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Effective High Speed Interpolations for Colour Demosaicking with Reconfigurable Units for Low Complexity

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Abstract: *In many real time applications captured image in surveillances has at least three color samples at each pixel location three sensors are required. But most modern digital cameras acquire images using a single image sensor. So measures need to be taken to get three channels for color image reconstruction. As an initial step, one needs to find a boundary which measures the similarity between every pair of pixels, then to an estimate of the full color image. After that, optimization is carried out: In this paper we present a fully pipelined color demosaicking design. To improve the quality of reconstructed images, a linear deviation compensation scheme was created to increase the correlation between the interpolated and neighboring pixels. Hardware sharing technique was used to reduce the hardware costs of three interpolators and pipelined architecture is used to improve the overall throughput rate.*

I. Introduction

Today, the majority of color cameras are equipped with a single CCD sensor. The surface of such a sensor is covered by a color filter array, which consists in a mosaic of spectrally selective filters, so that each CCD element samples only one of the three color components Red, Green or Blue. The Bayer CFA[1] is the most widely used one to provide the CFA image where each pixel is characterized by only one single color component. Image interpolation is a key aspect of digital image processing. This paper presents a novel interpolation method based on optimal recovery and adaptively determining the quadratic signal class from the local image behavior. The advantages of the new interpolation method are the ability to interpolate directly by any factor and to model properties of the data acquisition system into the algorithm itself. Through comparisons with other algorithms it is shown that the new interpolation is not only mathematically optimal with respect to the underlying image model, but visually it is very efficient at reducing jagged edges, a place where most other interpolation algorithms fail.Digital images or videos are currently a preeminent medium in environment perception. They are today almost always captured directly by a digital (still) camera, rather than digitized from a video signal provided by an analog camera as they used to be several years ago. Acquisition techniques of color images in particular have involved much research work and undergone many changes. Digital area scan cameras are devices able to convert color stimuli from the observed scene into a color digital image (or image sequence) thanks to photo sensors. Such an output image is spatially digitized, being formed of picture elements (pixels). With each pixel is generally associated a single photo sensor element, which captures the incident light intensity of the color stimulus. The parallel prefix adder -based algorithm is highly suitable for VLSI implementation, since it is built using shifters and adders only. Liang et al. [2] propose lifting scheme-based fast multiplier less approximation of the RCU [3] using only binary shift and addition operations. This result is a very low hardware complexity VLSI implementation. We use the modified unfolded RCU to realize a low hardware complexity VLSI implementation also using only binary shift and addition operations. Moreover, the computational accuracy can be selected based on the trade-off between the hardware Complexity and approximation error. In addition, since our proposed algorithm has uniform post-scaling factor, it is also suitable for scaled RCU implementation. Digital images are subject to a wide variety of distortions during acquisition, processing, compression, storage, transmission and reproduction, any of which may result in a degradation of visual quality. For applications in which images are ultimately to be viewed by human beings, the only “correct” method of quantifying visual image quality is through subjective evaluation. The simplest and most widely used full-reference quality metric is the mean squared error, computed by averaging the squared intensity differences of distorted and reference image pixels, along with the related quantity of peak signal-to-noise ratio.

II. Related Work

A low-complexity color interpolation algorithm is proposed for the VLSI implementation in real-time applications. The proposed novel algorithm consists of an edge detector, an anisotropic weighting model and a filter-based compensator. The anisotropic weighting model is designed to catch more information in horizontal than vertical directions. The filter-based compensation methodology includes a Laplacian and spatial sharpening filters which are developed to improve the edge information and reduce the blurring effect. In addition, the hardware cost was successfully reduced by hardware sharing and reconfigurable design techniques. The VLSI architecture of the proposed design achieves 200 MHz with 5.2 K gate counts, and its core area is 64,236 um2 synthesized by a 0.18 um CMOS [5] process. Compared with the previous low-complexity techniques, this work not only reduces gate counts or power consumption by more than 8 % or 91.7 %, respectively, but also improves the average CPSNR [2] quality by more than 1.6 dB. we present a novel color image demosaicking algorithm using a voting-based edge direction detection method and a directional weighted interpolation method. By introducing the voting strategy, the interpolation direction of the center missing color component can be determined accurately. Along the determined interpolation direction, the center missing color component is interpolated using the gradient weighted interpolation method by exploring the intra-channel gradient correlation of the neighboring pixels. As compared with the latest demosaicking algorithms, experiments show that the proposed algorithm provides superior performance in terms of both objective and subjective image qualities. Many demosaikcing algorithms have been introduced over the years to improve subjective and objective interpolation quality. We propose an orientation-free edge strength filter and apply it to the demosaikcing problem. Edge strength filter output is utilized both to improve the initial green channel interpolation and to apply the constant color difference rule adaptively. This simple edge directed method yields visually pleasing results with high CPSNR[3].We present a novel regularization framework for demosaicking by viewing image as smooth signal on a weighted graph. The restoration problem is formed as a minimization of variation of the signal on graph. As an initial step, we build a weight matrix which measures the similarity between every pair of pixels, from an estimate of the full color image. After that, a two-stage optimization is carried out: first, we assume that graph Laplacian is signal dependent and solve a non-quadratic problem by gradient descent; then, we pose a variational problem on graph with a static Laplacian [4], under the constraint of consistency with the available samples in each color component. Performance evaluation shows that our approach can improve the previous demosaicking methods both quantitively and visually, by alleviating the artifical effect. Although quite successful in making such inferences with very small relative error, state-of-the-art demosaicking methods fail when the local geometry cannot be inferred from the neigh- boring pixels. In such a case, which occurs when thin structures or fine periodic patterns were present in the original, state-of-the-art methods can create disturbing artifacts, known as zipper effect, blur, and color spots. The aim of this paper is to show that these artifacts can be avoided by involving the image self-similarity to infer missing colors. Detailed experiments show that a satisfactory solution can be found, even for the most critical cases. Extensive comparisons with state-of-the-art algorithms will be performed on two different classic image databases.

III. Proposed Color Demosaicking Algorithm

Dynamic Reconfiuration means to change a kind of and a number of processing elements and connection between processing elements at real time. This function realizes the optimum hardware to execute any software and decrease a scale of hardware to execute software.Our proposed processor is configured with cells, which make any kind of processing, and bus, which makes any routing between cells. We support reconfiguration based on very larger macro cell than a logic cell in this processor.. In this process include the image scaling. Image scaling [2] is the process of resizing the digital image. Scaling is a non-trivial process that involves a trade-off between efficiency, smoothness and sharpness. Apart from fitting a smaller display area, image size is most commonly decreased in order to produce thumbnails. Enlarging an image is generally common for making smaller imaginary fit a bigger screen in full screen mode. For example in zooming a bitmap image, it is not possible to discover any more information in the image than already exists, and image quality inevitably suffers.

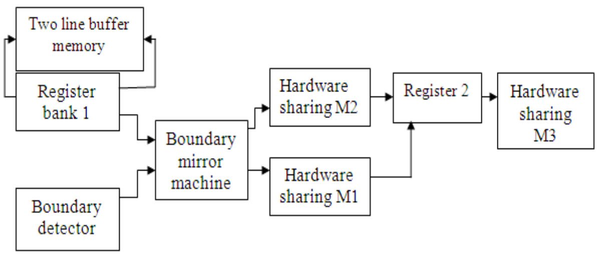


Fig 1. Block diagram of VLSI architecture

However, there are several methods of increasing the number of pixel that an image contains, which evens out the appearance of the original pixels.Two standard scaling algorithms are bilinear and bicubic interpolation. Filters like these work by interpolating pixel color values, introducing a continuous transition into the output even where the original material has discrete transitions. Although this is desirable for continuous-tone images, some algorithms reduce contrast (sharp edges) in a way that may be undesirable for line art.Nearest-neighbor interpolation preserves these sharp edges, but it increases aliasing (or jaggies; where diagonal lines and curves appear pixelated). Several approaches have been developed that attempt to optimize for bitmap art by interpolating areas of continuous tone, preserve the sharpness of horizontal and vertical lines [2] and smooth all other curves.Since a typical application of this technology is improving the appearance of fourth-generation and earlier video games on arcade and console emulators, many are designed to run in real time for sufficiently small input images at 60 frames per second. Many works only on specific scale factors: 2× is the most common, with 3× and 4× also present. Image interpolation occurs in all digital photos at some stage whether this is in bayer demosaicking or in photo enlargement. It happens anytime you resize or remap (distort) your image from one pixel grid to another. Image resizing is necessary when you need to increase or decrease the total number of pixels, whereas remapping can occur under a wider variety of scenarios: correcting for lens distortion, changing perspective, and rotating an image. Image enhancement is the process of adjusting digital images so that the results are more suitable for display or further image analysis. For example, you can remove noise, sharpen, or brighten an image, making it easier to identify key features. The difference between the original Hunter and CIE color [3] coordinates is that the CIE coordinates are based on a cube root transformation of the color data, while the Hunter coordinates are based on a square root transformation.This work can be realized by adders, subtractors, and shifters only without any dividers and multipliers. The silicon area of a divider or multiplier is much greater than an adder, subtractor, and shifter.

A)Imageresizing

Image interpolation in two directions, and tries to achieve a best approximation of a pixel color [2]and intensive based on the values at surroundings pixel. Unlike air fluctuation and the ideal gradient pixel value can change far more abruptly from one location to the next. Adaptive methods depending on what they are interpolating, where as non adaptive methods treats all pixel equally. Non adaptive algorithm includes nearest neighbor, bilinear, bicubic, spline, sinc and others. Depending on their complexity, these use anywhere from 0 to 256 (or more) adjacent pixels when interpolating. The more adjacent pixels they include, more accurate they can became, but this comes at expense of much longer processing time. This algorithm can be used to both distort and resize a photo. Adaptive algorithm [4] includes proprietary algorithm aiming to minimize unsightly interpolation artifacts in regions where they are most apparent. These algorithms are primarily designed to maximize artifacts free details in enlarged photo, so cannot be used to distort or resize on image. Nearest neighbor is the most basic and require the least processing of all interpolation algorithms because it considers only one pixel the closest to the interpolated points. This has the effect of simply making each pixel. The Image Interpolate operation covers a broad range of interpolation techniques that apply to different types of data. If you are starting from scatter data, i.e., data that is sampled on a non rectangular grid, your choices for interpolation are to use Kriging or Natural Neighborhood Interpolation. This type of interpolation applies to X, Y, Z, data where the X and Y values describe arbitrary points in the Z=0 plane. The interpolation is valid only for the convex domain containing the data. The algorithm first computes the Delaunay triangulation in the Z=0 plane and then uses the associated Voronoi polygons [3] to interpolate the Z-value for any other point in the domain.

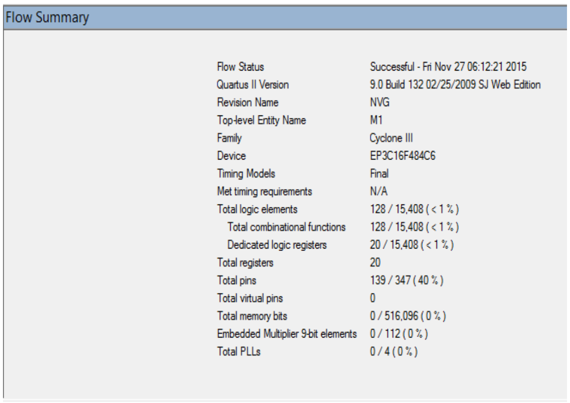
C) Image Resampling

The Image interpolate operation supports various forms of resampling. These might be useful, for example when you want to scale an image. The simplest interpolation method for resampling is called the "nearest neighbor" where a pixel in the output image is computed as the value of the nearest mapped pixel in the source image. Since there is little calculation involved in this interpolation method, it is the fastest. The next resampling method is the bilinear interpolation where the destination pixel is computed by combining the linear interpolation along two orthogonal axes. Although this interpolation method produces smoother results than the nearest neighbor approach, the results for sharp transitions are not ideal. Smoother results and anti- aliasing can be accomplished with spline, cubic polynomial and sinc interpolation considered as more "expansive" mthods as they tend to require more computation as they involve more data points from the surrounding neighborhood. Smoother interpolation results are not always desirable, e.g., when you scale a binary image or when you need to maintain high contrast for subsequent operations susch as edge detection. Furthermore, the sinc interpolation and to an extent also the cubic interpolation involve a larger neighborhood around the immediate pixel value.

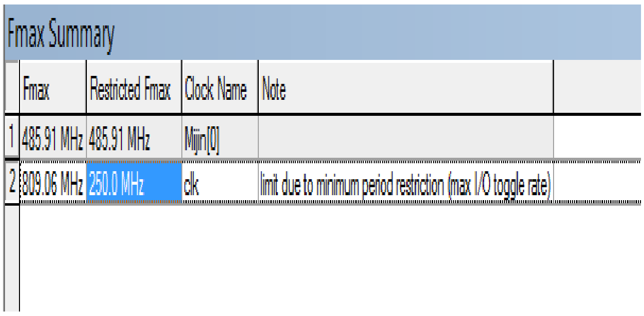
IV. Software Implementation Results

a) Simulated Output

b) Performance of area



c) Performance of speed



V. TABLE
TABLE I

Method	Executing time	Power(mw)
Existing method	7.9299	4.76
Proposed method	2.6067	4.66

V. Conclusion

In this paper, we proved the low complexity and high-performance of proposed hardware sharing and pipeline scheduling based color demosaicking VLSI design for real-time video applications. Through Linear deviation compensation, interpolated green color pixels, a boundary detector and a boundary mirror machine overall reconstruction quality of output image is increased. This paper presents a high performance processor for CFA color interpolation. Hence, a cost efficient method was proposed by using only simple operations such as addition, subtraction and shifter. The immediately interpolated pixels are first to be used in hardware-oriented color demosaicking algorithm, which can efficiently improve the quality of interpolated pixels located in boundary. Moreover, novel linear deviation compensation is also used to promote the performance of red-blue color interpolation. It proves the quality of reconstructed images, using linear deviation compensation scheme.

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