mark the lesions manually. However, the work of judging lesions and markings requires professional experience and is very time-consuming and repetitive. Taking advantage of the rapid development of artificial intelligence imaging research and technical methods will help dentists make accurate markings and improve medical treatments. It can also shorten the judgment time of professionals. In addition to the use of Gaussian high-pass filter and Otsu's threshold image enhancement technology, this research solves the problem that the original cutting technology cannot extract certain single teeth, and it proposes a caries and lesions area analysis model based on convolutional neural networks (CNN), which can identify caries and restorations from the bitewing images. Moreover, it provides dentists with more accurate objective judgment data to achieve the purpose of automatic diagnosis and treatment planning as a technology for assisting precision medicine. A standardized database established following a defined set of steps is also proposed in this study. There are three main steps to generate the image of a single tooth from a bitewing image, which can increase the accuracy of the analysis model. The steps include (1) preprocessing of the dental image to obtain a high-quality binarization, (2) a dental image cropping procedure to obtain individually separated tooth samples, and (3) a dental image masking step which masks the fine broken teeth from the sample and enhances the quality of the training. Among the current four common neural networks, namely, AlexNet, GoogleNet, Vgg19, and ResNet50, experimental results show that the proposed AlexNet model in this study for restoration and caries judgments has an accuracy as high as 95.56% and 90.30%, respectively. These are promising results that lead to the possibility of developing an automatic judgment method of bitewing film.

(J-3) Chun-Wei Li; Szu-Yin Lin*; He-Sheng Chou; Tsung-Yi Chen; Yu-An Chen; Sheng-Yu Liu; Yu-Lin Liu; Chiung-An Chen 4*; Yen-Cheng Huang; Shih-Lun Chen*; Yi-Cheng Mao; Patricia Angela R. Abu; Wei-Yuan Chiang; Wen-Shen Lo , "**Detection of dental apical lesions using CNNs on periapical radiograph**" Sensors 21.21 (2021): 7049. (SCI)

Detection of Dental Apical Lesions Using CNNs on Periapical Radiograph

By Li, CW (Li, Chun-Wei) [1] ; Lin, SY (Lin, Szu-Yin) [2] ; Chou, HS (Chou, He-Sheng) [3] ; Chen, SY (Chen, Tsung-Yi) [3] ; Chen, YA (Chen, Yu-An) [3] ; Liu, SY (Liu, Sheng-Yu) [3] ; Liu, YL (Liu, Yu-Lin) [3] ; Chen, CA (Chen, Chiung-An) [4] ; Huang, YC (Huang, Yen-Cheng) [1] ; Chen, SL (Chen, Shih-Lun) [3] , [5] ; Mao, YC (Mao, Yi-Cheng) [1] ; Abu, PAR (Abu, Patricia Angela R.) [6] ; Chiang, WY (Chiang, Wei-Yuan) [7] ; Lo, WS (Lo, Wen-Shen) [3] , [5] ...Less

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Abstract Apical lesions, the general term for chronic infectious diseases, are very common dental diseases in modern life, and are caused by various factors. The current prevailing endodontic treatment makes use of X-ray photography taken from patients where the lesion area is marked manually, which is therefore time consuming. Additionally, for some images the significant details might not be recognizable due to the different shooting angles or doses. To make the diagnosis process shorter and efficient, repetitive tasks should be performed automatically to allow the dentists to focus more on the technical and medical diagnosis, such as treatment, tooth cleaning, or medical communication. To realize the automatic diagnosis, this article proposes and establishes a lesion area analysis model based on convolutional neural networks (CNN). For establishing a standardized database for clinical application, the Institutional Review Board (IRB) with application number 202002030B0 has been approved with the database established by dentists who provided the practical clinical data. In this study, the image data is preprocessed by a Gaussian high-pass filter. Then, an iterative thresholding is applied to slice the X-ray image into several individual tooth sample images. The collection of individual tooth images that comprises the image database are used as input into the CNN migration learning model for training. Seventy percent (70%) of the image database is used for training and validating the model while the remaining 30% is used for testing and estimating the accuracy of the model. The practical diagnosis accuracy of the proposed CNN model is 92.5%. The proposed model successfully facilitated the automatic diagnosis of the apical lesion.

(J-4) Yen-Cheng Huang; Chiung-An Chen 2*; Tsung-Yi Chen; He-Sheng Chou; Wei-Chi Lin; Tzu-Chien Li; Jia-Jun Yuan; Szu-Yin Lin 4*; Chun-Wei Li; Shih-Lun Chen*; Yi-Cheng Mao; Patricia Angela R. Abu; Wei-Yuan Chiang; Wen-Shen Lo , "**Tooth position determination by automatic cutting and marking of dental panoramic X-ray film in medical image processing**" Applied Sciences 11.24 (2021): 11904. (SCI)

Tooth Position Determination by Automatic Cutting and Marking of Dental Panoramic X-ray Film in Medical Image Processing

By Huang, YC (Huang, Yen-Cheng) [1] ; Chen, CA (Chen, Chiung-An) [2] ; Chen, TY (Chen, Tsung-Yi) [3] ; Chou, HS (Chou, He-Sheng) [3] ; Lin, WC (Lin, Wei-Chi) [3] ; Li, TC (Li, Tzu-Chien) [3] ; Yuan, JJ (Yuan, Jia-Jun) [3] ; Lin, SY (Lin, Szu-Yin) [4] ; Li, CW (Li, Chun-Wei) [1] ; Chen, SL (Chen, Shih-Lun) [3] ; ...More

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Abstract

This paper presents a novel method for automatic segmentation of dental X-ray images into single tooth sections and for placing every segmented tooth onto a precise corresponding position table. Moreover, the proposed method automatically determines the tooth's position in a panoramic X-ray film. The image-processing step incorporates a variety of image-enhancement techniques, including sharpening, histogram equalization, and flat-field correction. Moreover, image processing was implemented iteratively to achieve higher pixel value contrast between the teeth and cavity. The next image-enhancement step is aimed at detecting the teeth cavity and involves determining the segment and points separating the upper and lower jaw, using the difference in pixel values to cut the image into several equal sections and then connecting each cavity feature point to extend a curve that completes the description of the separated jaw. The curve is shifted up and down to look for the gap between the teeth, to identify and address missing teeth and overlapping. Under FDI World Dental Federation notation, the left and right sides receive eight-code sequences to mark each tooth, which provides improved convenience in clinical use. According to the literature, X-ray film cannot be marked correctly when a tooth is missing. This paper utilizes artificial center positioning and sets the teeth gap feature points to have the same count. Then, the gap feature points are connected as a curve with the curve of the jaw to illustrate the dental segmentation. In addition, we incorporate different image-processing methods to sequentially strengthen the X-ray film. The proposed procedure had an 89.95% accuracy rate for tooth positioning. As for the tooth cutting, where the edge of the cutting box is used to determine the position of each tooth number, the accuracy of the tooth positioning method in this proposed study is 92.78%.

(J-5) Shih-Lun Chen, He-Sheng Chou, Chun-Hsiang Huang, Chih-Yun Chen, Liang-Yu Li, Ching-Hui Huang, Yu-Yu Chen, Jyh-Haw Tang, Wen-Hui Chang, and Je-Sheng Huang, "**An Intelligent Water Monitoring IoT System for Ecological Environment and Smart Cities**" Sensors 23, no. 20 (2023): 8540. (SCI)

An Intelligent Water Monitoring IoT System for Ecological Environment and Smart Cities

By Chen, SL (Chen, Shih-Lun) [1] ; Chou, HS (Chou, He-Sheng) [1] ; Huang, CH (Huang, Chun-Hsiang) [1] ; Chen, CY (Chen, Chih-Yun) [1] ; Li, LY (Li, Liang-Yu) [1] ; Huang, CH (Huang, Ching-Hui) [2] ; Chen, YY (Chen, Yu-Yu) [2] ; Tang, JH (Tang, Jyh-Haw) [3] ; Chang, WH (Chang, Wen-Hui) [4] ; Huang, JS (Huang, Je-Sheng) [5]

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Abstract Global precipitation is becoming increasingly intense due to the extreme climate. Therefore, creating new technology to manage water resources is crucial. To create a sustainable urban and ecological environment, a water level and water quality control system implementing artificial intelligence is presented in this research. The proposed smart monitoring system consists of four sensors (two different liquid level sensors, a turbidity and pH sensor, and a water oxygen sensor), a control module (an MCU, a motor, a pump, and a drain), and a power and communication system (a solar panel, a battery, and a wireless communication module). The system focuses on low-cost Internet of Things (IoT) devices along with low power consumption and high precision. This proposal collects rainfall from the preceding 10 years in the application region as well as the region's meteorological bureau's weekly weather report and uses artificial intelligence to compute the appropriate water level. More importantly, the adoption of dynamic adjustment systems can reserve and modify water resources in the application region more efficiently. Compared to existing technologies, the measurement approach utilized in this study not only achieves cost savings exceeding 60% but also enhances water level measurement accuracy by over 15% through the successful implementation of water level calibration decisions utilizing multiple distinct sensors. Of greater significance, the dynamic adjustment systems proposed in this research offer the potential for conserving water resources by more than 15% in an effective manner. As a result, the adoption of this technology may efficiently reserve and distribute water resources for smart cities as well as reduce substantial losses caused by anomalous water resources, such as floods, droughts, and ecological concerns.

(C-1) Shih-Yao Ke; He-Sheng Jhou; Chiung-An Chen; Ting-Lan Lin; Patricia Angela R. Abu; Shih-Lun Chen , "**A Hardware-Oriented Image Compression Algorithm Based on BTC and YEF Color Space**" 2021 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2021, pp. 1-5, doi: 10.1109/ICCE50685.2021.9427696.

A Hardware-Oriented Image Compression Algorithm Based on BTC and YEF Color Space

Shih-Yao Ke
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
stanly860302@gmail.com

He-Sheng Jhou
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
hank97217@gmail.com

Chiung-An Chen
Department of Electrical Engineering
Ming Chi University of Technology
New Taipei City, Taiwan
joannechen@mail.mcut.edu.tw

Ting-Lan Lin
Department of Electronic Engineering,
National Taipei University of Technology,
Taipei City, Taiwan
tinglan@ntut.edu.tw

Patricia Angela R. Abu
Department of Information Systems and Computer Science,
Ateneo de Manila University
Quezon City
pabu@ateneo.edu

Shih-Lun Chen*
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
chrischen@cycu.edu.tw

***Abstract*—This paper proposes a new compression algorithm based on color sampling and Block Truncation Coding (BTC). It is composed of several steps, color sampling, BTC parameter training, threshold selection, sub-sampling, prediction and quantization, and Huffman coding. The color sampling was applied using YEF color space which reduced 34% storage. The subsequent sub-sampling, quantization table prediction, and Huffman coding further increase compression rates. In addition, the BTC parameter training step finds the best reconstruction value for each 4*4 block and bitmap threshold value to improve the image quality. Compared with previously studies, the proposed algorithm shows a better average compression rate.**

Keywords*— *YEF Color Space, Block Truncation Coding, Bit Map, Threshold, Image Compression, Color sampling, Huffman coding

I. Introduction

With the recent breakthrough in technology, many electronic products have become smaller and smaller in size and volume, which in turn results in smaller and smaller memory size and capacity. Data compression is one vital step in order to store a large amount of data in a device with limited memory capacity. Provided that the widely used type of data nowadays is in the form of images and videos, data compression, more specifically image compression, plays a very important role in image and video transmission and storage. In the field of image compression, the type of compression can be classified as a lossless [1] compression or a lossy one.

The rate of compression of a lossy type of compression is often higher than that of lossless compression. Among the different lossy compression algorithms, JPEG [2] is the most famous compression one. JPEG divides the image into non-overlapping 8*8 blocks and utilizes a discrete cosine transform (DCT) to compress the image. However, JPEG is difficult to implement on hardware due to the complex calculations of DCT and requires more circuit costs. Compared with the JPEG compression method, the Block Truncation Code (BTC) [3] compression method, which also has image segmentation technology, is more suitable for implementation on hardware.

BTC is applied to reduce the complexity of the calculations. Averaging and standard deviation are used to calculate the reduction value for each 4*4 block. Chen et al. [4] proposed the use of BTC for hardware implementation of their proposed compression algorithm that consists of the threshold, bitmap generation, BTC parameter training, prediction, and coding.

Fig.1 presents the flowchart of the compression algorithm proposed by this paper. The proposed algorithm starts by converting the original image from its RGB color space to its equivalent YEF color space. A 4:2:0 color sampling is then applied on both the E and F color planes. It then performs a BTC parameter training on the Y, E, and F planes to find the two best reconstruction values for each 4*4 block of each color plane as well as their respective bitmaps. As for the E and F planes, their respective reconstruction values and their bitmaps are sampled in 4:2:2 color to reduce the stored bits. Finally, the two reconstruction values are predicted and the quantization table is compared to the Huffman coding. No sampling is conducted in the brightness component, Y plane. The Y plane plays an important role when the YEF plane is restored back to its RGB color space equivalent.

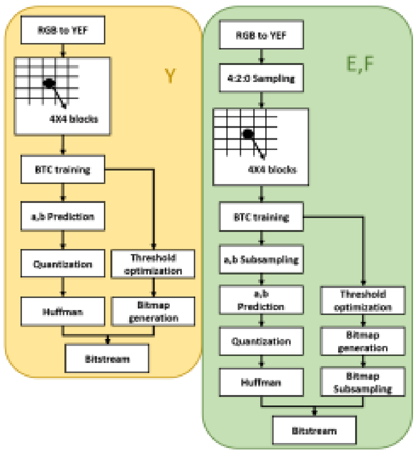


Fig.1 Flowchart of the proposed BTC-based image compression algorithm.

(C-2) Jr-Yu Lin; He-Sheng Chou; Kun-Ze Su; Shih-Yao Ke; Wen-Shen Lo; Chiung-An Chen; Shih-Lun Chen , "**Descriptor Sampling VLSI Design Based on BRIEF Algorithm for Surrounding View Application**" 2021 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), Penghu, Taiwan, 2021, pp. 1-2, doi: 10.1109/ICCE-TW52618.2021.9603183.

Descriptor Sampling VLSI Design Based on BRIEF Algorithm for Surrounding View Application

Jr-Yu Lin[a], He-Sheng Chou[a], Kun-Ze Su[a], Shih-Yao Ke[a], Wen-Shen Lo[b], Chiung-An Chen[c] and Shih-Lun Chen[a, b], *Member, IEEE*

[a]Department of Electronic Engineering, Chung Yuan Christian University, Taoyuan City, Taiwan
[b]Center for Internet of Things and Intelligent Cloud, Chung Yuan Christian University, Taoyuan City, Taiwan
[c]Department of Electrical Engineering, Ming Chi University of Technology, New Taipei City, Taiwan

***Abstract*-- This paper presents a new descriptor sampling method based on Binary Robust Independent Elementary Features (BRIEF). The proposed method is divided into several steps, split blocks, sampling, and descriptor construction. The proposed descriptor sampling method is realized by Very Large-Scale Integration (VLSI) technique. The usage of the split blocks keeps average accuracy attaining 88.01% and reduces 75% gate counts by using the same sampling model to construct descriptions. Comparing with previous studies, this design shows lower hardware cost and higher accuracy.**

Keywords—VLSI, BRIEF, ORB, Description

I. Introduction

The rapid growth of intelligent systems, such as intelligent monitoring systems and automated cars, many of technologies need to rely on image processing. The feature point detection is one of the foundations of image processing. There are several main methods for the feature detection, such as Oriented FAST Rotated BRIEF (ORB) [1], Scale Invariant Feature Transform (SIFT) [2] , and Speeded-Up Robust Features (SURF) [3]. ORB is composed of FAST and BRIEF. Many studies improved these algorithms, and some studies realized them by Very Large-Scale Integration (VLSI) technique, in which ORB based algorithms are popular due to its simple structure and fast calculation speed. A complete hardware implementation for ORB was present by Kulkarni *et al.* [4]. In advanced, some improved ORB based hardware architectures were proposed by [5][6][7]. Although it is not difficult to conduct random sampling for software, it is not easy to manage random sampling on hardware. The random sampling algorithm not only limits the speed but also requires more hardware resource. Therefore, the proposed method is developed to reduce hardware cost without decreasing the accuracy.

II. Descriptor Sampling Algorithm

The solution proposed in this paper is a shared sampling model. Although reducing the sampling point pairs can reduce the consumption of hardware resource, it decreases the accuracy as well. Hence, this paper proposes a method of sharing the sampling model without decreasing accuracy and requiring additional hardware resource. The proposed algorithm includes two steps. The first step is dividing to blocks and enlarged. The second step is to apply the sampling model.

A. Split blocks

The original BRIEF [8] is sampled from 31×31 pixels. In to reduce the number of sample pairs and maintain accuracy. Hence, it is necessary to cut 31×31 pixels and then enlarging it. The first step is to remove the center position and divide 30 by 2 to form 15×15 pixels and then to remove the central position again and divide 14 by 2 to form 7×7 pixels. Fig. 1 shows the details of dividing 31×31 pixels into three layers of blocks. In this paper, a 31×31 sampling model is selected. Hence, the 15×15 and 7×7 pixels needs to be enlarged to 31×31 pixels.

In the same way, a 31×31 sampling model will be used further. So, the 15×15 and 7×7 blocks to 31×31 pixels need to be enlarged. Because the descriptor is to describe the state around the feature point, extending the pixel is to keep the central pix as unchanged as possible, and to distribute other pixels equally, as shown in Fig. 1.

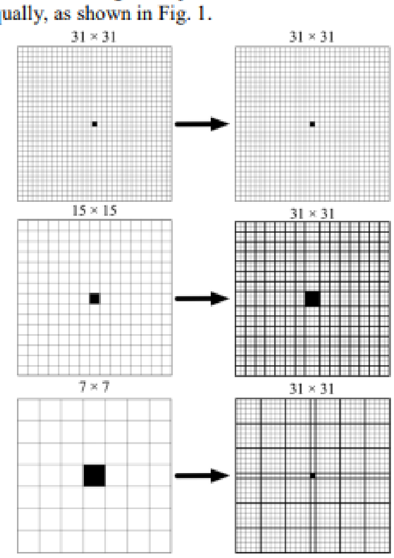


Fig. 1 Cutting and expanding pix

B. Sampling

Since segmented blocks are used in the proposed method, a set of 128 pairs of sampling models is used as shown in Fig. 2(a). The 128 pairs of sampling positions are randomly generated and recorded by the software. XY positions are sampled evenly between -15 and 15. This set of sampling models are respectively applied to the three enlarged pixels above, as shown in Fig. 2(b). It is equivalent to generate 384 pairs of sampling models, as shown in Fig. 2(c).

(C-3) Kun-Ze Su, He-Sheng Chou, Jr-Yu Lin, Shih-Yao Ke, Chiung-An Chen, Ting-Lan Lin, Wen-Shen Lo; Shih-Lun Chen , "**VLSI Design Based on Least Square Estimation Method for Back-Mapping of Barrel Distortion Correction**" 第 32 屆超大型積體電路設計暨計算機輔助設計技術研討會.

VLSI Design Based on Least Square Estimation Method for Back-Mapping of Barrel Distortion Correction

Kun-Ze Su[a], He-Sheng Chou[a], Jr-Yu Lin[a], Shih-Yao Ke[a], Chiung-An Chen[b], Ting-Lan Lin[c], Wen-Shen Lo[d] and Shih-Lun Chen[a,d]

[a]Department of Electronic Engineering, Chung Yuan Christian University, Taoyuan City, Taiwan
[b]Department of Electrical Engineering, Ming Chi University of Technology, New Taipei City, Taiwan
[c]Department of Electronic Engineering, National Taipei University of Technology, Taipei City, Taiwan
[d]Center for Internet of Things and Intelligent Cloud, Chung Yuan Christian University, Taoyuan City, Taiwan

ABSTRACT

This paper proposes a real-time correction VLSI implementation of back mapping for barrel distortion. The mathematical model is based on an inverse mapping expansion polynomials approximated by odd-order polynomials. In order to reduce the calculation process, the polynomial is determined to be a fourth-degree polynomial using two coefficients by estimating the total error value after correction. The finite state machine is used to control data transmission to reduce the demands of chip pads. Although the number of bits of the coefficients is increased by two times compared with the previous circuit design, it increased the accuracy of the results.

1. INTRODUCTION

Wide-angle lens is the most commonly photographic tool used in driver assistance systems. In order to show the situation outside the car from different perspectives, the vehicular image has been developed from the early parking assist system to the surround view system. However, the image taken by the wide-angle lens will cause barrel distortion. Therefore, it will be necessary to perform distortion correction before stitching the surrounding scene images. Barrel distortion correction is mainly divided into two stages: back mapping all of the pixels in the corrected image space (CIS) to the distorted image space (DIS), and calculating the intensity value of each pixel in CIS by the linear interpolation.

The mathematical model of barrel distortion correction is based on least-squares estimation method [1]. In [2], a pipeline architecture based on this model was proposed for real-time correction of barrel distortion. In the calibration process, the coordinate transformation before and after the back-mapping is usually the most time-consuming and computationally intensive stage. It is not conducive to hardware implementation. Accordingly, a low-cost pipelined VLSI architecture is presented in [3], which effectively removed square root and arc-tangent calculation. In addition, the iterative characteristic of Horner's algorithm is used in [4] to further reduce hardware cost and memory requirement. In this paper, the polynomial used for wide-angle distortion correction is based on [3] and [4], which omits coordinate conversion.

2. THE PROPOSED HARDWARE ARCHITECTURE

Each pixel position (x', y') in DIS can be used to calculate the new position (x, y) in CIS through a polynomial. [3] and [4] approximated the back-mapping expansion polynomial by using odd-order polynomial. The expansion polynomial of the mapping from the correction space to the distortion space can be obtained by:

$$y' = v_c + \left(1 + \sum_{n=1}^{N} k_n(\rho)^{2n}\right) \times (y - v_c). \qquad (1b)$$

where ρ is the distance from (x, y) to the distortion center (u_c, v_c) and k_n 's are the back-mapping polynomial coefficients. Four polynomial coefficients are adopted in both implementations. Since the pixel position (x', y') obtained after mapping contains decimals, the best pixel value must be obtained through linear interpolation.

Although the hardware requirements are reduced after the odd-order polynomial approximation, the calculation in the back-mapping stage still requires a lot of registers. Therefore, this paper will make improvements at this stage.

2.1. Least Total Error Estimation

In order to further reduce the hardware requirements, the degree of the polynomial is determined by calculating the least total error of the test dot pattern [5]. Fig. 1 shows the test dot pattern which fills the viewing area of the lens.

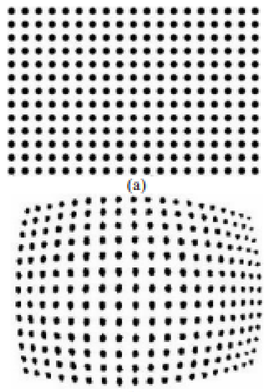


Fig. 1. The test dot pattern. (a) The test dots of the original dot pattern are neatly arranged in the horizontal and vertical directions. (b) The binary dot pattern taken by the distorted lens in [5].

The optimal expansion coefficients are obtained by continuously fitting the grid lines of the rows and columns. The least-squares estimation method is used to estimate the back-mapping coefficients. Table I shows the coefficients of the back-mapping polynomials of

(C-4) He-Sheng Chou, Hsiang-Yun Cheng, Jun-Xiang Qiu, Tsun-Kuang Chi, Tsung-Yi Chen, Shin-Lun Chen , "**Retinex Based on Weaken Factor with Truncated AGCWD for Backlight Image Enhancement**" 2022 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2022, pp. 1-5, doi: 10.1109/ICCE53296.2022.9730202.

Retinex Based on Weaken Factor with Truncated AGCWD for Backlight Image Enhancement

He-Sheng Chou
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
g10776018@cycu.edu.tw

Hsiang-Yun Cheng
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
gn881001@cycu.org.tw

Jun-Xiang Qiu
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
f10726343@cycu.org.tw

Tsun-Kuang Chi
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
g10602603@cycu.org.tw

Tsung-Yi Chen
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
g10976016@cycu.org.tw

Shin-Lun Chen*
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
chrischen@cycu.edu.tw

Abstract*—This paper proposes a new backlight image enhancement algorithm based on an Adaptive Gamma Correction with Weighting Distribution (AGCWD) algorithm. The proposed algorithm is based on Multi-scale Retinex (MSR). And it is composed of HSV color space, surrounding luminance blur(blurred-surrounding luminance), MSR-based just-noticeable difference (JND) curve weakening factor, and AGCWD. The proposal MSR's surrounding luminance was simulated by the Gaussian filter was replaced with the mean filter to reduce the complexity of the proposed algorithm. In order to avoid over-enhancing the areas with high luminance by AGCWD and keep the detail information of local areas, a restriction is added to the Cumulative Distribution Function curve in the proposed algorithm. The proposed algorithm has better performance than previous studies in the backlight image, especially shadow areas. In addition, it also reduces the complexity of the MSR's algorithm. Decreased 86.65% at the time of simulating surrounding luminance.

***Keywords*—HSV Color Space, MSR, JND curve, AGCWD, Backlight Image Enhancement**

I. Introduction

Image processing is already an indispensable technology for the development of science and technology. Whether it is image recognition, biomedicine, artificial intelligence, and even autonomous driving, the demands of image processing are more and more widely. Contrast is the difference in brightness and color between objects in an image. It is a basic but very important part of image processing. An excellent contrast image processing effectively improves the image quality, which could show good clarity performance and emphasize the details in images.

However, many possibilities such as backlight, haze, or even dark light environment cause low image contrast. These low-contrast images are hard to be used by other image processing like image recognition. Therefore, some of the algorithms that enhance the contrast of images are particularly focused on adjusting the luminance of images.

Histogram Equalization (**HE**) [1] is one of the most basic contrast processing methods. It is suitable for processing overexposed or backlight images. HE is through Probability Density Function, Cumulative Distribution Function, and horizontally stretches the over-concentrated part of the image pixels to make them evenly distributed to achieve the effect of enhancing the contrast.

Later, based on HE, someone proposed Adaptive Histogram Equalization (**AHE**) [2], which changed the way that HE used global processing. AHE solved the shortcoming of HE that the local contrast and lost object details due to the local processing. Soon after, the base on AHE proposed Contrast Limited Adaptive Histogram Equalization (**CLAHE**) [3]. By limiting the PDF, that exceeds the threshold is divided equally to the histogram bottom. And then a method based on smoothing the slope curve of CDF is proposed. It makes the local details of the over-concentrated pixel values more obvious and suppresses excessive noise enhancement.

Yi-Sheng Chiu et al. proposed an Adaptive Gamma Correction with Weight Distribution (**AGCWD**) [4] algorithm. It employs the method of the weight distribution, redistributes the PDF of the pixel values of the image to have the CDF curve smooth. Then the smooth CDF curve is used in gamma correction to adapt global image enhancement.

Edwin H. Land proposed a Retinex Theory of Color Vision [5] method, which assumes that the image observed by the human eyes is the product of the reflectance layer and the surrounding luminance layer. The theory is based on the consistency of color perception. In addition to the light, the color of the object is related to the ability of the reflectance layer. The contrast must maintain the high-frequency information of the reflectance layer $R(x,y)$ as much as possible, and reduce the influence of the surrounding luminance layer $L(x,y)$.

$$S(x,y) = R(x,y) \cdot L(x,y) \qquad (1)$$

Therefore, many scholars use this technology to divide the image into the surrounding luminance layer and reflectance layer. The surrounding luminance intensity is removed to eliminate the influence of light on the object. And the obtained reflectance layer is strengthened to achieve the effect of enhancing image quality. So the Single-Scale Retinex (**SSR**) is extended, and its formula is expressed as formula (2). Following the human visual system (**HVS**), the image is projected to the logarithmic domain for processing. Where i represents the color channels R, G, and B. R is the reflection layer of the image, S is the pixel value of the image, and $L(x, y)$ is the surrounding luminance layer. The Gaussian blur is shown in formula (3), in which $F(x,y)$ is the Gaussian filter function and * is the convolution operator.

(C-5) Tsung-Han Lee, He-Sheng Chou, Tsung-Yi Chen, Wen-Shen Lo, Jun-Ting Zhang, Chiung-An Chen, Ting-Lan Lin, Shih-Lun Chen , "**Laplacian of Gaussian Based on Color Constancy Algorithm for Surrounding Image Stitching Application**" 2022 IEEE International Conference on Consumer Electronics - Taiwan, Taipei, Taiwan, 2022, pp. 287-288, doi: 10.1109/ICCE-Taiwan55306.2022.9869055.

Laplacian of Gaussian Based on Color Constancy Algorithm for Surrounding Image Stitching Application

Tsung-Han Lee[1], He-Sheng Chou[1], Tsung-Yi Chen[1], Wen-Shen Lo[1], Jun-Ting Zhang[1], Chiung-An Chen[2], Ting-Lan Lin[3], *Member, IEEE* and Shih-Lun Chen[*1], *Member, IEEE*
[1]Department of Electronic Engineering, Chung Yuan Christian University, Taoyuan City, Taiwan
[2]Department of Electrical Engineering, Ming Chi University of Technology, New Taipei City, Taiwan
[3]Department of Electronic Engineering, National Taipei University of Technology, Taipei City, Taiwan

***Abstract*—This paper presents a new algorithm for Laplacian of Gaussian (LoG) image processing systems. In order to improve nowadays digital capture system and digital display calibration. Color constancy is added to improve the measurement of object color based on independent light sources. To satisfy the human eye's recognition of colors, the angular error must be corrected to make the light source reflect naturally in the image. In addition, the hardware design of classic white balance algorithms such as Gray-World, Max-RGB, and Gray-Edge with the Minkowski norms is implemented in this study. The proposed algorithm is simulating with a Gaussian filter and an additional Laplacian of Gaussian (LoG) to generate real-time masks that automatically brighten images. Compared with several previous studies, the proposed algorithm shows lower angular errors while maintaining the quality of the graphics. The motivation is to make better quality watches on display facilities and better capture systems.**

Keywords—White Balance, Color Constancy, Gaussian filter, Laplacian of Gaussian(LoG), Gray-World, Max-RGB, Gray-Edge, Minkowski norm, Angular error

I. Introduction

The color of an object usually defines the light source with the human eye, and the color constancy tends to affect digital images. These include the light source, the surface reflectivity of objects, and the sensing capabilities of the capture system. The factors affect the definition of color to reflect single capture systems, such as the human eye or digital camera, which restores the exact light source irradiated on each object. Applying the assumptions of Gray-World, Max-RGB, and Gray-Edge algorithms contained in a series of color constancy proposed by [1][2][3]. Modify the pixels toward the illuminant direction, the image set to ideal color and edge weights. Add light source estimation and edge detection based on image information, and calculate global adjustment variables. Use the Gaussian filter on homogenizing [4] and use the Laplacian of Gaussian (LoG) image enhancement [5][6] is added to improve the brightness of the whole image. Finally, the image is deblurred and restored. The main purpose is to improve the visual facilities and reduce the variation of image angular error caused by improper light source angle. Apply it to an image processing system.

II. White Balance Algorithms

This paper gathered three major color constancy methods based on the following algorithm assumptions. The proposed algorithm consists of three steps. Initially is to adjust the image with the main algorithm. The second step is to apply a Gaussian filter and dilate the brightness region. The last step is to enhance the image details. Adjust the brightness much better with the LoG algorithm simplified operators.

A. Color Constancy Assumptions

The original color constancy is a phenomenon based on Lambertian surface, in which each of the image values is derived by $f = (f_R, f_G, f_B)^T$ as shown in Equ. (1).

$$f = \int_{\omega} I(\lambda)s(\lambda,x)c(\lambda)d\lambda \tag{1}$$

Where $I(\lambda)$ is the light source, $s(\lambda)$ is the surface reflectivity, ω is the wavelength, and $c(\lambda)$ is the capture system sensitive to wavelength [2].

With a series of assumptions, Finlayson and Trezzi [7] proposed a method by using constrained Minkowski norms p in illuminant estimation in Equ. (2).

$$\left(\frac{\int (f(x))^p dx}{\int dx}\right)^{\frac{1}{p}} = ke \tag{2}$$

The Gray-World, White-Patch, and Gray-Edge algorithm assumptions respectively represent $p = 1$, $p = \infty$, and $p = 6$ as the best results in [3]. The proposed algorithm referred to the PSNR (Peak signal-to-noise ratio) [8] values as an objective image quality index. Finally, we choose the best image quality by selecting the best PSNR value and sending it to the next step.

B. Processing to Decrease Angular Error

Angular error is an index used in illuminant estimation [2] to calculate the image illuminant angle between the actual light ℓ_a and assumed white light ℓ_e, as shown in Equ. (3).

$$err = cos^{-1}\left(\frac{(\ell_a \cdot \ell_e)}{\|\ell_a\|\|\ell_e\|}\right), \ell_e = \frac{1}{\sqrt{3}}(1,1,1)^T \tag{3}$$

Anisotropic Gaussian filtering [6] is used to fast obtain the edge and ridge maps to analyze the directional scale-space by using the applicability features. The proposed algorithm applies a one-dimensional Gaussian filter in the x and y directions to reduce the image details of the processed images.

$$g_x(x;\sigma_x) = \frac{1}{\sqrt{2\pi}\sigma_x} exp\left(-\frac{1}{2}\frac{x^2}{\sigma_x^2}\right) \tag{4}$$

$$y = xtan\varphi \tag{5}$$

By using Equs. (4) and (5), the image details can be

(C-6) Chi-An Li; Tsung-Yi Chen; He-Sheng Chou; Ya-Yun Huang; Chiung-An Chen; Wen-Shen Lo; Tzu-Yu Chen; Ting-Lan Lin; Shih-Lun Chen , "**An Improved Image Feature Detection Algorithm Based on Oriented FAST and Rotated BRIEF for Nighttime Images**" 2022 IEEE International Conference on Consumer Electronics - Taiwan, Taipei, Taiwan, 2022, pp. 289-290, doi: 10.1109/ICCE-Taiwan55306.2022.9869224.

An Improved Image Feature Detection Algorithm Based on Oriented FAST and Rotated BRIEF for Nighttime Images

Chi-An Li[1], Tsung-Yi Chen[1], He-Sheng Chou[1], Ya-Yun Huang[1], Chiung-An Chen[2], Wen-Shen Lo[1], Tzu-Yu Chen[1]
Ting-Lan Lin[3], *Member, IEEE* and Shih-Lun Chen[*1], *Member, IEEE*
[1] Department of Electronic Engineering, Chung Yuan Christian University, Taoyuan City, Taiwan
[2] Department of Electrical Engineering, Ming Chi University of Technology, New Taipei City, Taiwan
[3]Department of Electronic Engineering, National Taipei University of Technology, Taipei City, Taiwan

***Abstract*-- This paper presents an improved feature detection and descriptor construction method for nighttime vehicle surrounding images. The proposed algorithm is based on the Oriented FAST and Rotated Brief (ORB) algorithms. In order to improve the accuracy of the proposed algorithm, the Contrast Limited Adaptive Histogram Equalization (CLAHE), feature detection, and descriptor construction were added. In addition, the proposed feature detection description method is realized by the Very Large-Scale Integration (VLSI) technique to meet the real-time application for vehicles. Compared with previous studies, the proposed design has better performance than previous methods of detecting features in nighttime for image stitching and recognition.**

Keywords—Oriented Rotated Brief, Description, Feature Detection, VLSI.

I. Introduction

The rapid growth of AI development, image processing technologies for self-driving cars and vehicles is a highly valued research topic in recent years. The feature detection is an important step in the geometric task based on computer vision, both for image stitching and image recognition. However, due to the dark light at night, traditional cameras usually perform poorly at night, which will cause difficulty in feature detection.

A system used light sources to feature mapping and positing is proposed in [1]. The deep learning model is used to detect and describe in [2]. In terms of VLSI technology, the ORB hardware proposed in [3] strikes a balance between performance and power consumption. The system of [4] proposed an improved hardware architecture of the Binary Robust Independent Elementary Features (BRIEF) in ORB to reduce hardware cost. Because the ORB algorithm has benefits of low power consumption and high speed, it is more suitable for application in high-speed vehicles than other mainstream feature detection methods.

II. Method

The purpose of this study is to improve the difficulty of nighttime image feature detection, and the proposed solution is that CLAHE can enhance the image contrast through the adjustment of the contrast of the night image. In addition, the proposed method also advances to enhance the features of night images, and with a fast and low hardware cost ORB to achieve the purpose of saving resources. The proposed algorithm mainly includes three steps: image preprocessing, feature detection, and descriptor construction, as shown in Fig. 1.

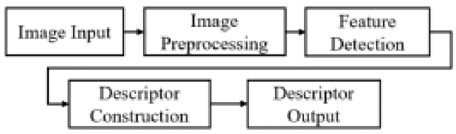


Fig. 1. Flowchart of the proposed algorithm.

A. Image Preprocessing

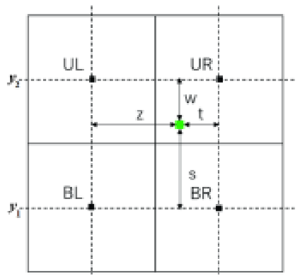
Since nighttime images are low in luminosity due to insufficient light, the proposed algorithm uses CLAHE, which is widely known for low-light image enhancement, to improve performance. The CLAHE divides the image into sub-regions, which can solve the problem of over-enhancement of large dark areas and bright areas better than Histogram Equalization (HE). Equ. (1) is used to calculate the Probability Density Function (PDF) of the pixel values of each sub-tile by the histogram.

$$p_x(i) = \frac{n_i}{n} \tag{1}$$

$$cdf_x(i) = \sum_{j=0}^{i} p_x(j) \tag{2}$$

where n_i indicates that the number of pixel values i appear, n is the total number of pixels. Thus, obtaining the Cumulative Distribution Function (CDF) is shown in Equ. (2).

Fig. 2 shows the interpolation of the pixels of the histogram by using bilinear interpolation to solve the problem of discontinuity in each sub-block. By limiting the slope of the CDF to limit the contrast, if it exceeds the threshold, the pixels in it will be evenly distributed to other PDFs to avoid image overexposure. Fig. 3 shows the hardware architecture of the linear interpolation simplified by factorization, followed by combining two linear interpolations to obtain bilinear interpolation.



(C-7) Jun-Ting Zhang; He-Sheng Chou; Tsung-Han Lee; Chiung-An Chen; Szu-Yin Lin; Chih-Hsien Hsia; Shih-Lun Chen* , "**Edge-Preserving Filter FPGA Design Based on Side-Window Filter**" 第 33 屆超大型積體電路設計暨計算機輔助設計技術研討會

Edge-Preserving Filter FPGA Design Based on Side-Window Filter

Jun-Ting Zhang[a], He-Sheng Chou[a], Tsung-Han Lee[a], Chiung-An Chen[b], Szu-Yin Lin[c] , Chih-Hsien Hsia[c] and Shih-Lun Chen[a]*

[a]Department of Electronic Engineering, Chung Yuan Christian University, Taoyuan City, Taiwan
[b]Department of Electrical Engineering, Ming Chi University of Technology, New Taipei City, Taiwan
[c]Department of Computer Science and Information Engineering, National Ilan University, Yilan County, Taiwan

ABSTRACT

This paper presents an edge-preserving filter design by using edge detection to reduce the computational complexity of the side window filter. By identifying edge types in advance, the side window filter is unnecessary to produce each result in the same time for comparing. The hardware architecture is implemented on Xilinx's FPGA, which can reduce 86% power consumption, 89% number of LUTs, 67% number of FFs, and 84% number of route nets, respectively. The synthetic results show that this method can reduce the computational complexity of the side window filter and achieve low-cost hardware implementation

Keyword：Side-Window Filter, Edge-Preserving, FPGA, VLSI

1. INTRODUCTION

Image processing is widely used such as image smoothing, noise removal, and edge preservation. Different applications require several types of filters such as Gaussian low pass filter, mean filter, and median filter. Smoothing is an important image processing method in distinct types of image recognition such as Automatic License Plate Recognition (ALPR) and traffic sign recognition. These image recognitions are overly sensitive to noise and needed to use filters to remove noise. The usage of general smoothing filters will lead to irreversible loss of details and reduce the accuracy of identification results. These researchers propose various edge-preserving filters to preserve the edge of the processed image such as the bilateral filter proposed by [1] and the guided image filter proposed by [2] which can achieve edge-preserving effects.

Bilateral Filter (BF) is a smoothing and edge-preserving nonlinear filter. In addition to using the geometrical proximity between pixels with traditional smoothing filters, the luminance and color differences between pixels are also considered. BF can effectively remove noise while preserving the edge information of the image. The principle is to use two functions to obtain the filter coefficients, in which the first function is determined by the geometric space distance and the second function is determined by the pixel color difference. However, when Bilateral Filter filters images, Gradient Reversal artifacts will appear in the edges, because the pixel changes on the edge part are relatively severe, resulting in artifacts after BF.

Guided Image Filter (GIF), like BF, is an image filter of non-linear and smooth. It also keeps the edges of the image and smooth the image. The difference is that the GIF has lower computational complexity and because the gradient directions of the two images used are the same, the problem of gradient reversal can be avoided. GIF uses two images as the input images and the guide image for processing. The guide and input images need to be linearly combined to achieve a smooth effect.

are not selected as the object of the hardware implementation. This paper decided to use the concept of Side Window Filter (SWF) proposed by [4] and the Sub-Window Box Filter (SWBF) proposed by [5] to implement hardware design.

2. SIDE WINDOW FILTER

The traditional filter will place the pixel to be processed in the middle of the window for processing. It cannot solve the problem that the edge will spread due to processing, which is the reason why traditional filter does not preserve the edge. Based on the analysis, the [4] proposed to place the edge of the Window at the pixel position to be processed, which can cut off the spread. The [4] splits the edge direction into eight directions, as shown in the figure below.

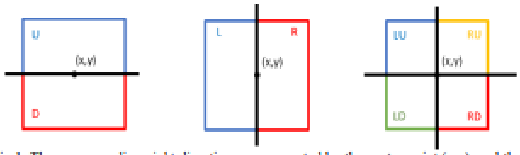
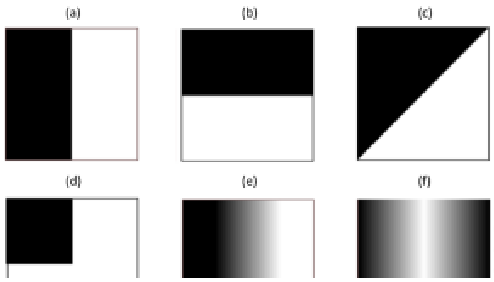


Fig.1. The corresponding eight directions are generated by the center point (x,y), and the edge is horizontal: (a) divided into U of the upper half of the edge and the corresponding lower half of D; The edges are vertical: the left half edge L and the right half edge R of (b); The oblique line edge (c) corresponds to LU, LD, RU, RD

The corresponding filter coefficients are generated in these eight directions and processed on the corresponding edges to obtain eight direction processing results. Comparing eight direction processing results with the value of center pixel to obtain the best result. The [4] proposes to use a variety of edges to do the general Box Filter (BOX) and use the SWF method of BOX Filter (S-BOX) to effect comparison. Six edge types are show in Fig. 2. The pixel value of the black part edge is x, the white part of the edge is y, and the difference from x to y is represented by Δx, and the difference from y to x is represented by Δy, and r is the radius of the window. The results are shown in TABLE I. The results in TABLE I show that S-BOX can retain the edges of (a)~(e) better than BOX.



(C-8) Ming-Zhan Lee, He-Sheng Chou, Yu-Lin Liu, Ting-Lan Lin, Wei-Chen Tu and Shin-Lun Chen, "**3D Point Cloud Denoising Algorithm Based on Two-Stage Filtering**" *2023 International Conference on Consumer Electronics - Taiwan (ICCE-Taiwan)*, PingTung, Taiwan, 2023, pp. 419-420

3D Point Cloud Denoising Algorithm Based on Two-Stage Filtering

Ming-Zhan Lee
Department of Electrical Engineering
National Cheng Kung University
Tainan City, Taiwan
q16101282@gs.ncku.edu.tw

He-Sheng Chou
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
g10776018@cycu.edu.tw

Yu-Lin Liu
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
g11176050@cycu.edu.tw

Ting-Lan Lin
Department of Electronic Engineering
National Taipei University of Technology
Taipei City, Taiwan
tinglan@ntut.edu.tw

Wei-Chen Tu*
[1]*Department of Electrical Engineering,*
National Cheng Kung University
[2]*Academy of Innovative Semiconductor and Sustainable Manufacturing,*
National Cheng Kung University
Tainan City, Taiwan
wctu@gs.ncku.edu.tw

Shin-Lun Chen
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City, Taiwan
chrischen@cycu.edu.tw

***Abstract*—This research introduces a method for smoothing 3D Point Clouds, which is a two-stage algorithm designed for models that are affected by Gaussian noise. The first stage utilizes a median filter to arrange the positions of neighboring points and determine the most probable relative position. The second stage applies a bilateral filter to achieve surface smoothing. This algorithm adds a low-complexity median filter to the original bilateral filter, which can improve the Peak Signal-to-Noise Ratio (PSNR) by 14%, and reduce the Mean Squared Error (MSE) by 75%. Furthermore, this research preserves both the complexity of the bilateral filter and the number of neighboring point searches. This study represents a valuable contribution to the field of 3D Point Cloud smoothing technology.**

***Keywords*—3D Point Cloud, Gaussian Noise, Median Filter, Bilateral Filter**

I. INTRODUCTION

As 3D scanning technology has improved, it has become increasingly convenient for people to generate 3D Point Cloud data of real-life objects for preservation or utilization, such as for autonomous driving of electric vehicles, preservation of historical sites and cultural relics, and research on natural terrain. Compared to traditional 2D images, which can easily result in incomplete data due to occlusion, 3D Point Cloud data offer significant advantages in presentation. Nevertheless, 3D Point Cloud data is often polluted by noise due to various reasons, such as instrument error, environmental influence, object reflection, etc. In view of this, the development of effective denoising algorithms is crucial for improving the accuracy of 3D Point Cloud data.

The presence of noise in the original data can lead to significant issues in subsequent applications. Hence, some scholars use the traditional smoothing algorithm for processing two-dimensional images to apply to three-dimensional images. G. Taubin [1] uses the Laplacian operator to smooth three-dimensional images. S. Fleishman [2] and J. Digne [3] modified the traditional bilateral filter by incorporating point-to-point distance and normal vector projection distance as factors to improve the smoothing effect of 3D Point Clouds. However, the impact of noise on 3D Point noise. The radius filter is used to remove the large noise. Besides, the bilateral filter is processed as small noise to achieve filtering. H. Zhang [5] proposed categorizing noise into two types: huge and tiny. Huge noise refers to outlier points that are far from the subject and can be removed using radius and statistical filtering. Tiny noise, on the other hand, is mixed in with the target data point and can be addressed by smoothing with a feature image learning algorithm. By analyzing the quality assessment dataset of rendered 3D Point Clouds [6], it is possible to evaluate the effectiveness of various smoothing techniques for 3D Point Cloud data.

II. PROPOSAL ALGORITHM

To avoid losing edge features due to over-smoothing, this paper proposes an algorithm that uses a median filter to adjust the position of the target point. The proposed algorithm uses the bilateral filter to smooth the position of these adjacent points surrounding the target point, as shown in Fig.1. The effect is better than only using the bilateral filter, without excessive smoothing, and preserving the edges information.

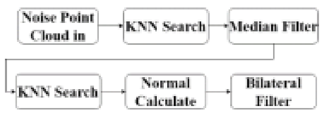


Fig. 1. Flowchart of the proposed algorithm

A. Implementation of median filter

Before performing the median filter, it is necessary to find the adjacent points (P_i) of the target point (P). The research for adjacent points (P_i) can be searched using the k nearest neighbor search. The proposed (1) sorts the XYZ groups of the adjacent points (P_i), finding the middle value of each group, and replacing the target value. The median filter can effectively smooth the 3D Point Cloud data polluted by noise. Moreover, sorting by the k-nearest neighbor (KNN) search can exclude outliers without causing excessive smoothing.

$$P(x) = median(P_i(x))$$

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High Compression Rate Architecture For Texture Padding Based on V-PCC

Cheng-Lin Lu
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City,Taiwan
g11076054@cycu.edu.tw

He-Sheng Chou
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City,Taiwan
g10776018@cycu.edu.tw

Ya-Yun Huang
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City,Taiwan
g11076004@cycu.edu.tw

Mei-Ling Chan
School of Physical Educational College
Jiaying University
Meizhou City, Guangdong Province, China;
Lynn202207017@jyu.edu.cn

Szu-Yin Lin
Department of Computer Science and Information Engineering
National Ilan University
Yilan City, Taiwan
szuyin@niu.edu.tw

Shih-Lun Chen*
Department of Electronic Engineering
Chung Yuan Christian University
Taoyuan City,Taiwan
chrischen@cycu.edu.tw

***Abstract*—Video-based point cloud compression(V-PCC)is a point cloud compression standard formulated by the Moving Picture Experts Group(MPEG) organization. The concept of this standard is to project 3D point cloud information onto a 2D plane and generate 2D image, namely geometry map, texture map, and occupancy map. Overlap 2D images to form 3D depth from three images, combine color and position information, and then encode and decode using High Efficiency Video Coding (HEVC) compression. However, the projected image will have obvious holes. These holes are regarded as high-frequency signal in the image, which will have a bad impact on the subsequent compression rate. It is necessary to use image filling to smooth the image, reduce high-frequency signal, and facilitate subsequent compression processing. Therefore, the purpose of this research is to develop a series of anti-noise procedures to fill and smooth images with High-Efficiency Video Coding(HEVC), including mean filter, Smooth Pull Push Algorithm(SPP), etc. This algorithm has been implemented in mpeg-pcc-tmc2-release-v8.0[1], and the obtained data proves that although PSNR needs to be sacrificed, it can effectively reduce the number of compressed bytes after texture map filling.**

Keywords*—*video-based point cloud compression, mean filter, point cloud compression, texture padding, high efficiency video coding.

I. Introduction

With the changes of the times and the rapid advancement of technology, many novel technologies have also appeared before the eyes of the world, such as virtual reality and 5G technology. These technologies are inseparable from the 3D point cloud because the characteristics of the 3D point cloud that can record information completely and realistically complement each other. But it is also because of this that the compression and transmission of point clouds has become a huge challenge. Therefore, the MPEG organization has formulated two standards for point cloud compression, which are divided into Video-based point cloud compression (V-PCC) and Geometry-based point cloud compression (G-PCC).[2]

G-PCC is based on the Octree algorithm to directly encode the information in the 3-dimensional space. V-PCC is a 2D video compression technology. Firstly, the 3D space image is

filling algorithms, dividing unoccupied and occupied pixels into two groups, and designs a suitable filling algorithm for each group. J. Xiong et al.[4] also proposed a fast coding method guided by occupancy graphs, which can effectively save computing time.

Figure 1.geometry(left)、texture(middle)、occupancy(right)

II. Proposal Algorithm

As mentioned in the first section, when V-PCC is projected onto a plane, image blocks are used to place the image on the same two-dimensional plane, but there will be obvious holes, as shown in Figure 1. But this voids will be considered as high-frequency signal, which will have a bad impact on the subsequent compression ratio. Therefore, this hole needs to be filled with image fill. Fortunately, several image padding methods are proposed in the V-PCC standard, such as Pull Push Background Filling, Smooth Pull Push Background Filling, and Harmonic Background Filling.[5] This article is expected to use the method based on Smooth Pull Push Background Filling. After the Pull Push is completed, the image is further smoothed using mean filtering. The overall process architecture as shown in Figure 2, and in section II part A, the Smooth Pull Push algorithm will be explained, and in section II part B, the algorithm of the mean filter will be explained.

Figure 2. Proposed Algorithm Architecture

A. Smooth Pull Push algorithm

(C-10) Yu-Lin Liu, He-Sheng Chou, Ming-Zhan Lee, Mei-Ling Chan, Ting-Lan Lin, Shih-Lun Chen, "**Point Cloud Inpainting Based on Delaunay Triangulation**" *2023 Asia Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA ASC)*, Taipei, Taiwan, 2023, pp. 1525-1529, doi: 10.1109/APSIPAASC58517.2023.10317549.

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Point Cloud Inpainting Based on Delaunay Triangulation

Yu-Lin Liu 1, He-Sheng Chou 2, Ming-Zhan Lee 3, Mei-Ling Chan 4, Ting-Lan Lin 5, Chiung-An Chen 6,and Shin-Lun Chen 7*

Department of Electronic Engineering, Chung Yuan Christian University, Taiwan
E-mail: g11176050@cycu.edu.tw Tel: +886-3-265-4644
Department of Electronic Engineering, Chung Yuan Christian University, Taiwan
E-mail: g10776018@cycu.edu.tw Tel: +886-3-265-4644
Department of Electrical Engineering National Cheng Kung University, Taiwan
E-mail: q16101282@gs.ncku.edu.tw Tel: +886-3-265-4644
College of Physical Education, Jiaying University, Meizhou City College of Physical Education
E-mail: Lynn202207017@jyu.edu.cn
Department of Electronic Engineering National Taipei University of Technology, Taiwan
E-mail: tinglan@ntut.edu.tw Tel: +886-2-2771-2171 #2278
Department of Electrical Engineering, Ming Chi University of Technology, New Taipei City 243303, Taiwan
E-mail: joannechen@mail.mcut.edu.tw Tel: +886-2-2908-9899 #5219
*Department of Electronic Engineering, Chung Yuan Christian University, Taiwan
E-mail: chrischen@cycu.edu.tw Tel: +886-3-265-4610

***Abstract*— Point cloud is a point-based representation of three-dimensional data used to describe the geometry of objects or scenes However, due to its large data volume, a point cloud needs to be compressed to reduce the data volume. After point cloud compression, some points may be lost, causing the loss of edge details and the appearance of point cloud holes and outliers, leading to a significant subjective quality decrease and affecting point cloud development in practical applications. In this paper, an effective point cloud repair method is proposed. First, use the mean filter to remove outliers, so that the subsequent point-filling algorithm can avoid errors caused by outliers. Secondly, the point cloud is analyzed by the Delaunay triangulation method. Perform statistical analysis on the areas of all triangles. If an individual triangle has an area larger than the average, it is marked. After comparing the triangles, the coordinates of all the holes in the point cloud can be found, so as to identify the holes in the point cloud. In the hole-filling strategy, the interpolation method is used to average the coordinates and color information of the three vertices of the triangle to obtain the filling point, that is, to complete the restoration of the point cloud data. When evaluating the results, in addition to PSNR, the GraphSim index proposed by**

I. Introduction

Point cloud has become an important research direction in computer vision, robotics, autonomous driving, and other fields. The subjective visual quality of the point cloud is crucial in its applications. Therefore, point cloud repair has become a popular research topic. Two common reasons for point cloud holes are identified. Firstly, specialized scanning devices usually acquire point cloud data using 3D laser scanning to obtain 3D data on object surfaces. However, occlusions or scanning surface reflection errors can cause holes in the collected point cloud [3]. Secondly, point clouds typically have a large amount of data and require compression, such as the Motion Picture Experts Group (MPEG) established video-based point cloud compression (V-PCC) standard [2]. The compression standard employed in this study involves storing point clouds in 2D image format to reduce data size, and decoding them back to 3D point clouds when necessary. However, this process will cause a large loss of edge details, which will lead to the loss of information at the edge.

In recent years, several methods have been proposed for

(C-11) Wei-Chi Lin, Ming Zhan Lee, He-Sheng Chou, Yuan-Jin Lin, Li Kuo-Chen, Ting-Lan Lin, Shih-Lun Chen, "**3D Point Cloud Denoising Based on Color Attribute**" *2023 Asia Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA ASC)*, Taipei, Taiwan, 2023, pp. 1512-1516, doi: 10.1109/APSIPAASC58517.2023.10317301.

3D Point Cloud Denoising Based on Color Attribute

Wei-Chi Lin 1, Ming-Zhan Lee 2, He-Sheng Chou 3, Yuan-Jin Lin 4,
Kuo-Chen Li 5, Ting-Lan Lin 6, and Shin-Lun Chen 7*
Department of Electronic Engineering, Chung Yuan Christian University, Taiwan
E-mail: g11176043@cycu.edu.tw Tel: +886-3-265-4644
Department of Electrical Engineering National Cheng Kung University, Taiwan
E-mail: q16101282@gs.ncku.edu.tw Tel: +886-3-265-4644
Department of Electronic Engineering, Chung Yuan Christian University, Taiwan
E-mail: g10776018@cycu.edu.tw Tel: +886-3-265-4644
Department of Electrical Engineering National Cheng Kung University, Taiwan
E-mail: m26124069@gs.ncku.edu.tw Tel: +886-3-265-4644
Information Management Department Chung Yuan Christian University, Taiwan
E-mail: kuochen@cycu.edu.tw Tel: +886-3-265-5414
Department of Electronic Engineering National Taipei University of Technology, Taiwan
E-mail: tinglan@ntut.edu.tw Tel: +886-2-2771-2171 #2278
*Department of Electronic Engineering, Chung Yuan Christian University, Taiwan
E-mail: chrischen@cycu.edu.tw Tel: +886-3-265-4610

***Abstract* —Collecting or transmitting point cloud data is often subject to noise, which can potentially affect the accuracy of geometry and color representation in different spatial domains. This study addresses the denoising problem specifically for 3D point cloud color data and proposes two dedicated denoising algorithms based on the characteristics of noise in different spatial domains. In the denoising process, the RGB color space is first transformed into the YUV color space for further denoising operations. Surface smoothing is achieved by employing either a median filter or a bilateral filter based on the impact of noise on spatial information. These algorithms, built upon 2D image processing techniques, offer two key contributions: 1) color correction on spatial points to enhance denoising performance, and 2) the use of low-complexity filters while maintaining comparable filtering effectiveness, resulting in nearly a twofold reduction in processing time.**

Keywords – Median Filter, Bilateral Filter, Point Cloud.

I. Introduction

Point cloud is an unordered collection of points in 3D space. Information such as color, normals, transparency, position, or light intensity can be obtained through various acquisition methods such as scanning or capturing reconstruction. Point clouds have been increasingly applied in various fields, including medical modeling, heritage reconstruction, autonomous vehicle navigation, urban planning, and more. Compared to traditional 2D images that can only present a occlusion and viewpoint transformation. However, during the acquisition process, point cloud data may suffer from geometric and color noise due to sensor errors, environmental interference, improper operation during acquisition, or noise introduced during transmission and compression, resulting in a degradation of its original quality.

Denoising has always been one of the significant challenges in point cloud technology. Unlike one-dimensional signals or two-dimensional images, point clouds do not possess explicit structural data. Therefore, the problem is primarily defined using Graph Signal Processing (GSP) [1] techniques. In previous literature, numerous denoising algorithms have been proposed [2]-[3], but most of them focus on addressing noise affecting the 3D positions. However, the color attributes of point clouds often come with noise, and even the noise in the positional attributes can indirectly impact the color information.

This paper focuses on the color denoising problem in point cloud space. Assuming the geometric space is either noise-free or has been corrected by previous denoising algorithms in the position space, the objective is to reduce noise in the color attributes without decreasing the number of points or altering the position properties of the point set. By adopting the concept of graph signal processing, each point in the point cloud is treated as a node in an undirected graph. Building upon well-

(C-12) Yu-Wen Peng, Chia-Yu Hu, Yen-Ju Chin, He-Sheng Chou, Yuan-Jin Lin, Yu-Lin Liu, Shih-Lun Chen, "**The Color Demosaicing and Image Scaling Based on Improve Hamilton-Adams**" *2023 Asia Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA ASC)*, Taipei, Taiwan, 2023 , pp. 892-897, doi: 10.1109/APSIPAASC58517.2023.10317437.

The color demosaicing and image scaling based on improve Hamilton-Adams

Yu-Wen Peng [1], Chia-Yu Hu [1], Yen-Ju Chin [1], He-Sheng Chou [1], Yuan-Jin Lin [2], Yu-Lin Liu [1], Shih-Lun Chen [1]*
Tsung-Yi Chen [3], Kuo-Chen Li [4], and Chiung-An Chen [5]
*Department of Electronic Engineering, Chung Yuan Christian University, Chung Li City 32023, Taiwan;
E-mail: s10926313@cycu.edu.tw; s10926209@cycu.edu.tw; s10926204@cycu.edu.tw;
g11176050@cycu.edu.tw; g10776018@cycu.edu.tw; chrischen@cycu.edu.tw; Tel: +886-3-265-4644
Department of Electrical Engineering, National Cheng Kung University, Taiwan;
E-mail: m26124069@gs.ncku.edu.tw; Tel: +886-3-265-4644
Department of Electronic Engineering, Feng Chia University, Taichung City 407102, Taiwan;
E-mail:tsungychen@fcu.edu.tw; Tel: +886-4-2451-7250#4910
Department of Information Management, Chung Yuan Christian University, Chung Li City 32023, Taiwan;
E-mail:kuochen@cycu.edu.tw; Tel: +886-3-265- 2050
Department of Electrical Engineering, Ming Chi University of Technology, New Taipei City 243303, Taiwan
E-mail:joannechen@mail.mcut.edu.tw; Tel: +886-2-2908-9899#4813

***Abstract* —The demosaicing process is the most critical step in image processing, this study presents a Hamilton-Adams-based algorithm for mosaic removal and image scaling. The algorithm consists of three steps: image pre-processing, image scaling, and improved Hamilton-Adams mosaic removal. The image pre-processing stage employs a mean filter to reduce high-frequency signals at the image edges, effectively mitigating the zipper effect caused by image scaling and improving image quality. The improved Hamilton-Adams method incorporates high-quality linear interpolation to achieve more accurate edge computations. In terms of image quality assessment, this paper increased 1.13 dB of PSNR, 1.19 dB of CPSNR, and 0.03 of SSIM values compared to high-quality linear interpolation with bicubic interpolation.**

KEYWORDS: Color filter array, Image pre-processing, Demosaicing, Hamilton-Adams, Image scaling

I. INTRODUCTION

Consumer electronic products commonly feature image signal processors, such as digital cameras and smartphones. This product internally incorporates a charge-coupled device (CCD) or a complementary metal-oxide-semiconductor and utilizes the color filter array (CFA) for image acquisition. Most of the CFAs use the Bayer pattern [1], as shown in Fig.1, where

(red, green, or blue) can be recorded for each pixel, resulting in a monochrome representation. By applying a demosaicing algorithm, such as bilinear interpolation (BI) [2], it is possible to reconstruct the RGB values for each pixel. However, this approach often leads to unnatural colors and the appearance of zipper artifacts. Other methods, such as High-quality linear interpolation (HQLI) [3] and Hamilton-Adams (HA) [4], have been proposed to mitigate zipper artifacts and provide more realistic color reproduction.

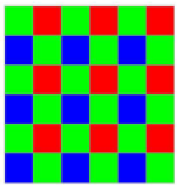

Fig. 1. Bayer format.

A. Linear interpolation demosaicing

HQLI introduces a high-quality linear interpolation demosaicing method for Bayer pattern color images. This method emphasizes the preservation and restoration of image details. Linear interpolation demosaicing is a prevalent technique that employs linear interpolation methods to interpolate the missing color values for each pixel in the image.