(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau

(43) International Publication Date
4 October 2012 (04.10.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/134923 A1

(54) Title: COMPOSITE IMAGE FORMED FROM AN IMAGE SEQUENCE
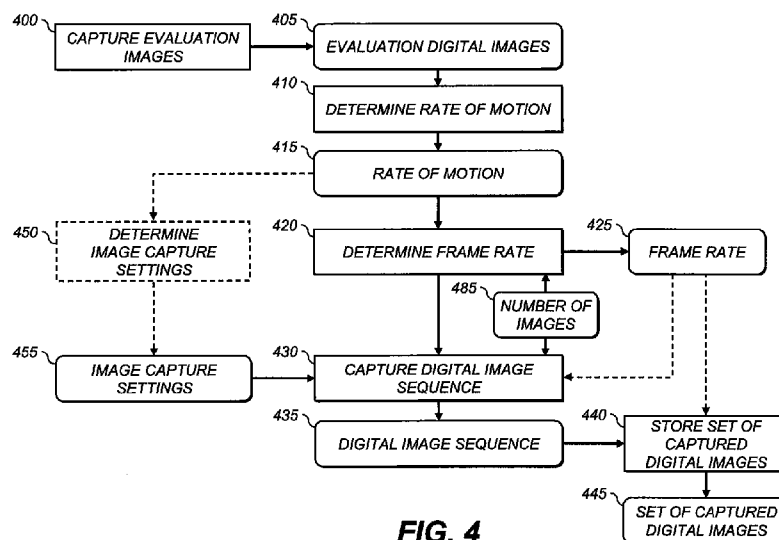
FIG. 4

(57) Abstract: A method for forming a composite image from a sequence of digital images, comprising: receiving a sequence of digital images of a scene, each digital image being captured at a different time, wherein the scene includes a moving object; using a data processor to automatically analyze two or more of the digital images in the sequence of digital images to determine a rate of motion for the moving object; determining a frame rate responsive to the rate of motion for the moving object; selecting a subset of the digital images from the sequence of digital images corresponding to the determined frame rate; and forming the composite image by combining the selected subset of digital images from the sequence of digital images.

COMPOSITE IMAGE FORMED FROM AN IMAGE SEQUENCE

FIELD OF THE INVENTION

This invention pertains to the field of digital imaging, and more particularly to a method for adjusting a frame rate used to form a composite image from a sequence of digital images based upon a determined rate of motion for a moving object.

BACKGROUND OF THE INVENTION

Digital camera devices have continued to increase in complexity and capabilities with the advent of new image capture modes that offer the user unique output image characteristics. One such image capture mode is a composite burst image capture mode where a plurality of images are acquired over a specified time interval and one or more subjects in the scene are extracted from multiple images and combined onto a common background. The resulting composite image provides a stop action effect for the subject in motion as illustrated in FIG. 1A. As a creative mode, this capability enables the user to observe the motion of a skier, the running of a child or any other conditions where subject motion allows for a proper stop-action effect.

A key consideration of the composite burst image mode is the proper selection of the time separation between individual captures that are combined into the single composite image. Currently, for typical embodiments of this image capture mode, various image capture settings (e.g., the number of "burst" images and, either the total time duration for the image sequence or the time spacing between sequential image captures) must be specified via a user interface prior to the user capturing the moment of action. This requires the user to make a guess about the appropriate image capture settings prior to initiating the capture of the sequence of images. Given that knowledge about the motion of the moving objects will be rarely known in advance, this can lead to unsatisfactory results in many cases. This can be further complicated by the fact that the user may forget to adjust the image capture settings before the capture of new conditions. An example of an unsatisfactory result would correspond to the subject moving too slowly relative to the capture rate, resulting in too little separation between the object positions in the resulting composite image as

illustrated in FIG. 1B. An analogous problem would occur when the subject is moving too rapidly relative to the capture rate so that it moves too quickly through the camera's field of view. Both of these examples would result in a poor user experience of the resulting output composite image.

5   Some recently introduced digital cameras include a capability to automatically analyze captured images to determine the motion characteristics present within the image content of interest. The motion characteristics are used for purposes such as determining the optimal exposure time.

Various methods of estimating motion are available to those 10   skilled in the art, the most common of which is to capture two images separated in time and measure the change in spatial location of objects between frames. One such method is described by De Haan in U.S. Patent 5,929,919, entitled "Motion-compensated field rate conversion."

U.S. Patent Application Publication 2007/0237514 to Pillman et 15   al., entitled "Varying camera self-determination based on subject motion," teaches a method for capturing digital images where motion in the scene is measured prior to image capture. Various camera settings are adjusted responsive to the determined scene motion.

There remains a need for a method to adjust image capture settings 20   and image buffer management for an electronic image capture device to provide improved image quality of a final composite image containing moving objects captured in a burst image capture mode.

SUMMARY OF THE INVENTION

25   The present invention represents a method for forming a composite image from a sequence of digital images, comprising:

receiving a sequence of digital images of a scene, each digital image being captured at a different time, wherein the scene includes a moving object;

30   using a data processor to automatically analyze two or more of the digital images in the sequence of digital images to determine a rate of motion for the moving object;

determining a frame rate responsive to the rate of motion for the moving object;

selecting a subset of the digital images from the sequence of digital images corresponding to the determined frame rate; and

forming the composite image by combining the selected subset of digital images from the sequence of digital images.

5   This invention has the advantage that the frame rate used to select the subset of digital images is optimized relative to the rate of motion of the moving object.

It has the further advantage that the spatial displacement of the moving object within the composite image is optimized without the need for the

10   user to guess at settings that would be needed to produce a desirable result.

It has the additional advantage that the rate of motion can be determined by automatically analyzing the digital images in the sequence of digital images to identify moving objects that are likely to be of interest to the user. In this way, the frame rate can be determined in a manner that accounts for

15   the object motions that are most likely to affect perceived image quality of the composite image.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is an illustration of a composite image captured using a

20   composite burst image capture mode;

FIG. 1B is an illustration of a composite image captured using a composite burst image capture mode using a sub-optimal time interval;

FIG. 2 is a high level schematic diagram of a camera system in a preferred configuration of the present invention for controlling the burst rate

25   capture of an image sequence.

FIG. 3 is a high-level diagram showing the components of a digital camera system;

FIG. 4 is a flow chart of a method for capturing a sequence of digital images in a burst image capture mode;

30   FIG. 5 is a flow chart showing additional details for the determine frame rate step of FIG. 4 according to one embodiment;

FIGS. 6A-6C show examples of composite images formed using a composite burst mode in accordance with various embodiments;

FIG. 7A illustrates a moving object transitioning through an image field of view with a constant velocity;

FIG. 7B illustrates a moving object transitioning through an image field of view with a non-constant velocity; and

5   FIG. 8 flow chart showing additional details for the capture digital image sequence step of FIG. 4 according to one embodiment

It is to be understood that the attached drawings are for purposes of illustrating the concepts of the invention and may not be to scale.

10   **DETAILED DESCRIPTION OF THE INVENTION**

The present invention represents a digital camera having a burst image capture mode setting where the velocity of an object in the frame of view is used to determine the capture frame rate and the memory buffer requirements, which are then used to generate a composite image highlighting the object in

15   motion. This invention provides a configuration for automatically determining various image capture settings, thereby reducing the need for the operator to manually determine the image capture settings, and reducing the number of unacceptable results.

In the following description, a preferred embodiment of the present

20   invention will be described in terms that would ordinarily be implemented as a software program. Those skilled in the art will readily recognize that the equivalent of such software can also be constructed in hardware. Because image manipulation algorithms and systems are well known, the present description will be directed in particular to algorithms and systems forming part of, or cooperating

25   more directly with, the system and method in accordance with the present invention. Other aspects of such algorithms and systems, and hardware or software for producing and otherwise processing the image signals involved therewith, not specifically shown or described herein, can be selected from such systems, algorithms, components and elements known in the art. Given the system

30   as described according to the invention in the following materials, software not specifically shown, suggested or described herein that is useful for implementation of the invention is conventional and within the ordinary skill in such arts.

Still further, as used herein, a computer program for performing the method of the present invention can be stored in a computer readable storage medium, which can include, for example; magnetic storage media such as a magnetic disk (such as a hard drive or a floppy disk) or magnetic tape; optical

5   storage media such as an optical disc, optical tape, or machine readable bar code; solid state electronic storage devices such as random access memory (RAM), or read only memory (ROM); or any other physical device or medium employed to store a computer program having instructions for controlling one or more computers to practice the method according to the present invention.

10   The invention is inclusive of combinations of the embodiments described herein. References to "a particular embodiment" and the like refer to features that are present in at least one embodiment of the invention. Separate references to "an embodiment" or "particular embodiments" or the like do not necessarily refer to the same embodiment or embodiments; however, such

15   embodiments are not mutually exclusive, unless so indicated or as are readily apparent to one of skill in the art. The use of singular or plural in referring to the "method" or "methods" and the like is not limiting. It should be noted that, unless otherwise explicitly noted or required by context, the word "or" is used in this disclosure in a non-exclusive sense.

20   Because digital cameras employing imaging devices and related circuitry for signal capture and processing, and display are well known, the present description will be directed in particular to elements forming part of, or cooperating more directly with, the method and apparatus in accordance with the present invention. Elements not specifically shown or described herein are

25   selected from those known in the art. Certain aspects of the embodiments to be described are provided in software. Given the system as shown and described according to the invention in the following materials, software not specifically shown, described or suggested herein that is useful for implementation of the invention is conventional and within the ordinary skill in such arts.

30   The following description of a digital camera will be familiar to one skilled in the art. It will be obvious that there are many variations of this embodiment that are possible and are selected to reduce the cost, add features or improve the performance of the camera.

FIG. 2 depicts a block diagram of a digital photography system, including a digital camera 10 in accordance with the present invention. Preferably, the digital camera 10 is a portable battery operated device, small enough to be easily handheld by a user when capturing and reviewing images.

5   The digital camera 10 produces digital images that are stored as digital image files using image memory 30. The phrase "digital image" or "digital image file", as used herein, refers to any digital image file, such as a digital still image or a digital video file.

In some embodiments, the digital camera 10 captures both motion
10   video images and still images. The digital camera 10 can also include other functions, including, but not limited to, the functions of a digital music player (e.g. an MP3 player), a mobile telephone, a GPS receiver, or a programmable digital assistant (PDA).

The digital camera 10 includes a lens 4 having an adjustable
15   aperture and adjustable shutter 6. In a preferred embodiment, the lens 4 is a zoom lens and is controlled by zoom and focus motor drives 8. The lens 4 focuses light from a scene (not shown) onto an image sensor 14, for example, a single-chip color CCD or CMOS image sensor. The lens 4 is one type optical system for forming an image of the scene on the image sensor 14. In other embodiments, the
20   optical system may use a fixed focal length lens with either variable or fixed focus.

The output of the image sensor 14 is converted to digital form by Analog Signal Processor (ASP) and Analog-to-Digital (A/D) converter 16, and temporarily stored in buffer memory 18. The image data stored in buffer memory
25   18 is subsequently manipulated by a processor 20, using embedded software programs (e.g. firmware) stored in firmware memory 28. In some embodiments, the software program is permanently stored in firmware memory 28 using a read only memory (ROM). In other embodiments, the firmware memory 28 can be modified by using, for example, Flash EPROM memory. In such embodiments,
30   an external device can update the software programs stored in firmware memory 28 using the wired interface 38 or the wireless modem 50. In such embodiments, the firmware memory 28 can also be used to store image sensor calibration data, user setting selections and other data which must be preserved when the camera is turned off. In some embodiments, the processor 20 includes a program memory

(not shown), and the software programs stored in the firmware memory 28 are copied into the program memory before being executed by the processor 20.

It will be understood that the functions of processor 20 can be provided using a single programmable processor or by using multiple

5   programmable processors, including one or more digital signal processor (DSP) devices. Alternatively, the processor 20 can be provided by custom circuitry (e.g., by one or more custom integrated circuits (ICs) designed specifically for use in digital cameras), or by a combination of programmable processor(s) and custom circuits. It will be understood that connectors between the processor 20 from

10   some or all of the various components shown in FIG. 2 can be made using a common data bus. For example, in some embodiments the connection between the processor 20, the buffer memory 18, the image memory 30, and the firmware memory 28 can be made using a common data bus.

The processed images are then stored using the image memory 30.

15   It is understood that the image memory 30 can be any form of memory known to those skilled in the art including, but not limited to, a removable Flash memory card, internal Flash memory chips, magnetic memory, or optical memory. In some embodiments, the image memory 30 can include both internal Flash memory chips and a standard interface to a removable Flash memory card, such as a

20   Secure Digital (SD) card. Alternatively, a different memory card format can be used, such as a micro SD card, Compact Flash (CF) card, MultiMedia Card (MMC), xD card or Memory Stick.

The image sensor 14 is commonly controlled by a timing generator 12, which produces various clocking signals to select rows and pixels and

25   synchronizes the operation of the ASP and A/D converter 16. The image sensor 14 can have, for example, 12.4 megapixels (4088×3040 pixels) in order to provide a still image file of approximately 4000×3000 pixels. To provide a color image, the image sensor 14 is generally overlaid with a color filter array, which provides an image sensor having an array of pixels that include different colored pixels.

30   The different color pixels can be arranged in many different patterns. As one example, the different color pixels can be arranged using the well-known Bayer color filter array, as described in commonly assigned U.S. Patent 3,971,065, "Color imaging array" to Bayer. As a second example, the different color pixels

can be arranged as described in commonly assigned U.S. Patent Application Publication 2007/0024931 to Compton and Hamilton, entitled "Image sensor with improved light sensitivity". These examples are not limiting, and many other color patterns may be used.

5   A motion analysis block 54 is used to analyze captured preview images to characterize motion in the scene. Preferably, the motion analysis block 54 uses consecutively captured analysis images to determine image motion vectors representing the velocity associated with specific image subject content. The motion analysis block 54 can use any method known in the art to determine

10   the image motion vectors. In one embodiment, the method for estimating subject motion described in co-pending, commonly assigned U.S. Patent Application Serial No. 13/021,067 to Jasinski et al., entitled, "Estimating subject motion between image frames" can be used to determine image motion vectors for one or more objects in the image. Other methods for determining image motion vectors

15   would include the method described by De Haan in U.S. Patent 5,929,919, entitled "Motion-compensated field rate conversion," and the method described by Barjatya in the article "Block matching algorithms for motion estimation" (DIP 6620 final project paper, Utah State University, Spring 2004).

        As will be discussed in more detail later, when the digital camera

20   10 is being operated in a burst image capture mode, the present invention incorporates the information from the motion analysis block 54 and the timing generator 12 to determine various image capture parameters and to control allocation of the buffer memory 18.

        It will be understood that the image sensor 14, timing generator 12,

25   and ASP and A/D converter 16 can be separately fabricated integrated circuits, or they can be fabricated as a single integrated circuit as is commonly done with CMOS image sensors. In some embodiments, this single integrated circuit can perform some of the other functions shown in FIG. 2, including some of the functions provided by processor 20.

30   The image sensor 14 is effective when actuated in a first mode by timing generator 12 for providing a motion sequence of lower resolution sensor image data, which is used when capturing video images and also when previewing a still image to be captured, in order to compose the image. This preview mode sensor image data can be provided as HD resolution image data,

for example, with 1920×1040 pixels, or as VGA resolution image data, for example, with 640×480 pixels, or using other resolutions which have significantly fewer columns and rows of data, compared to the resolution of the image sensor.

The preview mode sensor image data can be provided by
5   combining values of adjacent pixels having the same color, or by eliminating some of the pixels values, or by combining some color pixels values while eliminating other color pixel values. The preview mode image data can be processed as described in commonly assigned U.S. Patent 6,292,218 to Parulski, et al., entitled "Electronic camera for initiating capture of still images while
10   previewing motion images".

The image sensor 14 is also effective when actuated in a second mode by timing generator 12 for providing high resolution still image data. This final mode sensor image data is provided as high resolution output image data, which for scenes having a high illumination level includes all of the pixels of the
15   image sensor, and can be, for example, a 12 megapixel final image data having 4000×3000 pixels. At lower illumination levels, the final sensor image data can be provided by "binning" some number of like-colored pixels on the image sensor 14, in order to increase the signal level and thus the "ISO speed" of the sensor.

The zoom and focus motor drivers 8 are controlled by control
20   signals supplied by the processor 20, to provide the appropriate focal length setting and to focus the scene onto the image sensor 14. The exposure level of the image sensor 14 is controlled by controlling the F/# and exposure time of the adjustable aperture and adjustable shutter 6, the exposure period of the image sensor 14 via the timing generator 12, and the gain (i.e., ISO speed) setting of the
25   ASP and A/D converter 16. The processor 20 also controls a flash 2 which can illuminate the scene. As described in commonly-assigned, co-pending U.S. Patent Application Serial No. 13/021,034 to Jasinski et al., entitled "Estimating subject motion for capture setting determination," the F/# and the exposure time, as well as the flash setting are preferably determined responsive to a detected motion
30   velocity.

The lens 4 of the digital camera 10 can be focused in the first mode by using "through-the-lens" autofocus, as described in commonly-assigned U.S. Patent 5,668,597, entitled "Electronic Camera with Rapid Automatic Focus of an

Image upon a Progressive Scan Image Sensor" to Parulski et al.. This is

accomplished by using the zoom and focus motor drivers 8 to adjust the focus

position of the lens 4 to a number of positions ranging between a near focus

position to an infinity focus position, while the processor 20 determines the

5   closest focus position which provides a peak sharpness value for a central portion

of the image captured by the image sensor 14. The focus distance which

corresponds to the closest focus position can then be utilized for several purposes,

such as automatically setting an appropriate scene mode, and can be stored as

metadata in the image file, along with other lens and camera settings.

10   The processor 20 produces menus and low resolution color images

that are temporarily stored in display memory 36 and are displayed on the image

display 32. The image display 32 is typically an active matrix color liquid crystal

display (LCD), although other types of displays, such as organic light emitting

diode (OLED) displays, can be used. A video interface 44 provides a video output

15   signal from the digital camera 10 to a video display 46, such as a flat panel HDTV

display. In preview mode, or video mode, the digital image data from buffer

memory 18 is manipulated by processor 20 to form a series of motion preview

images that are displayed, typically as color images, on the image display 32. In

review mode, the images displayed on the image display 32 are produced using

20   the image data from the digital image files stored in image memory 30.

The graphical user interface displayed on the image display 32 is

controlled in response to user input provided by user controls 34. The user

controls 34 are used to select various camera modes, such as video capture mode,

still capture mode, burst image capture mode, and review mode, and to initiate

25   capture of still images, recording of motion images. The user controls 34 are also

used to set user processing preferences, and to choose between various

photography modes based on scene type and taking conditions. In some

embodiments, various camera settings may be set automatically in response to

analysis of preview image data, audio signals, or external signals such as GPS,

30   weather broadcasts, or other available signals.

In some embodiments, when the digital camera 10 is in a still

photography mode the above-described preview mode is initiated when the user

partially depresses a shutter button, which is one of the user controls 34, and the

still image capture mode is initiated when the user fully depresses the shutter

button. The user controls 34 are also used to turn on the digital camera 10, control
the lens 4, and initiate the picture taking process. User controls 34 typically
include some combination of buttons, rocker switches, joysticks, or rotary dials.
In some embodiments, some of the user controls 34 are provided by using a touch

5   screen overlay on the image display 32. In other embodiments, the user controls
34 can include a means to receive input from the user or an external device via a
tethered, wireless, voice activated, visual or other interface. In other
embodiments, additional status displays or images displays can be used.

The camera modes that can be selected using the user controls 34

10   include a "timer" mode. When the "timer" mode is selected, a short delay (e.g., 10
seconds) occurs after the user fully presses the shutter button, before the processor
20 initiates the capture of a still image.

An audio codec 22 connected to the processor 20 receives an audio
signal from a microphone 24 and provides an audio signal to a speaker 26. These

15   components can be used to record and playback an audio track, along with a video
sequence or still image. If the digital camera 10 is a multi-function device such as
a combination camera and mobile phone, the microphone 24 and the speaker 26
can be used for telephone conversation.

In some embodiments, the speaker 26 can be used as part of the

20   user interface, for example to provide various audible signals which indicate that
a user control has been depressed, or that a particular mode has been selected. In
some embodiments, the microphone 24, the audio codec 22, and the processor 20
can be used to provide voice recognition, so that the user can provide a user input
to the processor 20 by using voice commands, rather than user controls 34. The

25   speaker 26 can also be used to inform the user of an incoming phone call. This
can be done using a standard ring tone stored in firmware memory 28, or by using
a custom ring-tone downloaded from a wireless network 58 and stored in the
image memory 30. In addition, a vibration device (not shown) can be used to
provide a silent (e.g., non audible) notification of an incoming phone call.

30   The processor 20 also provides additional processing of the image
data from the image sensor 14, in order to produce rendered sRGB image data
which is compressed and stored within a "finished" image file, such as a well-
known Exif-JPEG image file, in the image memory 30.

The digital camera 10 can be connected via the wired interface 38
to an interface/recharger 48, which is connected to a computer 40, which can be a
desktop computer or portable computer located in a home or office. The wired
interface 38 can conform to, for example, the well-known USB 2.0 interface

5   specification. The interface/recharger 48 can provide power via the wired
interface 38 to a set of rechargeable batteries (not shown) in the digital camera 10.

The digital camera 10 can include a wireless modem 50, which
interfaces over a radio frequency band 52 with the wireless network 58. The
wireless modem 50 can use various wireless interface protocols, such as the well-

10   known Bluetooth wireless interface or the well-known 802.11 wireless interface.
The computer 40 can upload images via the Internet 70 to a photo service
provider 72, such as the Kodak EasyShare Gallery. Other devices (not shown) can
access the images stored by the photo service provider 72.

In alternative embodiments, the wireless modem 50 communicates

15   over a radio frequency (e.g. wireless) link with a mobile phone network (not
shown), such as a 3GSM network, which connects with the Internet 70 in order to
upload digital image files from the digital camera 10. These digital image files
can be provided to the computer 40 or the photo service provider 72.

FIG. 3 is a flow diagram depicting image processing operations

20   that can be performed by the processor 20 in the digital camera 10 (FIG. 2) in
order to process color sensor data 100 from the image sensor 14 output by the
ASP and A/D converter 16. In some embodiments, the processing parameters
used by the processor 20 to manipulate the color sensor data 100 for a particular
digital image are determined by various photography mode settings 175, which

25   are typically associated with photography modes that can be selected via the user
controls 34, which enable the user to adjust various camera settings 185 in
response to menus displayed on the image display 32. As will be described later,
in the Composite mode settings 190 and the camera settings 185 (including the
image capture settings for the buffer memory 18 and the timing generator 12 from

30   FIG. 2) are adjusted responsive to a determined motion velocity according to a
preferred embodiment.

The color sensor data 100 which has been digitally converted by
the ASP and A/D converter 16 is manipulated by a white balance step 95. In some
embodiments, this processing can be performed using the methods described in

commonly-assigned U.S. patent 7,542,077 to Miki, entitled "White balance adjustment device and color identification device". The white balance can be adjusted in response to a white balance setting 90, which can be manually set by a user, or which can be automatically set by the digital camera 10.

5   The color image data is then manipulated by a noise reduction step 105 in order to reduce noise from the image sensor 14. In some embodiments, this processing can be performed using the methods described in commonly-assigned U.S. patent 6,934,056 to Gindele et al., entitled "Noise cleaning and interpolating sparsely populated color digital image using a variable noise cleaning kernel".

10   The level of noise reduction can be adjusted in response to the exposure index setting 110, so that more filtering is performed at higher exposure index setting.

The color image data is then manipulated by a demosaicing step 115, in order to provide red, green and blue (RGB) image data values at each pixel location. Algorithms for performing the demosaicing step 115 are

15   commonly known as color filter array (CFA) interpolation algorithms or "deBayering" algorithms. In one embodiment of the present invention, the demosaicing step 115 can use the luminance CFA interpolation method described in commonly-assigned U.S. Patent 5,652,621, entitled "Adaptive color plane interpolation in single sensor color electronic camera," to Adams et al.. The

20   demosaicing step 115 can also use the chrominance CFA interpolation method described in commonly-assigned U.S. Patent 4,642,678, entitled "Signal processing method and apparatus for producing interpolated chrominance values in a sampled color image signal", to Cok.

In some embodiments, the user can select between different pixel

25   resolution modes, so that the digital camera 10 can produce a smaller size image file. Multiple pixel resolutions can be provided as described in commonly-assigned U.S. Patent 5,493,335, entitled "Single sensor color camera with user selectable image record size," to Parulski et al.. In some embodiments, a resolution mode setting 120 can be selected by the user to be full size (e.g.

30   4,000×3,000 pixels), medium size (e.g. 2,000×1,500 pixels) or small size (750×500 pixels).

The color image data is color corrected in color correction step 125. In some embodiments, the color correction is provided using a 3×3 linear

space color correction matrix, as described in commonly-assigned U.S. Patent 5,189,511, entitled "Method and apparatus for improving the color rendition of hardcopy images from electronic cameras" to Parulski, et al.. In some embodiments, different user-selectable color modes can be provided by storing

5   different color matrix coefficients in firmware memory 28 of the digital camera 10. For example, four different color modes can be provided, so that the color mode setting 130 is used to select one of the following color correction matrices:

Setting 1 (normal color reproduction)

10

$$\begin{bmatrix} R_{out} \\ G_{out} \\ B_{out} \end{bmatrix} = \begin{bmatrix} 1.50 & -0.30 & -0.20 \\ -0.40 & 1.80 & -0.40 \\ -0.20 & -0.20 & 1.40 \end{bmatrix} \begin{bmatrix} R_{in} \\ G_{in} \\ B_{in} \end{bmatrix} \qquad (1)$$

Setting 2 (saturated color reproduction)

15

$$\begin{bmatrix} R_{out} \\ G_{out} \\ B_{out} \end{bmatrix} = \begin{bmatrix} 2.00 & -0.60 & -0.40 \\ -0.80 & 2.60 & -0.80 \\ -0.40 & -0.40 & 1.80 \end{bmatrix} \begin{bmatrix} R_{in} \\ G_{in} \\ B_{in} \end{bmatrix} \qquad (2)$$

Setting 3 (de-saturated color reproduction)

$$\begin{bmatrix} R_{out} \\ G_{out} \\ B_{out} \end{bmatrix} = \begin{bmatrix} 1.25 & -0.15 & -0.10 \\ -0.20 & 1.40 & -0.20 \\ -0.10 & -0.10 & 1.20 \end{bmatrix} \begin{bmatrix} R_{in} \\ G_{in} \\ B_{in} \end{bmatrix} \qquad (3)$$

20

Setting 4 (monochrome)

$$\begin{bmatrix} R_{out} \\ G_{out} \\ B_{out} \end{bmatrix} = \begin{bmatrix} 0.30 & 0.60 & 0.10 \\ 0.30 & 0.60 & 0.10 \\ 0.30 & 0.60 & 0.10 \end{bmatrix} \begin{bmatrix} R_{in} \\ G_{in} \\ B_{in} \end{bmatrix} \qquad (4)$$

25   In other embodiments, a three-dimensional lookup table can be used to perform the color correction step 125.

The color image data is also manipulated by a tone scale correction step 135. In some embodiments, the tone scale correction step 135 can be performed using a one-dimensional look-up table as described in U.S. Patent No.

30   5,189,511, cited earlier. In some embodiments, a plurality of tone scale correction

look-up tables is stored in the firmware memory 28 in the digital camera 10. These can include look-up tables which provide a "normal" tone scale correction curve, a "high contrast" tone scale correction curve, and a "low contrast" tone scale correction curve. A user selected contrast setting 140 is used by the

5   processor 20 to determine which of the tone scale correction look-up tables to use when performing the tone scale correction step 135.

When the digital camera 10 is operating in the burst image capture mode, a burst image compositing step 195 can optionally be used to form a composite image according to composite settings 190. This step is shown with a

10   dashed outline reflecting the fact that it is an optional step that is only applied when the user has set the user controls 34 of the digital camera 10 to form a composite image using the burst image capture mode. Using the selected digital images contained within the image buffer 18, specific image scene components within each digital image are combined to form the composite image. Typically,

15   an image background is formed using image content from one or more of the digital images. Then subject image regions corresponding to one or more objects that had transitioned across the image background are extracted from the selected digital images and merged onto the image background. Additional details regarding the capturing of a set of digital images that can be used for the burst

20   image compositing step 195 will be described later.

The color image data is also manipulated by an image sharpening step 145. In some embodiments, this can be provided using the methods described in commonly-assigned U.S. Patent 6,192,162 entitled "Edge enhancing colored digital images" to Hamilton, et al.. In some embodiments, the user can select

25   between various sharpening settings, including a "normal sharpness" setting, a "high sharpness" setting, and a "low sharpness" setting. In this example, the processor 20 uses one of three different edge boost multiplier values, for example 2.0 for "high sharpness", 1.0 for "normal sharpness", and 0.5 for "low sharpness" levels, responsive to a sharpening setting 150 selected by the user of the digital

30   camera 10.

The color image data is also manipulated by an image compression step 155. In some embodiments, the image compression step 155 can be provided using the methods described in commonly-assigned U.S. Patent 4,774,574, entitled "Adaptive block transform image coding method and apparatus" to Daly

et al.. In some embodiments, the user can select between various compression settings. This can be implemented by storing a plurality of quantization tables, for example, three different tables, in the firmware memory 28 of the digital camera 10. These tables provide different quality levels and average file sizes for the compressed digital image file 180 to be stored in the image memory 30 of the digital camera 10. A user selected compression mode setting 160 is used by the processor 20 to select the particular quantization table to be used for the image compression step 155 for a particular image.

The compressed color image data is stored in a digital image file 180 using a file formatting step 165. The image file can include various metadata 170. Metadata 170 is any type of information that relates to the digital image, such as the model of the camera that captured the image, the size of the image, the date and time the image was captured, and various camera settings, such as the lens focal length, the exposure time and f-number of the lens, and whether or not the camera flash fired. In a preferred embodiment, all of this metadata 170 is stored using standardized tags within the well-known Exif-JPEG still image file format. In a preferred embodiment of the present invention, the metadata 170 includes information about various camera settings 185, including the photography mode settings 175.

When the digital camera 10 is operated in a burst image capture mode, the image sensor 14 is actuated by the timing generator 12 as specified by the motion analysis 54 to fill the buffer memory 18 with a set of captured digital images. In some embodiments, the set of captured digital images is then used to form a composite burst image using the burst image compositing step 195.

FIG. 4 shows a flowchart for a method of capturing digital images in a burst image capture mode according to an embodiment of the present invention. A capture evaluation images step 400 is used to capture two or more evaluation digital images 405 of a scene that includes at least one moving object. In some embodiments, this step is performed at the time when the user activates a user interface control (e.g., a shutter button) to initiate the capture of a burst of digital images. In other embodiments, the digital camera 10 (FIG. 1) is configured so that the capture evaluation images step 400 runs continuously in the background when the digital camera 10 is turned on and is set to operate in the burst image capture mode. In some embodiments, the capture evaluation images

step 400 is initiated when the user presses the shutter button to an intermediate position in preparation for initiating the capture of a burst of digital images.

A determine rate of motion step 410 is used to determine a rate of motion 415 for at least one moving object by analyzing the evaluation digital images 405. In a preferred embodiment, the rate of motion 415 is an image motion vector giving a direction and a magnitude of the object motion. The determine rate of motion step 410 is performed by the motion analysis block 54 shown in FIG. 2. As mentioned earlier, the motion analysis block 54 can use any method known in the art to determine the rate of motion, such as the method for estimating subject motion described in the aforementioned U.S. Patent Application Serial No. 13/021,067, entitled "Estimating subject motion between image frames."

In a preferred embodiment, the determine rate of motion step 410 determines the rate of motion 415 for a moving foreground object in the scene. In some instances, the determine rate of motion step 410 may detect a plurality of moving foreground objects in the scene. In such cases, a number of different strategies can be used to determine the rate of motion 415. For example, the rate of motion 415 can be determined for the fastest moving object, or the moving object nearest to the center of the frame.

In some embodiments, the rates of motion for the plurality of moving foreground objects can be combined to determine a combined rate of motion. For example, a weighted average of the magnitudes of the rates of motion can be computed. The weights used for the weighted average can be determined in a variety of ways. For example, they can be a function of the size or the position of the moving objects.

In some embodiments, a main subject detection algorithm can be used to identify a main subject in the scene. If the main subject corresponds to one of the moving objects, the rate of motion 415 can then be determined based on the main subject. Any method for detecting the main subject known in the art can be used to identify the main subject. Main subject detection algorithms are well-known in the art. One example of a main subject detection algorithm that can be used in accordance with the present invention is described in U.S. Patent 6,282,317 to Luo et al., entitled "Method for automatic determination of main subjects in photographic images".

A determine frame rate step 420 is used to determine a frame rate 425 to be used to capture the burst of digital images responsive to the rate of motion 415. The frame rate 425 will also typically be a function of a number of images 485 to be included in the burst of digital images. In some configurations, the number of images 485 can be predefined at some fixed value. In other configurations, the number of images 485 can be selected by the user using appropriate user interface elements, such as a menu of options displayed on the image display 32 (FIG. 2). In some embodiments, the number of images 485 can be automatically determined responsive to other factors such as the size of the moving object or the rate of motion 415. For example, the number of images 485 can be determined so that the image of the moving object in each of the captured digital images will be substantially non-overlapping with the images of the moving object in the other captured digital images. In this case, for larger objects it would be necessary to use a smaller number of images 485 relative to the number of images that could be used for smaller objects. By substantially non-overlapping, we mean that the images of the moving objects in the captured digital images only overlap to small extent (e.g., <10% of the object areas).

The determine frame rate step 420 can determine the frame rate 425 using a variety of different strategies. Generally, the frame rate 425 should be selected such that the moving foreground object is spaced out with aesthetically pleasing spatial separations. Additional details for the determine frame rate step 420 according to a preferred embodiment is shown in FIG. 5. A determine initial object position step 460 is used to determine an initial object position 465 for the moving object corresponding to the determined rate of motion 415.

A determine projected time interval step 470 is used to determine a projected time interval 475 responsive to the rate of motion 415 and the initial object position 465. The projected time interval 475 corresponds to the time required for the moving object to reach the edge of the image. In a preferred embodiment, the rate of motion 415 is a motion vector having both a direction and a magnitude. In this case, the projected time interval 475 can be determined by finding a distance D between the initial object position 465 and the edge of the image in the direction associated with the rate of motion 415. In some embodiments, the distance D can be chosen such that most, or all, of the moving object still falls within the image area at the time when the last image is captured.

In this case, the initial object position 465 can be taken to be the position of the "leading edge" of the moving object, so that the distance D corresponds to the distance that the leading edge needs to travel before it reaches the edge of the image. In a preferred embodiment, the distance D is given in units of pixels.

5   However, in other embodiments, the distance D can be expressed in any convenient unit.

Given the distance D, the projected time interval 475 can be computed using the following equation:

10

$$T = D / V \tag{5}$$

where V is the magnitude of the rate of motion 415 (i.e., the "speed"), and T is the projected time interval 475. The value of V can be expressed in any convenient unit such as pixels/sec. (In some embodiments, the displacement (in units of

15   pixels) for the moving object between two consecutive evaluation digital images 405 can be used as a surrogate for the velocity since it will be proportional to the velocity.) It will generally be convenient if the spatial component of V use the same units (e.g., pixels) as the distance D.

A compute frame rate step 480 is used to compute the frame rate

20   425 responsive to the projected time interval 475 and the number of images 485. In a preferred embodiment, the frame rate 425 can be determined using the following equation:

$$R = N / T \tag{6}$$

25

where N is the number of images 485 and R is the frame rate 425 expressed in terms of images per unit time (e.g., images/sec).

Returning to a discussion of FIG. 4, a capture digital image sequence step 430 is used to capture a digital image sequence 435 including a

30   burst of digital images. In a preferred embodiment, the capture digital image sequence step 430 captures the digital image sequence 435 by adjusting the signal timing produced by the timing generator 12 (FIG. 2) to capture the digital images at the frame rate 425. In one configuration, this can be done using the variable

frame rate configuration described in U.S. Patent 5,140,434 to Van Blessinger et al., entitled "Record on command recording in a solid state fast frame recorder".

In some embodiments, the digital image sequence 435 can include one or more of the evaluation digital images 405 that were captured by the capture evaluation images step 400. For example, in one configuration the capture evaluation images step 400 is performed when the user activates the shutter button and two evaluation digital images 405 are captured at the highest possible frame rate. The rate of motion 415 is then determined based on an evaluation of these two evaluation digital images 405, and an appropriate frame rate 425 is determined. One or more of the evaluation digital images 405 are then used to initialize the digital image sequence 435. The capture digital image sequence step 430 then captures additional digital images for inclusion in the digital image sequence 435. If the determined frame rate 425 is slower than the frame rate used to capture the evaluation digital images 405, then any of the evaluation digital images 405 that do not match the determined frame rate 425 can be deleted.

A stored set of captured digital images step 440 is used to store a set of captured digital images 445 in a processor-accessible memory. The processor-accessible memory can be the image memory 30 (FIG. 2), or some other memory such as the buffer memory 18. For the case where the capture digital image sequence step 430 captured the digital image sequence 435 at the determined frame rate 425, the set of captured digital images 445 can include all of the images in the digital image sequence 435.

In an alternate embodiment, the capture digital image sequence step 430 captures the digital image sequence 435 at a predetermined fixed frame rate that is faster than the frame rate 425. In this case, the store set of captured digital images step 440 can select a subset of the captured digital images in the digital image sequence 435 to be stored in the set of captured digital images 445 in accordance with the frame rate 425. For example, the capture digital image sequence step 430 can capture a set of 20 digital images at a fixed frame rate of 8 images/sec and temporarily store the captured digital images in the buffer memory 18 (FIG. 2). If the user has set the number of images 485 in the burst to be N = 5, and the determined frame rate 425 is 4 images/sec, the store set of captured digital images step 440 can store images #1, #3, #5, #7 and #9, which would correspond to the images captured at the determined frame rate 425.

In some embodiments, the method of the present invention can be used to extract a burst of digital images from a digital video sequence. In this case, the digital video sequence can be used as the digital image sequence 435. Two or more frames from the digital video sequence can be used for the

5   evaluation digital images 405 in order to determine the rate of motion 415. The store set of captured digital images 440 can then extract a subset of the frames in the digital video sequence corresponding to the determined frame rate 425 to include in the set of captured digital images 445. This process can be done at the time that the digital video sequence is captured, or alternately can be done at any

10 later time as desired by the user. In some cases, the process can be performed after the digital video sequence has been downloaded to a host computer, using software residing on the host computer rather than using software in the digital video camera itself.

The store set of captured digital images 440 can store the set of

15 captured digital images 445 in a variety of different ways. In some embodiments, each digital image in the set of captured digital images 445 can be stored in the image memory 30 (FIG. 2) in separate digital image files. The digital image files can be stored using any format known in the art. In a preferred embodiment, the set of captured digital images 445 can be stored as JPEG files according to the

20 well-known EXIF digital image storage format. In other cases, the set of captured digital images 445 can be stored using other file formats (e.g., using the TIFF file format or a proprietary raw file format).

In other embodiments, the set of captured digital images 445 can be combined to form a composite image, and the composite image can then be

25 stored in the image memory 30 (FIG. 2). In some digital camera implementations, the user can be given the choice to choose between two different burst image capture modes: one mode where the set of captured digital images 445 are each stored in separate files, and a second "composite burst mode" where a composite image is formed from the set of captured digital images 445. In other digital

30 camera implementations, only one type of burst image capture mode may be supported.

A composite image can be formed from the set of captured digital images 445 using any method known in the art. In one embodiment, the composite image is a montage image formed by inserting each of the digital

images in the set of captured digital images 445 into a template so that they can be viewed together. FIG. 6A shows an example of a montage composite image 490 using a "film strip" template. Similarly, FIG. 6B shows an example of a montage composite image 492 using a 2×2 rectangular template.

5   In other embodiments, the composite image is formed by extracting the moving object from each of the digital images in the set of captured digital images 445 and combining them onto a common background image. Methods for identifying the boundaries of the moving object and extracting the moving object from the digital image are well-known in the art. Such methods

10   typically work by aligning the backgrounds in the digital images, then computing differences between the aligned sequential digital images to identify the regions where there was movement. In some embodiments, the background from one of the digital images in the set of captured digital images 445 can be used as the common background image. In other embodiments, the backgrounds from a

15   plurality of the digital images can be combined (e.g., by averaging them to remove noise) to form the common background image. FIG. 6C shows an example of a composite image 494 of this type where a moving object 496 is extracted from a plurality of digital images and combined with a common background image 498.

20   Returning now to a discussion of FIG. 4, the capture digital image sequence step 430 captures the digital image sequence 435 according to a set of image capture settings 455. The image capture settings 455 would include various settings such as an exposure time setting, a lens aperture setting, an exposure index setting, an image resolution setting, or a sensor readout configuration

25   setting. In some embodiments one or more of the image capture settings is automatically determined using a determine image capture settings step 450 responsive to the determined rate of motion 415 for the moving object. The determine image capture settings step 450 can use any method known in the art to adjust the image capture settings 455 responsive to the rate of motion 415. One

30   such method is taught in commonly-assigned, co-pending U.S. Patent Application Serial No. 13/021,034 to Jasinski et al., entitled "Estimating subject motion for capture setting determination". According to this method, image capture settings, including an exposure time setting and an exposure index setting, are automatically determined for an electronic image capture device responsive to a

motion velocity. In this way, an exposure time setting can be selected that is sufficient to stop the action of the moving object, while trading off against other considerations such as the increased level of spatial noise in the image that will result from the corresponding increase in the exposure index setting.

5   In some configurations, the image resolution setting to be used to capture the digital image sequence 435 will be a function of the frame rate 425, which in turn will be a function of the rate of motion 415. For high frame rates, it may be necessary to use a lower image resolution in order to have sufficient time to store the captured digital image into the buffer memory 18.

10   Similarly, it may be desirable to use different sensor readout configuration settings as a function of the rate of motion 415. If the moving object moves a significant distance during the time it takes to read out the lines of image data from the sensor, this can introduce a noticeable geometric distortion where the object position for the bottom of the image is spatially translated relative to

15   the object position at the top of the image. To reduce this problem, a sensor readout configuration setting can be selected which enables the captured digital image to be read out from the image sensor 14 (FIG. 2) in a shorter time interval. For example, multiple lines of sensor data can be binned together so that a smaller number of image lines need to be read out. Full resolution image data can then be

20   reconstructed by interpolation.

The above description assumes that the moving object has a uniform velocity. This situation is illustrated in FIG. 7A, which shows a moving object 500 transitioning through an image field of view with a constant rate of motion. The position of the moving object 500 is shown at three equally spaced

25   times. In this example, the frame rate 425 (FIG. 4) that is determined based on the initial rate of motion will produce a set of captured digital images 445 (FIG. 4) having the desired distribution of object positions.

In some situations, the rate of motion for the moving object may vary during the time that the digital image sequence 435 (FIG. 4) is being

30   captured. This is illustrated in Fig. 7B, which shows a moving object 505 transitioning through an image field of view with a non-constant velocity where the rate of motion is accelerating with time. In some embodiments, it may be desirable to adjust the determined frame rate 425 during the time that the digital image sequence 435 (FIG. 4) is being captured in order to compensate for the

changing rate of motion. In one embodiment, this is done by determining a new
rate of motion 415 after capturing each digital image in the digital image
sequence. A new frame rate 425 can then be determined based on the new rate of
motion 415. In this case, the number of images 485 can be decremented to

5   correspond to the number of remaining digital images that still need to be
captured. In this way, the spatial separation of the moving object can be
maintained at an approximately equal value when the final composite image is
generated.

FIG. 8 shows a flow chart for an embodiment of the capture digital

10   image sequence step 430 where the frame rate 425 is updated to account for a
moving object with a variable rate of motion. A capture digital image step 200
captures a digital image 235 of the scene. A store digital image step 205, then
stores the digital image 235 in the buffer memory 18 (FIG. 2) as part of the digital
image sequence 435. A done test 210 is used to determine whether the full burst

15   of digital images has been captured. If the number of digital images that have
been captured is equal to the number of images 485 then the capture digital image
sequence step 430 terminates at terminate image capture step 215. Otherwise,
execution proceeds to an evaluate rate of motion step 220. In some cases, the done
test 210 may also check to verify that the buffer memory 18 (FIG. 2) is not full. If

20   the buffer memory 18 is full then execution of the capture digital image sequence
step 430 is terminated.

The evaluate rate of motion step 220 determines a new rate of
motion for the moving object in the scene. In a preferred embodiment, this is done
by determining the spatial position of the moving object in the two most recent

25   digital images that were captured, and computing a rate of motion based on the
difference between the spatial positions. A rate different test 225 is used to
compare the new rate of motion to the previously determined rate of motion. If
the difference between the two rates of motion is less than some predefined
threshold, then execution loops back to the capture digital image step 200, where

30   another digital image 235 is captured. If the rate different test 225 determines that
the rate of motion has changed significantly, an update frame rate step 230 is used
to determine a new frame rate 425 appropriate for the new rate of motion. If the
new rate of motion is significantly slower than the previous rate of motion, then
the spatial separation between the two previous images may be too small. In this

case, it may be desirable to delete the previously captured digital image from the digital image sequence 435. Execution then loops back to the capture digital image step 200, where another digital image 235 is captured.

A computer program product can include one or more non-transitory, tangible, computer readable storage medium, for example; magnetic storage media such as magnetic disk (such as a floppy disk) or magnetic tape; optical storage media such as optical disk, optical tape, or machine readable bar code; solid-state electronic storage devices such as random access memory (RAM), or read-only memory (ROM); or any other physical device or media employed to store a computer program having instructions for controlling one or more computers to practice the method according to the present invention.

PARTS LIST

	2	flash
	4	lens
5	6	adjustable aperture and adjustable shutter
	8	zoom and focus motor drives
	10	digital camera
	12	timing generator
	14	image sensor
10	16	ASP and A/D Converter
	18	buffer memory
	20	processor
	22	audio codec
	24	microphone
15	26	speaker
	28	firmware memory
	30	image memory
	32	image display
	34	user controls
20	36	display memory
	38	wired interface
	40	computer
	44	video interface
	46	video display
25	48	interface/recharger
	50	wireless modem
	52	radio frequency band
	54	motion analysis block
	58	wireless network
30	70	Internet
	72	photo service provider
	90	white balance setting
	95	white balance step
	100	color sensor data

	105	noise reduction step
	110	exposure index setting
	115	demosaicing step
	120	resolution mode setting
5	125	color correction step
	130	color mode setting
	135	tone scale correction step
	140	contrast setting
	145	image sharpening step
10	150	sharpening setting
	155	image compression step
	160	compression mode setting
	165	file formatting step
	170	metadata
15	175	photography mode settings
	180	digital image file
	185	camera settings
	190	composite settings
	195	burst image compositing step
20	200	capture digital image step
	205	store digital image step
	210	done test
	215	terminate image capture step
	220	evaluate rate of motion step
25	225	rate different test
	230	update frame rate step
	235	digital image
	400	capture evaluation images step
	405	evaluation digital images
30	410	determine rate of motion step
	415	rate of motion
	420	determine frame rate step
	425	frame rate
	430	capture digital image sequence step

	435	digital image sequence
	440	store set of captured digital images step
	445	set of captured digital images
	450	determine image capture settings step
5	455	image capture settings
	460	determine initial object position step
	465	initial object position
	470	determine projected time interval step
	475	projected time interval
10	480	compute frame rate step
	485	number of images
	490	montage composite image
	492	montage composite image
	494	composite image
15	496	moving object
	498	background image
	500	moving object
	505	moving object

CLAIMS:

1.   A method for forming a composite image from a sequence of digital images, comprising:

receiving a sequence of digital images of a scene, each digital image being captured at a different time, wherein the scene includes a moving object;

using a data processor to automatically analyze two or more of the digital images in the sequence of digital images to determine a rate of motion for the moving object;

determining a frame rate responsive to the rate of motion for the moving object;

selecting a subset of the digital images from the sequence of digital images corresponding to the determined frame rate; and

forming the composite image by combining the selected subset of digital images from the sequence of digital images.

2.   The method of claim 1 wherein the rate of motion includes both a direction and a magnitude.

3.   The method of claim 1 wherein the determination of the frame rate includes:

determining an initial object position for the moving object;

determining a projected time interval required for the moving object to reach the edge of the image based on the rate of motion; and

determining the frame rate responsive to the projected time interval and a specified number of digital images.

4.   The method of claim 3 wherein the specified number of digital images is predefined.

5.   The method of claim 3 wherein the specified number of digital images is user-selectable using a user interface.

6. The method of claim 3 wherein the specified number of digital images is determined responsive to the rate of motion.

7. The method of claim 3 wherein the specified number of
5   digital images is determined responsive to a size of the moving object.

8. The method of claim 3 wherein the specified number of digital images is determined such that the image of the moving object in each of the captured digital images will be substantially non-overlapping with the images
10 of the moving object in the other captured digital images.

9. The method of claim 1 wherein the moving object is a main subject in the scene as determined using a main subject detection algorithm.

15   10. The method of claim 1 wherein the moving object is a foreground object in the scene.

11. The method of claim 1 wherein the moving object is an object determined to be the fastest moving object in the scene.
20

12. The method of claim 1 wherein each of the digital images in the stored set of captured digital images are stored in separate digital image files.

25   13. The method of claim 1 wherein the composite image is a montage image including each of the selected subset of digital images.

14. The method of claim 1 wherein the composite image is formed by extracting the moving object from the selected subset of digital images
30 and combining them onto a common background image.

15. The method of claim 14 wherein the common background image corresponds to the background from one of the digital images in the

selected subset of digital images, or to a combination of the backgrounds from a plurality of the digital images in the selected subset of digital images.

16.   The method of claim 1 wherein rates of motion are
5   determined for a plurality of moving objects, and wherein the frame rate is determined responsive to the rates of motion for the plurality of moving objects.

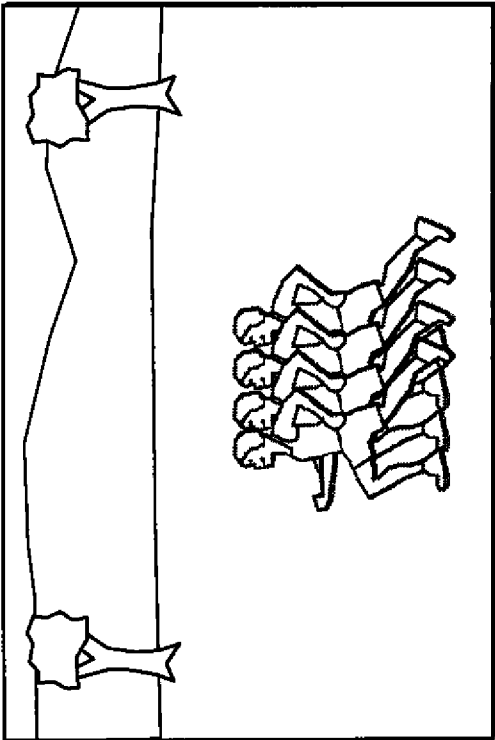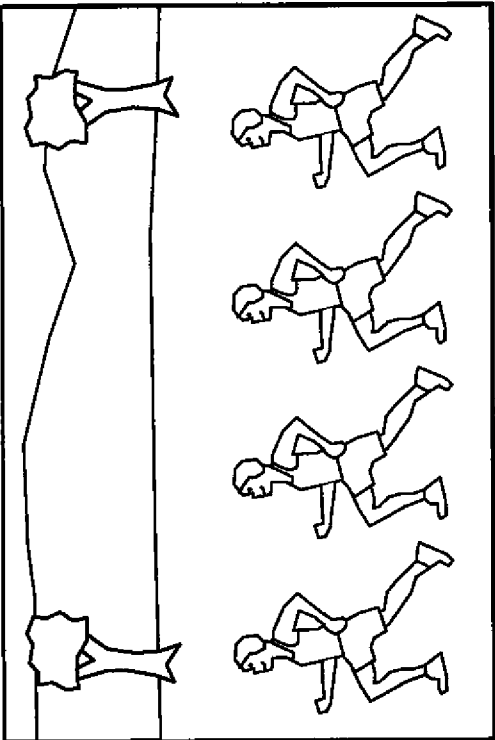17.   The method of claim 1 wherein the sequence of digital images is a digital video sequence.
10

FIG. 1B
(PRIOR ART)

FIG. 1A
(PRIOR ART)

FIG. 2

3/8
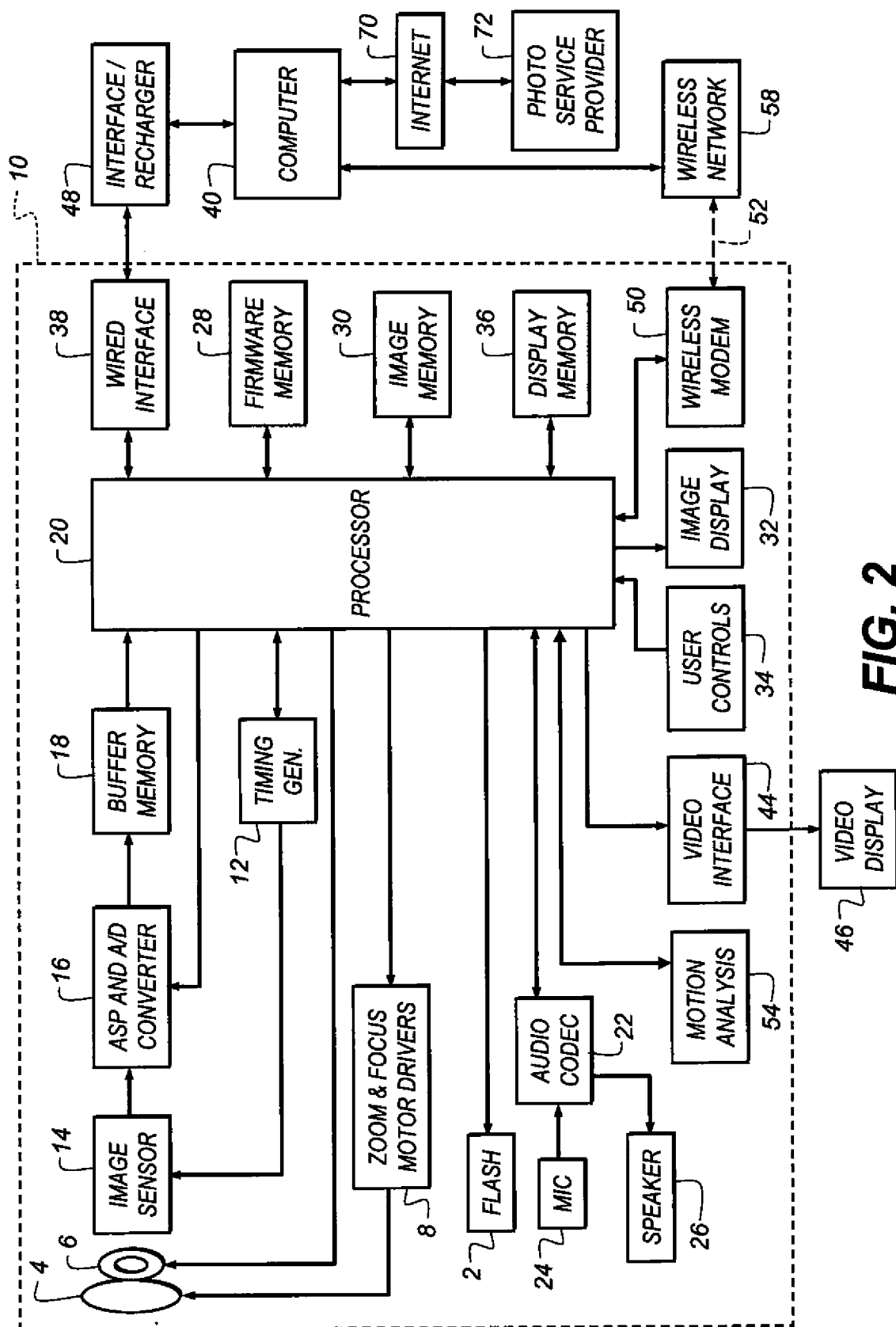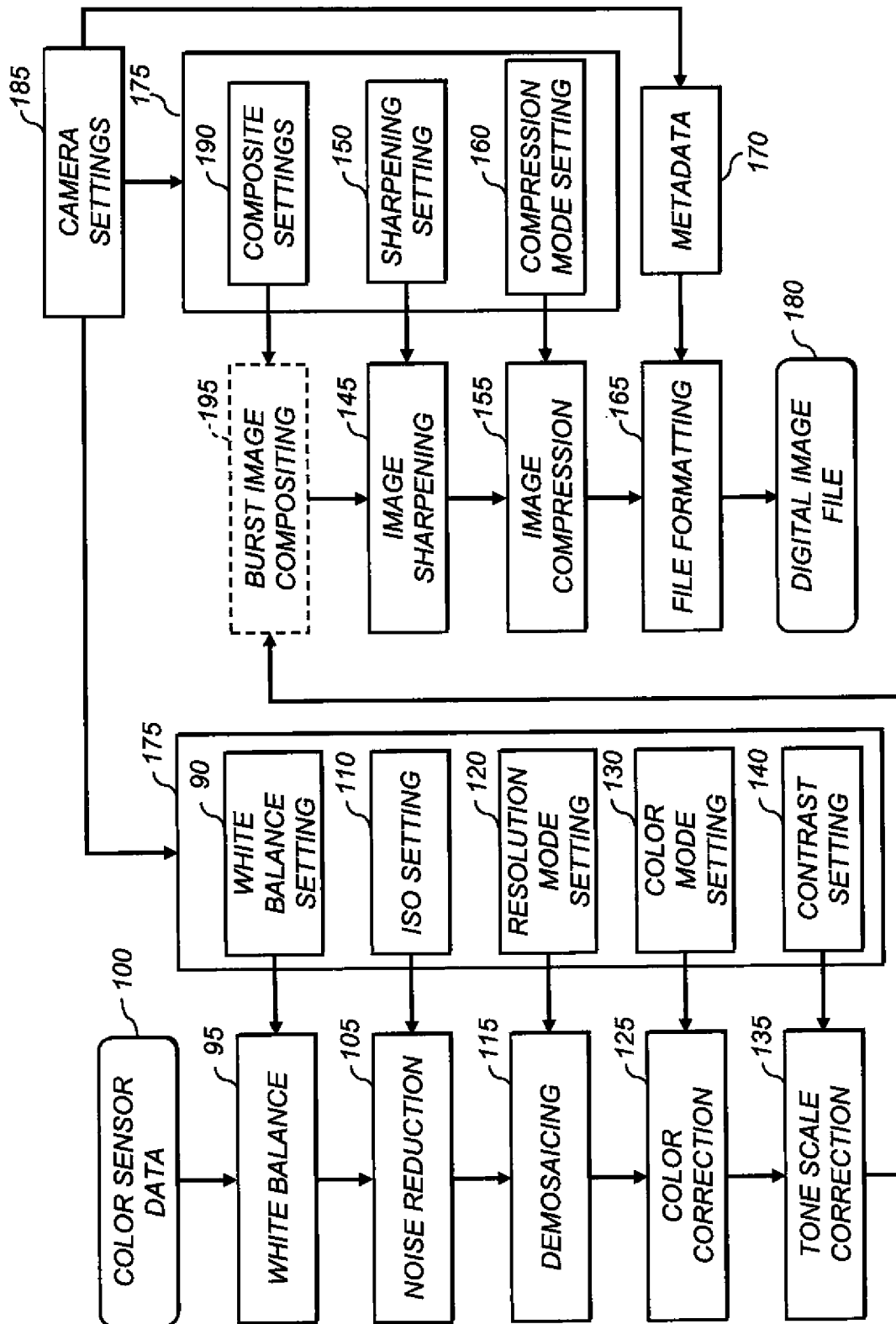
FIG. 3
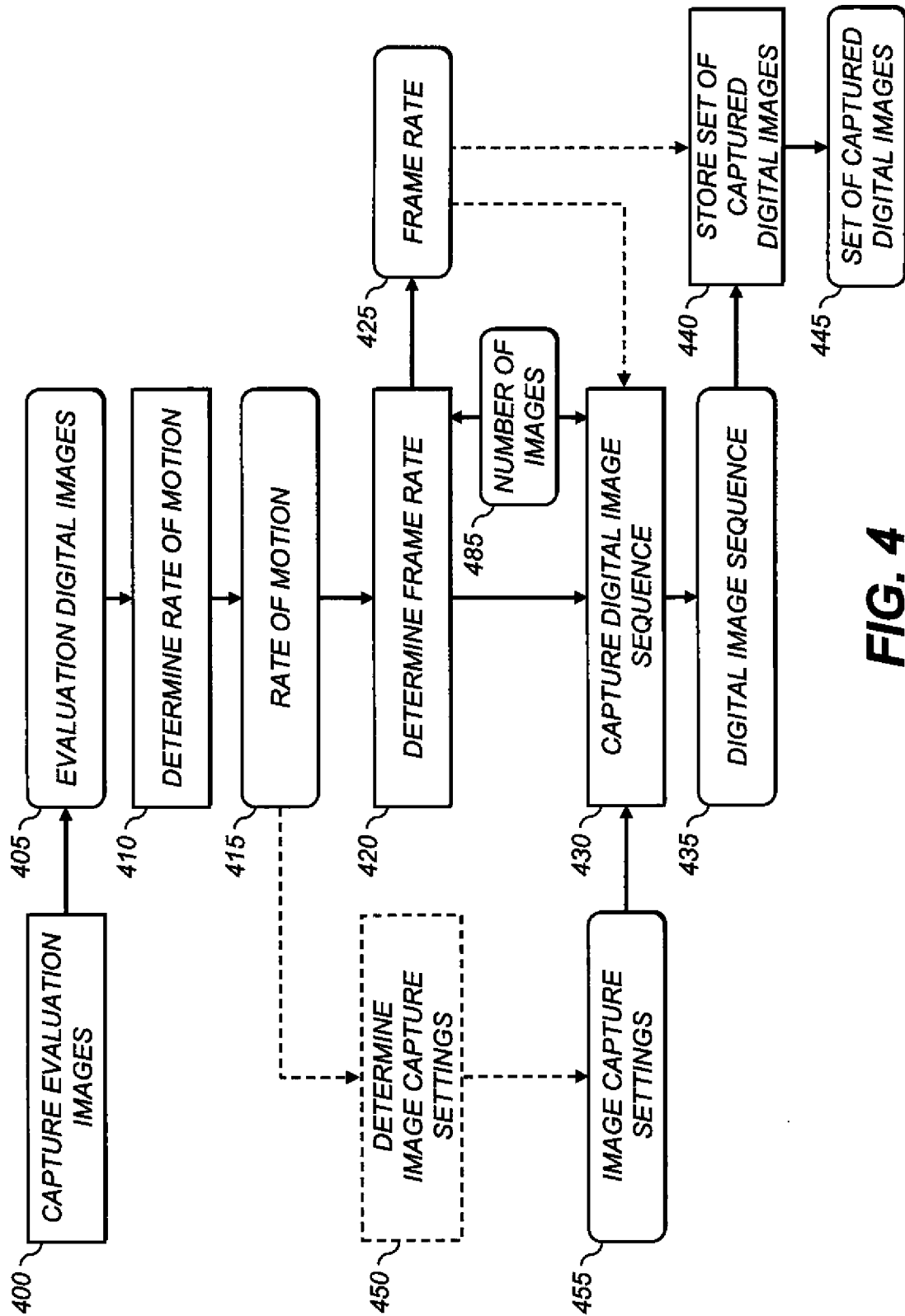
FIG. 4
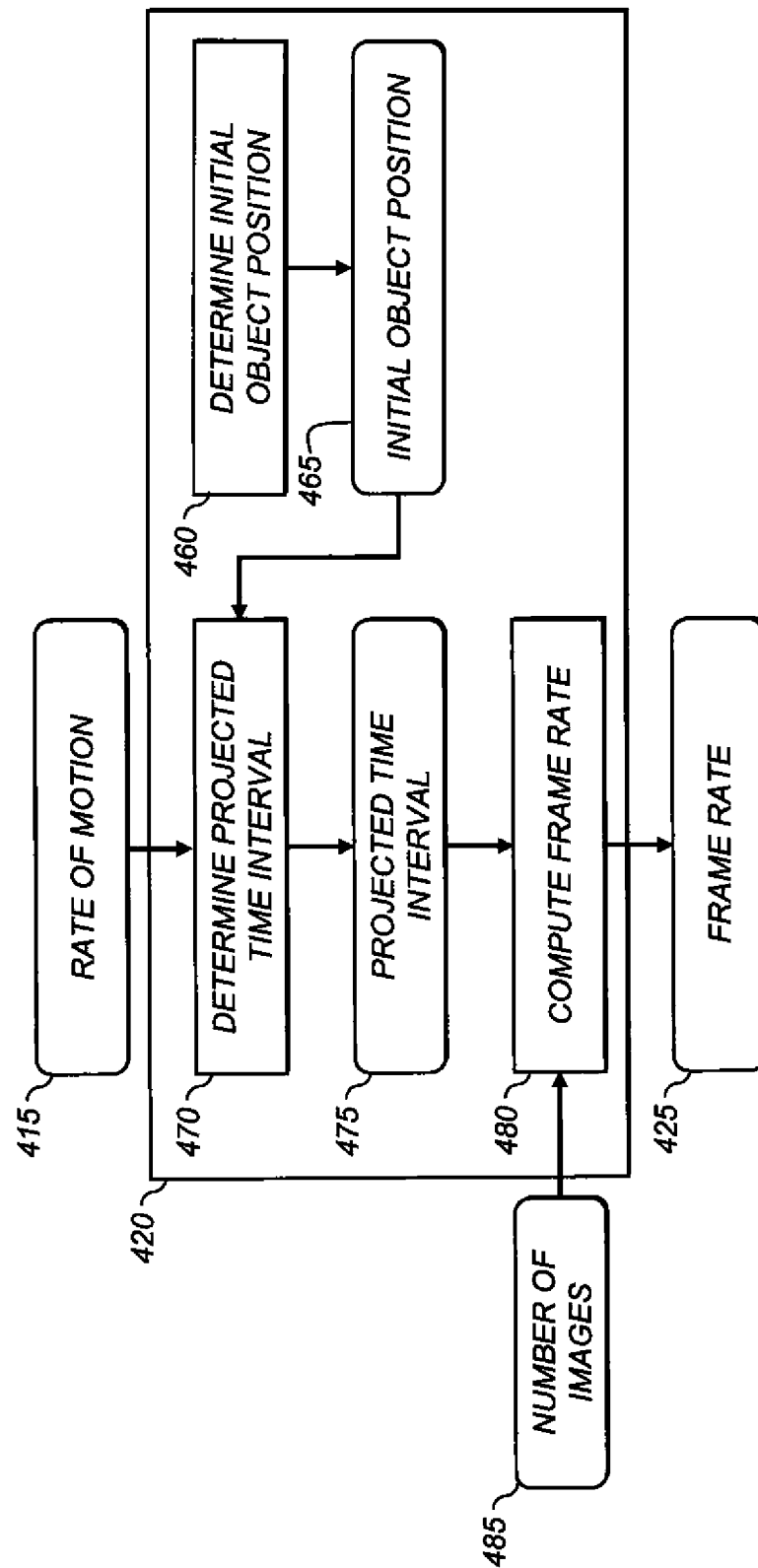
FIG. 5

FIG. 6B

FIG. 6C

FIG. 6A
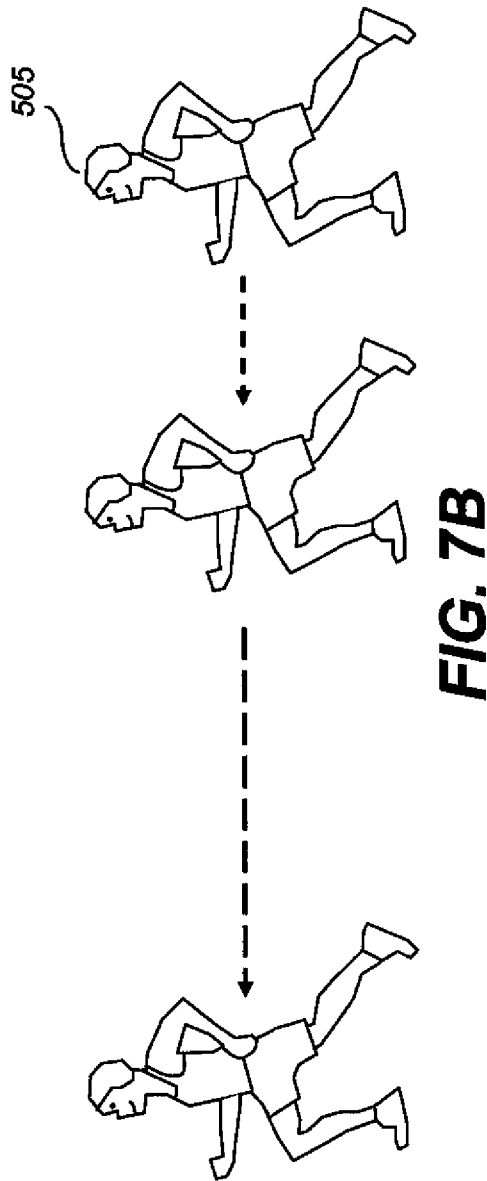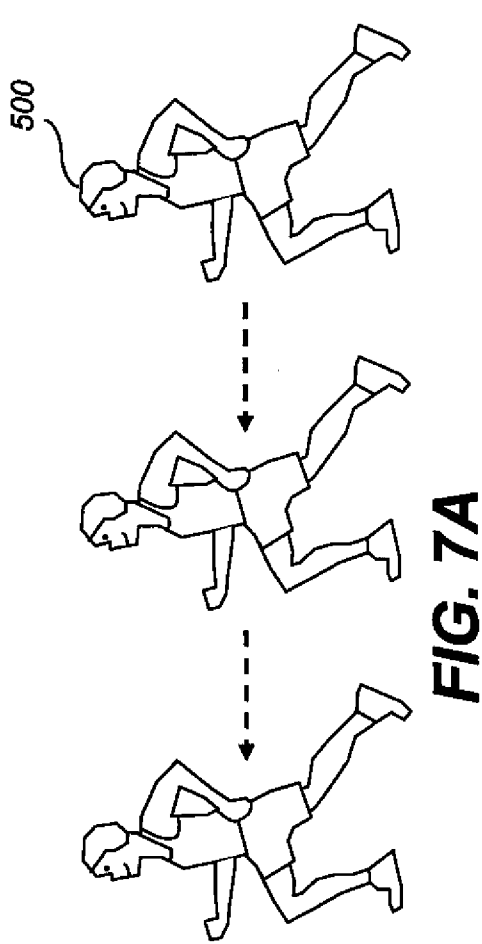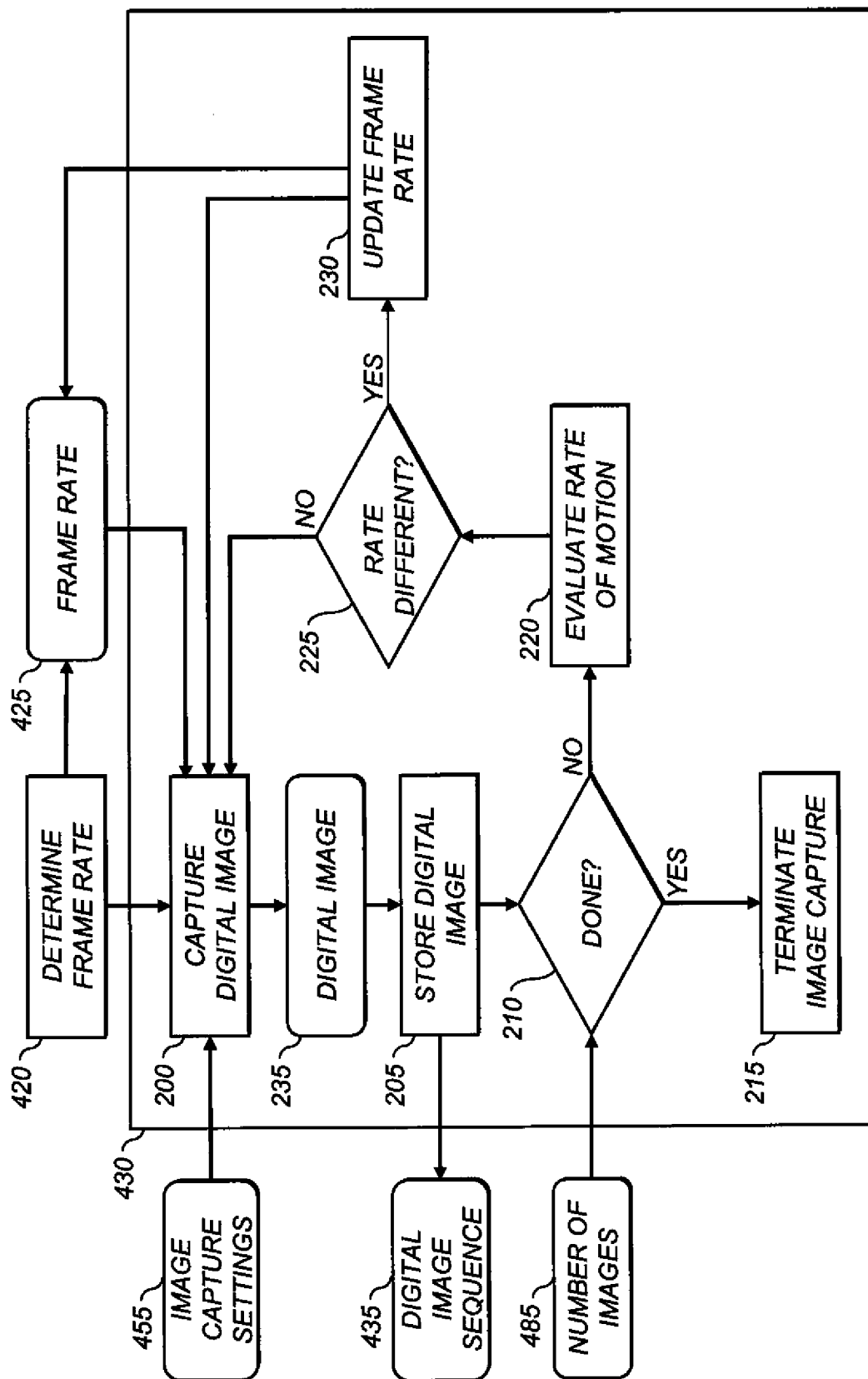
FIG. 7A

FIG. 7B

FIG. 8

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04N5/262
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/043639 A1 (YOKOHATA MASAHIRO [JP]) 24 February 2011 (2011-02-24) figures 1,3,5,9-11,18,25,26,30,31 paragraphs [0005], [0010], [0055], [0062] - [0067], [0072], [0073], [0079], [0082], [0086], [0091], [0099], [0100] - [0120], [0132] paragraphs [0141] - [0148], [0157], [161.168], [0175] -----	1-17
A	US 2009/201382 A1 (MAKINO TETSUJI [JP]) 13 August 2009 (2009-08-13) figures 2,5,11,14,17 paragraphs [0047], [0050], [0-55], [0066], [0085], [0091] - [0094], [0104], [0134] - [0136], [0143] -----	1,4,7-17

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 June 2012	13/06/2012

| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016 | Authorized officer Keck, Wolfram |

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT
Information on patent family members

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 2011043639	A1	24-02-2011	CN	101998058 A	30-03-2011
			JP	2011066873 A	31-03-2011
			US	2011043639 A1	24-02-2011
US 2009201382	A1	13-08-2009	JP	4513869 B2	28-07-2010
			JP	2009194530 A	27-08-2009
			US	2009201382 A1	13-08-2009