VIDEO CAMERA

BACKGROUND

Field of the Inventions

[0001] The present inventions are directed to digital cameras, such as those for capturing still or moving pictures, and more particularly, to digital cameras that compress image data.

Description of the Related Art

[0002] Despite the availability of digital video cameras, the producers of major motion pictures and some television broadcast media continue to rely film cameras. The film used for such provides video editors with very high resolution images that can be edited by conventional means. More recently, however, such film is often scanned, digitized and digitally edited.

SUMMARY OF THE INVENTIONS

[0003] Although some currently available digital video cameras include high resolution image sensors, and thus output high resolution video, the image processing and compression techniques used on board such cameras are too lossy and thus eliminate too much raw image data to be acceptable in the high end portions of the market noted above. ~~An aspect of at least one of the e~~Embodiments disclosed herein includes the realization that video quality that is acceptable for the higher end portions of the markets noted above, such as the major motion picture market, can be satisfied by cameras that can capture and store raw or substantially raw video data having a resolution of at least about 2k and at a frame rate of at least about 23 frames per second.

~~**[0004]** Thus, in accordance with an embodiment, a video camera can comprise a~~ portable housing, and a lens assembly supported by the housing and configured to focus light. A light sensitive device can be configured to convert the focused light into raw image data with a resolution of at least 2k at a frame rate of at least about twenty-three frames per second. The camera can also include a memory device and an image processing system ~~configured to compress and store in the memory device the raw image data at a compression~~

~~ratio of at least six to one and remain substantially visually lossless, and at a rate of at least~~ about 23 frames per second.

[0005] In accordance with another embodiment, a method of recording a motion video with a camera can comprise guiding light onto a light sensitive device. The method can also include converting the light received by the light sensitive device into raw digital image data at a rate of at least greater than twenty three frames per second, compressing the raw digital image data, and recording the raw image data at a rate of at least about 23 frames per second onto a storage device.

[0006] In accordance with yet another embodiment, a video camera can comprise a lens assembly supported by the housing and configured to focus light and a light sensitive device configured to convert the focused light into a signal of raw image data representing the focused light. The camera can also include a memory device and means for compressing and recording the raw image data at a frame rate of at least about 23 frames per second.

[0007] In accordance with yet another embodiment, a video camera can comprise a portable housing having at least one handle configured to allow a user to manipulate the orientation with respect to at least one degree of movement of the housing during a video recording operation of the camera. A lens assembly can comprise at least one lens supported by the housing and configured to focus light at a plane disposed inside the housing. A light sensitive device can be configured to convert the focused light into raw image data with a horizontal resolution of at least 2k and at a frame rate of at least about twenty three frames per second. A memory device can also be configured to store video image data. An image processing system can be configured to compress and store in the memory device the raw image data at a compression ratio of at least six to one and remain substantially visually ~~lossless, and at a rate of at least about 23 frames per second.~~

[0004] According to a first aspect, there is provided a video camera comprising: a portable housing; a lens assembly supported by the housing and configured to focus light; a light sensitive device configured to convert the focused light into raw mosaiced image data with a resolution of at least 2 k at a frame rate of at least about twenty-three frames per second; a memory device; and an image processing system configured to compress and store in the memory device the raw mosaiced image data at a compression ratio of at least six to one and remain substantially visually lossless, and at a rate of at least about 23 frames per second.

[0005] According to a second aspect, there is provided a method of recording a motion video with a camera, the method comprising: guiding light onto a light sensitive device of a camera; converting the light received by the light sensitive device into raw digital mosaiced image data having a horizontal resolution of at least 2 k at a rate of at least greater than twenty three frames per second; compressing the raw digital mosaiced image data into compressed digital image data such that the data remains substantially visually lossless upon decompression; and recording the compressed digital mosaiced image data at a rate of at least about 23 frames per second onto a storage device of the camera.

[0006] According to a third aspect, there is provided a video camera comprising: a lens assembly supported by a housing and configured to focus light; a light sensitive device configured to convert the focused light into a signal of raw mosaiced image data representing the focused light and having a resolution of at least 2 k; a memory device; and means for compressing and recording the raw mosaiced image data in the memory device at a frame rate of at least about 23 frames per second such that the mosaiced image data remains substantially visually lossless upon decompression.

[0007] According to a fourth aspect, there is provided a video camera comprising: a portable housing having at least one handle configured to allow a user to manipulate the orientation with respect to at least one degree of movement of the housing during a video recording operation of the camera; a lens assembly comprising at least one lens supported by the housing and configured to focus light at a plane disposed inside the housing; a light sensitive device configured to convert the focused light into raw mosaiced image data with a horizontal resolution of at least 2 k and at a frame rate of at least about twenty three frames per second; a memory device configured to store video image data; an image processing system configured to compress and store in the memory device the raw mosaiced image data at a compression ratio of at least six to one and remain substantially visually lossless, and at a rate of at least about 23 frames per second.

[0008] Embodiments~~Another aspect of at least one of the inventions~~ disclosed herein includes the realization that because the human eye is more sensitive to green wavelengths than any other color, green image data based modification of image data output from an image sensor can be used to enhance compressibility of the data, yet provide a higher quality video image. One such technique can include subtracting the magnitude of green light detected from the magnitudes of red and/or blue light detected prior to compressing the data. This can convert

store and/or replay video image data. For example, the system 14 can include optics hardware 16, an image sensor 18, an image processing module 20, a compression module 22, and a storage device 24. Optionally, the camera 10 can also include a monitor module 26, a playback module 28, and a display 30.

[0033] Figure 2 illustrates a nonlimiting exemplary embodiment of the camera 10. As shown in Figure 2, the optics hardware 16 can be supported by the housing 12 in a manner that leaves it exposed at its outer surface. In some embodiments, the system 14 is supported within the housing 12. For example, the image sensor 18, image processing module 20, and the compression module 22 can be housed within the housing 12. The storage device 24 can be mounted in the housing 12. Additionally, in some embodiments, the storage device 24 can be mounted to an exterior of the housing 12 and connected to the remaining portions of the system 14 through any type of known connector or cable. Additionally, the storage device 24 can be connected to the housing 12 with a flexible cable, thus allowing the storage device 24 to be moved somewhat independently from the housing 12. For example, with such a flexible cable connection, the storage device 24 can be worn on a belt of a user, allowing the total weight of the housing 12 to be reduced. Further, in some embodiments, the housing can include one or more storage devices 24 inside and mounted to its exterior. Additionally, the housing 12 can also support the monitor module 26, and ~~playbook~~playback module 28. Additionally, in some embodiments, the display 30 can be configured to be mounted to an exterior of the housing 12.

[0034] The optics hardware 16 can be in the form of a lens system having at least one lens configured to focus an incoming image onto the image sensor 18. The optics hardware 16, optionally, can be in the form of a multi-lens system providing variable zoom, aperture, and focus. Additionally, the optics hardware 16 can be in the form of a lens socket supported by the housing 12 and configured to receive a plurality of different types of lens systems for example, but without limitation, the optics hardware 16 include a socket configured to receive various sizes of lens systems including a 50-100 millimeter (F2.8) zoom lens, an 18-50 millimeter (F2.8) zoom lens, a 300 millimeter (F2.8) lens, 15 millimeter (F2.8) lens, 25 millimeter (F1.9) lens, 35 millimeter (F1.9) lens, 50 millimeter (F1.9) lens, 85 millimeter (F1.9) lens, and/or any other lens. As noted above, the optics hardware 16 can be

indication of which of the plurality of different image data deletion patterns was used. This data field can be used by downstream components and or processes to determine to which ~~spacial~~spatial positions the remaining image data corresponds.

[0046] In some embodiments, the image processing module can be configured to retain all of the raw green image data, e.g., the data shown in Figure 5. In such embodiments, the image processing module can include one or more green image data processing modules.

[0047] As noted above, in known Bayer pattern filters, there are twice as many green elements as the number of red elements and the number of blue elements. In other words, the red elements comprise 25% of the total Bayer pattern array, the blue elements corresponded 25% of the Bayer pattern array and the green elements comprise 50% of the elements of the Bayer pattern array. Thus, in some embodiments, where all of the green image data is retained, the image processing module 20 can include a second green data image processing module 38. As such, the first green data image processing module 36 can process half of the green elements and the second green image data processing module 38 can process the remaining green elements. However, the present inventions can be used in conjunction with other types of patterns, such as for example, but without limitation, CMY and RGBW.

[0048] Figure 7 includes schematic illustrations of the red, blue and two green data components processed by modules 32, 34, 36, and 38 (Figure 4). This can provide further advantages because the size and configuration of each of these modules can be about the same since they are handling about the same amount of data. Additionally, the image processing module 20 can be selectively switched between modes in which is processes all of the green image data (by using both modules 36 and 38) and modes where ½ of the green image data is deleted (in which it utilizes only one of modules 36 and 38). However, other configurations can also be used.

[0049] Additionally, in some embodiments, the image processing module 20 can include other modules and/or can be configured to perform other processes, such as, for example, but without limitation, gamma correction processes, noise filtering processes, etc.

[0050] Additionally, in some embodiments, the image processing module 20 can be configured to subtract a value of a green element from a value of a blue element and/or red

WHAT IS CLAIMED IS:

1. A video camera comprising:

a portable housing;

a lens assembly supported by the housing and configured to focus light;

a light sensitive device configured to convert the focused light into raw image data with a resolution of at least 2k at a frame rate of at least about twenty-three frames per second;

a memory device; and

an image processing system configured to compress and store in the memory device the raw image data at a compression ratio of at least six to one and remain substantially visually lossless, and at a rate of at least about 23 frames per second.

2. A video camera according to Claim 1, wherein the image processing system further comprises an image processing module configured to modify the image data representing at least one of the first and second colors based on the image data of the third color.

3. A video camera according to Claim 2, wherein the third color is green.

4. A video camera according to Claim 2, wherein the image processing module is configured to subtract a value of the image data of the third color from values of the image data of the first and second colors.

5. A video camera according to Claim 2, wherein the image processing system is configured to compress the image data of the first, second, and third colors after the image processing module has modified the image data representing at least one of the first and second colors.

6. A video camera according to Claim 2, wherein the image processing system is configured to delete about half of the image data representing the third color.

7. A video camera according to Claim 6, wherein the light sensitive device includes a first group of sensor cells configured to detect the first color, a second group of sensor cells configured to detect the second color, and a third group of sensor cells configured to detect the third color, the third group of sensor cells comprising twice as many sensor cells as the second group of sensor cells.

8. A video camera according to Claim 1, wherein the memory device is disposed within the housing.

9. A video camera according to Claim 1, wherein the memory device is supported on the outside of the housing.

10. A video camera according to Claim 1, wherein the memory device is connected to the housing with a flexible cable.

11. A video camera according to Claim 1, wherein the image processing system is configured to manipulate the raw image data so as to reduce an entropy of the raw image data before compression.

12. A video camera according to Claim 1, wherein the image processing system is configured to reduce an entropy of the raw image data before compression.

13. A video camera comprising:

a lens assembly supported by the housing and configured to focus light;

a light sensitive device configured to convert the focused light into a raw signal of image data representing at least first, second, and third colors of the focused light;

an image processing module configured to modify image data of at least one of the first and second colors based on the image data of the third color;

a memory device; and

a compression device configured to compress the image data of the first, second, and third colors and to store the compressed image data on the memory device at a frame rate of at least about 23 frames per second.

14. A video camera according to Claim 13, wherein the third color is green.

15. A video camera according to Claim 13, wherein the image processing module is configured to subtract the values of the image data of the third color from the values of image data of at least one of the first and second colors.

16. A video camera according to Claim 15, wherein the values of the image data of the third color comprise an average of values of selected image data of the third color.

17. A video camera according to Claim 13, wherein the image processing module is configured to calculate an average of values of image data of the third color from at least

two sensor cells adjacent to a sensor cell of the first color and to subtract the average value from a value of the image data from the sensor cell of the first color.

18. A video camera according to Cling 17, wherein the average of values comprises the average of values of image data of the third color from at least for sensor cells adjacent to the sensor cell of the first color.

19. A video camera according to Claim 13, wherein the light sensitive device comprises a Bayer sensor.

20. A method of recording a motion video with a camera, the method comprising:

guiding light onto a light sensitive device;

converting the light received by the light sensitive device into raw digital image data at a rate of at least greater than twenty three frames per second;

compressing the raw digital image data; and

recording the raw image data at a rate of at least about 23 frames per second onto a storage device.

21. The method according to Claim 20, wherein the step of compressing the raw digital image data comprises compressing the raw digital image data to an effective compression ratio of at least 6 to 1.

22. The method according to Claim 20, wherein the step of compressing the raw digital image data comprises compressing the raw digital image data with an effective compression ratio of at least about 12:1.

23. The method according to Claim 20, wherein the step of compressing the raw digital image data comprises compressing the raw digital image data such that the data remains visually lossless.

24. The method according to Claim 20, wherein the step of recording comprises storing the compressed raw digital image data.

25. The method according to Claim 20, wherein the step of recording comprises recording the raw image data at a rate of at least about 23.976 frames per second onto the storage device.

26. The method according to Claim 20 additionally comprising a step of manipulating the raw image data to reduce an entropy of the raw image data, before the step of recording.

27. The method according to Claim 20 additionally comprising a step of reducing an entropy of the raw image data, before the step of recording.

28. The method according to Claim 27 additionally comprising a step of compressing the raw image data in a visually lossless manner after the step of reducing an entropy.

29. A method of processing an image, comprising:

converting an image and into raw first image data representing a first color, raw second image data representing a second color, and raw third image data representing a third color;

modifying at least the raw first image data and the raw second image data based on the raw third image data;

compressing the raw third image data and the modified raw first and raw second image data; and

storing the compressed data at a frame rate of at least about 23 frames per second.

30. The method according to Claim 29, wherein the step of storing comprises storing the compressed data on a camera including an image sensing device used for the step of converting.

31. The method according to Claim 29 additionally comprising the step of deleting half of the third image data.

32. The method according to Claim 29, where the step of modifying comprises calculating an average of at least two pixels of third image data in subtracting the average from a pixel of the first image data that is adjacent to both of the at least two pixels of third image data.

33. The method according to Claim 32, where the step of calculating comprises calculating an average of at least four pixels of third image data.

34. The method according to Claim 29, wherein the third image data represents green image data.

35. The method according to Claim 29 additionally comprising decompressing the third image data and the modified first and second image data.

36. The method according to Claim 35 additionally comprising demosaicing the third image data.

37. The method according to Claim 36 additionally comprising demosaicing the first image data based on the demosaiced third image data.

38. The method according to Claim 36 additionally comprising demosaicing the first image data, then modifying the demosaiced first image data based on the demosaiced third image data.

39. The method according to Claim 29, wherein the step of modifying comprises calculating a value based on the third image data, subtracting the value from a value of the first image data, and wherein the method further comprises decompressing the third image data and the first and second modified image data, demosaicing the third image data, then demosaicing the first image data, then modifying the demosaiced first image data based on a value of the demosaiced third image data.

40. A video camera comprising:

a lens assembly supported by the housing and configured to focus light;

a light sensitive device configured to convert the focused light into a signal of raw image data representing the focused light;

a memory device; and

means for compressing and recording the raw image data at a frame rate of at least about 23 frames per second.

41. The video camera according to Claim 40, additionally comprising means for reducing an entropy of the raw image data before the means for compressing compresses the raw image data.

42. A video camera comprising:

a portable housing having at least one handle configured to allow a user to manipulate the orientation with respect to at least one degree of movement of the housing during a video recording operation of the camera;

a lens assembly comprising at least one lens supported by the housing and configured to focus light at a plane disposed inside the housing;

a light sensitive device configured to convert the focused light into raw image data with a horizontal resolution of at least 2k and at a frame rate of at least about twenty three frames per second;

a memory device configured to store video image data;

an image processing system configured to compress and store in the memory device the raw image data at a compression ratio of at least six to one and remain substantially visually lossless, and at a rate of at least about 23 frames per second.

43. The video camera according to Claim 42, wherein the image processing system is configured to reduce an entropy of the raw image data before compressing the raw image data.

CLAIMS

1. video camera comprising:

a portable housing;

a lens assembly supported by the housing and configured to focus light;

a light sensitive device configured to convert the focused light into raw mosaiced image data with a resolution of at least 2 k at a frame rate of at least about twenty-three frames per second;

a memory device; and

an image processing system configured to compress and store in the memory device the raw mosaiced image data at a compression ratio of at least six to one and remain substantially visually lossless, and at a rate of at least about 23 frames per second.

2. A video camera according to claim 1, wherein the light sensitive device includes a first group of sensor cells configured to detect a first color, a second group of sensor cells configured to detect a second color, and a third group of sensor cells configured to detect a third color, the third group of sensor cells comprising twice as many sensor cells as the second group of sensor cells.

3. A video camera according to claim 1, wherein the memory device is disposed within the housing.

4. A video camera according to claim 1, wherein the memory device is supported on the outside of the housing.

5. A video camera according to claim 1, wherein the memory device is connected to the housing with a flexible cable.

6. A method of recording a motion video with a camera, the method comprising:

guiding light onto a light sensitive device of a camera;

converting the light received by the light sensitive device into raw digital mosaiced image data having a horizontal resolution of at least 2 k at a rate of at least greater than twenty three frames per second;

compressing the raw digital mosaiced image data into compressed digital image data such that the data remains substantially visually lossless upon decompression; and

recording the compressed digital mosaiced image data at a rate of at least about 23 frames per second onto a storage device of the camera.

7. The method according to claim 6, wherein the step of compressing the raw digital mosaiced image data comprises compressing the raw digital mosaiced image data to an effective compression ratio of at least 6 to 1.

8. The method according to claim 6, wherein the step of compressing the raw digital mosaiced image data comprises compressing the raw digital mosaiced image data with an effective compression ratio of at least about 12:1.

9. The method according to claim 6, wherein the step of recording comprises storing the compressed digital mosaiced image data.

10. The method according to claim 6, wherein the step of recording comprises recording the compressed digital mosaiced image data at a rate of at least about 23.976 frames per second onto the storage device.

11. A video camera comprising:

a lens assembly supported by a housing and configured to focus light;

a light sensitive device configured to convert the focused light into a signal of raw mosaiced image data representing the focused light and having a resolution of at least 2 k;

a memory device; and

means for compressing and recording the raw mosaiced image data in the memory device at a frame rate of at least about 23 frames per second such that the mosaiced image data remains substantially visually lossless upon decompression.

12. A video camera comprising:

a portable housing having at least one handle configured to allow a user to manipulate the orientation with respect to at least one degree of movement of the housing during a video recording operation of the camera;

a lens assembly comprising at least one lens supported by the housing and configured to focus light at a plane disposed inside the housing;

a light sensitive device configured to convert the focused light into raw mosaiced image data with a horizontal resolution of at least 2 k and at a frame rate of at least about twenty three frames per second;

a memory device configured to store video image data;

an image processing system configured to compress and store in the memory device the raw mosaiced image data at a compression ratio of at least six to one and remain substantially visually lossless, and at a rate of at least about 23 frames per second.

13. A video camera according to claim 1 additionally comprising a playback module configured to receive data from the memory device, and decompress and demosaic the compressed raw mosaiced image data stored in the memory device.

14. A video camera according to claim 1 wherein the image processing module comprises a compression chip.

15. A video camera according to claim 14 wherein the compression chip is configured to perform compression using a JPEG 2000 standard.

16. A video camera according to Claim 1, wherein the light sensitive device is configured to convert light into raw mosaiced image data with a resolution of at least 4 k.

17. A video camera according to Claim 1, wherein the image processing system is configured to alter the raw mosaiced image data by subtracting values based on some of the raw mosaiced image data from other values of the raw mosaiced image data and to compress and store the raw mosaiced image data after subtracting.

18. A video camera according to Claim 1, wherein the image processing system is configured to compress and store the raw mosaiced image data which is Bayer patterned mosaiced data.

19. The method according to claim 6 additionally comprising decompressing and demosaicing the compressed raw mosaiced image data stored in the storage device.

20. The method according to claim 6, wherein the step of compressing comprises compressing raw mosaiced image data with a compression chip.

21. The method according to claim 20 wherein step of compressing comprises compressing raw mosaiced image data with a JPEG 2000 standard.

22. The method according to claim 6, wherein the step of converting comprises converting light into raw mosaiced image data with a resolution of at least 4 k.

23. The method according to claim 6, additionally comprising subtracting values based on some of the raw mosaiced image data from other values of the raw mosaiced image data before the steps of compressing and recording the raw mosaiced image data.

24. The method according to claim 6, wherein the step of compressing comprises compressing the raw mosaiced image which is Bayer patterned mosaiced data.

25. A video camera according to claim 11 additionally comprising a playback module configured to receive data from the means for compressing and recording, and to

decompress and demosaic the compressed raw mosaiced image data stored in the memory device.

26. A video camera according to claim 11 wherein the means for compressing and recording comprises a compression chip.

27. A video camera according to claim 26 wherein the compression chip is configured to perform compression using a JPEG 2000 standard.

28. A video camera according to claim 11, wherein the light sensitive device is configured to convert light into raw mosaiced image data with a resolution of at least 4 k.

29. A video camera according to Claim 11, wherein the means for compressing and recording is configured to alter the raw mosaiced image data by subtracting values based on some of the raw mosaiced image data from other values of the raw mosaiced image data and to record and store the raw mosaiced image data after subtracting.

30. A video camera according to Claim 11, wherein the means for compressing and recording is configured to compress and record the raw mosaiced image data which is Bayer patterned mosaiced data.

31. A video camera according to claim 12 additionally comprising a playback module configured to receive data from the memory device, and decompress and demosaic the compressed raw mosaiced image data stored in the memory device.

32. A video camera according to claim 12 wherein the image processing system comprises a compression chip.

33. A video camera according to claim 32 wherein the compression chip is configured to perform compression using the JPEG 2000 standard.

34. A video camera according to claim 12, wherein the light sensitive device is configured to convert light into raw mosaiced image data with a resolution of at least 4 k.

35. A video camera according to Claim 12, wherein the image processing system is configured to alter the raw mosaiced image data by subtracting values based on some of the raw mosaiced image data from other values of the raw mosaiced image data and to compress and store the raw mosaiced image data after subtracting.

36. A video camera according to Claim 12, wherein the image processing system is configured to compress and store the raw mosaiced image data which is Bayer patterned mosaiced data.