COMPUTING COLOR SPECIFICATION (LUMINANCE AND CHROMINANCE) VALUES FOR IMAGES

FIELD OF THE INVENTION

This invention relates to the field of electronic imaging and is particularly suitable to electronic still imaging with improved luminance and chrominance pixel values from a measured digital image originally produced by an image sensor.

BACKGROUND OF THE INVENTION

In electronic color imaging, it is desirable to simultaneously capture image data in three color planes, usually red, green and blue, although cyan, magenta, and yellow can also be used. When the three color planes are combined, it is possible to create high-quality color images. Capturing these three sets of image data can be done in a number of ways. In electronic photography, this is sometimes accomplished by using a single two dimensional array of sensors that are covered by a pattern of red, green and blue filters. This type of sensor is known as a color filter array or CFA. Below is shown the red (R), green (G) and blue (B) pixels as are commonly arranged on a CFA sensor.

When a color image is captured using a CFA, it is necessary to interpolate the red, green and blue values so that there is an estimate of all three color values for each sensor location. Once the interpolation is done, each picture element, or pixel, has three color values and can be processed by a variety of known image processing techniques depending on the needs of the system. Some examples of the reasons for processing are to do image sharpening, color correction or halftoning.

The following shows how red green and blue pixels can be arranged in a particular color filter array pattern, hereinafter referred to as the Bayer color filter array. For a more detailed description see U.S. Pat. No. 3,971,065 to Bayer.

G R G R

B G B G

G R G R

B G B G

In processing color digital images produced by an image sensor, color specification values such as, for example, luminance and chrominance values for each pixel need to be computed. One of the problems found in processing color image values produced by an image sensor is that the luminance values for pixels on the edge of a feature of an image can be inaccurately interpolated.

SUMMARY OF THE INVENTION

An object of this invention is to provide an improved apparatus which produces color specification values for pixels particularly those on the diagonal edge of a feature of the digital image.

This object is achieved in apparatus for processing a digital color image value originally obtained from an image sensor or the like having color image pixels aligned in rows and columns having diagonal pixels with sufficient information to permit luminance estimation the digital image having at least three separate color values but only one color value for each image pixel location, such apparatus computing the luminance values for each image pixel, comprising:

means for storing the digital image;

processor means operative with said storing means and responsive to said stored measured digital color image values for computing low frequency luminance values;

means responsive to the computed low frequency luminance values for obtaining Laplacian second-order and gradient values in at least two image orientations from neighboring image pixels;

means for combining the Laplacian second-order and the gradient values to define a value for each image pixel in the kernel such that there are sets of values with each value corresponding to a classifier and for selecting a preferred orientation from a group of orientations for the interpolation based upon the classifier; and

means responsive to the preferred orientation and the measured digital image for estimating a portion of the color specification for each corresponding image pixel.

ADVANTAGES

An advantage of this invention is that it is computationally efficient both in execution time and memory storage requirements for producing improved luminance or chrominance values. It is another advantage of the present invention to use the combination of the Laplacian second-order and gradient values to produce a classifier which substantially reduces artifacts (color interpolation) in output image are substantially reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an electronic still camera employing interpolation processing according to the invention;

FIG. **2** is a block diagram of the logic of the interpolation processing technique for producing luminance in accordance with the invention;

FIGS. **3**A and **3**B respectively show detailed block diagrams of the luminance values block **32** and the chrominance values block **34** shown in FIG. **2**;

FIG. **4** depicts a kernel used in computing low frequency luminance values;

FIGS. **5**A–C depict pixel weights used in computing a classifier in the classification block **48** shown in FIGS. **3**A and **3**B;

FIGS. **6**A–C also depict pixel weights used in computing another classifier produced by the classification block **48**;

FIGS. **7**A–**7**E respectively show the kernel weights for predicting luminance for pixels which have been classified as horizontal, vertical, flat, diag1, and diag2;

FIG. **8**A shows a prior art pixel pattern;

FIG. **8**B shows a pixel array pattern which is suitable for chrominance correction; and

FIG. **9** depicts a block of interpolated chrominance values.

DETAILED DESCRIPTION OF THE INVENTION

For any given pixel, the luminance and chrominance values constitute color specification for a pixel. For purposes of this disclosure, the term "portion of a color specification" will refer to a pixel's luminance or chrominance values.

Single-sensor electronic cameras employing color filter arrays are well known. Elements not specifically shown or described herein may be selected from those known in the art.