Imaging Apparatus With Scene Adaptive Auto Exposure Compensation

Field

This disclosure relates generally to a scene adaptive auto-exposure compensation method and an imaging apparatus operable to perform this method.

Background

It is often desirable to use an auto-exposure algorithm in a camera to ensure that the image is acquired at a balanced shutter-time and gain under different lighting conditions. Often the objective of the auto-exposure algorithm is to maintain a constant global luminance for the image by adjusting the shutter-time and gain. The problem with this approach is that if the scene contains objects that are very small (<1% of image pixels) but much brighter than the rest of the image, these objects will be over-exposed and appear saturated in the image. This problem is specifically severe for a camera equipped with an infrared ("IR") illuminator because certain small objects of interest (e.g. license plates) have a much higher IR reflectivity than the rest of the scene. However if the camera ensures that no area of the image is saturated, a small background light in the image can result in the majority of the image being permanently underexposed.

There are several cameras in the market that try to solve the problems of saturated objects as a result of IR-Illumination by simply reducing the intensity of the IR illuminator. Controlling IR intensity to control saturation will only work for a camera with built-in IR illuminator which can be directly controlled. In particular, this approach will not work with cameras that use an external IR illuminator wherein the illumination intensity cannot be directly controlled.

Summary

According to one aspect of the invention, there is provided a method for adjusting an auto exposure target in an auto-exposure operation on a sequence of images.

The method comprises identifying pixels in an image that have repeatedly exceeded a saturation threshold; obtaining a histogram of the image in which the identified pixels are excluded; applying a weighted histogram table to the histogram to obtain weighted tonal value bins wherein at least some bins in the histogram containing oversaturated pixels are assigned a higher weighting value and at least some bins in the histogram containing non-saturated pixels are assigned a lower weighting value, and summing the weighted histogram bins to obtain a saturation score and decreasing an auto exposure target for an auto exposure operation when the saturation score indicates that the image is oversaturated, and increasing the auto exposure target when the saturation score indicates that the image is non-saturated and when the image is underexposed.

Prior to obtaining a histogram of at the image, the static or mostly static background saturated pixels in the image can be masked by identifying pixels in the image that have exceeded a saturation threshold a selected number of times over a time period; and applying a mask to the identified pixels such that the masked pixels are not included in the histogram. The step of identifying pixels as being static or mostly static background pixels can comprise reading a saturation level of a pixel and incrementing a counter when the pixel exceeds the saturation threshold and identifying the pixel as being a static or mostly static saturated background pixel when the counter exceeds a background saturated pixel threshold value. The method can further comprise unmasking masked pixels by reading a saturation level of a masked pixel and decrementing a counter when the masked pixel falls below the saturation threshold, and removing the mask from the masked pixel when the counter falls below a background saturated pixel threshold value.

The histogram can be obtained from only one out of every selected number of images in the sequence of images, wherein the selected number of images is greater than the number of images in the sequence of images to which the auto-exposure operation is applied. The weighted histogram table can have a weighting value that linearly increases from the bins assigned the lower weighting value to the bins assigned the higher weighting value, wherein the linear increase occurs over a selected range of bins. The higher weighting value can be 1 and the lower weighting value can be 0.

The method can further comprise decreasing the auto exposure target by a first amount when the image is highly oversaturated, and decreasing the auto exposure target by a second amount when the image is slightly oversaturated, wherein the saturation score when the image is highly saturated is higher than the saturation score when the image is slightly saturated. The first amount can be a function of the original auto exposure target, and the second amount can be a function of the global mean exposure level of the image. The images can be infrared images.

According to another aspect of the invention, there is provided an imaging apparatus comprising: an imager; and processing circuitry communicative with the imager to receive an image captured by the imager. The processing circuitry comprises a processor and a memory having encoded thereon program code executable by the processor to perform the method of adjusting an auto exposure target in an auto-exposure operation on a sequence of images, comprising:

identifying pixels in the image that have repeatedly exceeded a saturation threshold;

obtaining a histogram of an the image in which the identified pixels are excluded;

applying a weighted histogram table to the histogram to obtain weighted tonal value bins wherein at least some bins in the histogram containing oversaturated pixels are assigned a higher weighting value and at least some bins in the histogram containing non-saturated pixels are assigned a lower weighting value; and

summing the weighted histogram bins to obtain a saturation score and decreasing an auto exposure target for an auto exposure operation when the saturation score indicates that the image is oversaturated, and increasing the auto exposure target when the saturation score indicates that the image is non-saturated and when the image is underexposed.

According to another aspect of the present invention, there is provided a method comprising:

identifying pixels in an image that exceed a saturation threshold a selected number of times over a time period as being static or mostly static background saturated pixels;

storing information in a memory as to which pixels in the image are the identified pixels;

employing the stored information to make calculations within a processor contained in a camera; and

carrying out an exposure control operation in the camera based on the calculations.

According to another aspect of the present invention, there is provided a camera comprising:

(a) an imager; and

(b) processing circuitry communicative with the imager to receive an image captured by the imager, the processing circuitry comprising a processor and memory having encoded thereon program code executable by the processor to perform a method comprising:

identifying pixels in the image that exceed a saturation threshold a selected number of times over a time period as being static or mostly static background saturated pixels;

storing information in the memory as to which pixels in the image are the identified pixels;

employing the stored information to make calculations within the processor; and

carrying out an exposure control operation in the camera based on the calculations.

There is also disclosed a method for generating a mask of background saturated objects in an image, comprising: identifying pixels in the image that exceed a saturation threshold a selected number of times over a time period as being static or mostly static background saturated pixels; and assigning a mask flag to each pixel in the image identified as being a mostly static background saturated pixel. The method can further comprise identifying masked pixels in the image that have fallen below a saturation threshold a selected number of times over a time period as being non-saturated pixels, and removing the mask flag from masked pixels that are non-saturated.

The method can further comprise two saturation thresholds, namely an upper saturation threshold above which a pixel is considered saturated and a lower saturation threshold below which a pixel is considered non-saturated. The step of identifying pixels as being static or mostly static background pixels can comprise reading a saturation level of a pixel and incrementing a counter when the pixel exceeds the saturation threshold and identifying the pixel as being a static or mostly static saturated background pixel when the counter exceeds a background saturated pixel threshold value. The step of identifying masked pixels that are non-saturated can comprises reading a saturation

Claims

1. A method for adjusting an auto exposure target in an auto-exposure operation on a sequence of images, comprising:

identifying pixels in an image that have repeatedly exceeded a saturation threshold;

obtaining a histogram of the image in which the identified pixels are excluded;

applying a weighted histogram table to the histogram to obtain weighted tonal value bins wherein at least some bins in the histogram containing oversaturated pixels are assigned a higher weighting value and at least some bins in the histogram containing non-saturated pixels are assigned a lower weighting value; and

summing the weighted histogram bins to obtain a saturation score and decreasing an auto exposure target for an auto exposure operation when the saturation score indicates that the image is oversaturated, and increasing the auto exposure target when the saturation score indicates that the image is non-saturated and when the image is underexposed.

2. The method as claimed in claim 1 further comprising applying a mask to the identified pixels.

3. The method as claimed in claim 1 wherein the identifying comprises reading a saturation level of a pixel and incrementing a counter when the pixel exceeds the saturation threshold and identifying the pixel as being a static or mostly static saturated background pixel when the counter exceeds a background saturated pixel threshold value.

4. The method as claimed in claim 2 further comprising unmasking masked pixels by reading a saturation level of a masked pixel and decrementing a counter when the masked pixel falls below the saturation threshold, and removing the mask from the masked pixel when the counter falls below a background saturated pixel threshold value.

5. The method as claimed in claim 1 wherein the histogram is obtained from only one out of every selected number of images in the sequence of images, wherein the selected number of images is greater than the number of images in the sequence of images to which the auto-exposure operation is applied.

6. The method as claimed in claim 5 wherein the weighted histogram table has a weighting

value that linearly increases from the bins assigned the lower weighting value to the bins assigned the higher weighting value, wherein the linear increase occurs over a selected range of bins.

7. The method as claimed in claim 6 wherein the higher weighting value is 1 and the lower weighting value is 0.

8. The method as claimed in claim 7 further comprising decreasing the auto exposure target by a first amount when the image is highly oversaturated, and decreasing the auto exposure target by a second amount when the image is slightly oversaturated, wherein the saturation score when the image is highly saturated is higher than the saturation score when the image is slightly saturated.

9. The method as claimed in claim 8 wherein the first amount is a function of the original auto exposure target, and the second amount is a function of the global mean exposure level of the image.

10. The method as claimed in claim 1 wherein the images are infrared images.

11. The method as claimed in claim 1 wherein the image is underexposed when a selected number of pixels with the highest tonal values in the image have a mean tonal value that is below a tonal value threshold above which a pixel is considered oversaturated.

12. The method as claimed in claim 11 wherein the auto exposure target is increased by the global mean exposure level of the image multiplied by the ratio of the tonal value threshold above which a pixel is considered oversaturated to the mean tonal value of the selected number of pixels having the highest tonal values in the image.

13. An imaging apparatus comprising:

(a) an imager; and

(b) processing circuitry communicative with the imager to receive an image captured by the imager, the processing circuitry comprising a processor and a memory having encoded thereon program code executable by the processor to perform a method of adjusting an auto exposure target in an auto-exposure operation on a sequence of images, comprising:

identifying pixels in the image that have repeatedly exceeded a saturation threshold;

obtaining a histogram of an the image in which the identified pixels are excluded;

applying a weighted histogram table to the histogram to obtain weighted tonal value bins wherein at least some bins in the histogram containing oversaturated pixels are assigned a higher weighting value and at least some bins in the histogram containing non-saturated pixels are assigned a lower weighting value; and

summing the weighted histogram bins to obtain a saturation score and decreasing an auto exposure target for an auto exposure operation when the saturation score indicates that the image is oversaturated, and increasing the auto exposure target when the saturation score indicates that the image is non-saturated and when the image is underexposed.

14. The apparatus as claimed in claim 13 wherein the imager is an infrared imager.

15. A method comprising:

identifying pixels in an image that exceed a saturation threshold a selected number of times over a time period as being static or mostly static background saturated pixels;

storing information in a memory as to which pixels in the image are the identified pixels;

employing the stored information to make calculations within a processor contained in a camera; and

carrying out an exposure control operation in the camera based on the calculations.

16. The method as claimed in claim 15 wherein the identifying comprises reading a saturation level of a pixel and incrementing a counter when the pixel exceeds the saturation threshold and identifying the pixel as being a static or mostly static saturated background pixel when the counter exceeds a background saturated pixel threshold value.

17. A camera comprising:

(a) an imager; and

(b) processing circuitry communicative with the imager to receive an image captured by the imager, the processing circuitry comprising a processor and memory having encoded thereon program code executable by the processor to perform a method comprising:

identifying pixels in the image that exceed a saturation threshold a selected number of times over a time period as being static or mostly static background saturated pixels;

storing information in the memory as to which pixels in the image are the identified pixels;

employing the stored information to make calculations within the processor; and

carrying out an exposure control operation in the camera based on the calculations.

18. The camera as claimed in claim 17 wherein the processing circuitry is contained in a system on chip of the camera.