KINETIC MOTION ANALYZER

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Appl. No.: 10/367,312
Filed: Feb. 14, 2003

Publication Classification

Int. Cl.7 ................. A63B 53/16; A63B 69/36

U.S. Cl. ..................... 473/266; 345/704; 473/151

ABSTRACT

An apparatus for analyzing kinetic motion is provided. The apparatus includes a plurality of video capture devices, such as high speed digital video cameras, a device for storing videos obtained by the video cameras, a video display device, and a computer. The computer is operatively connected to a display device for playing the video from each of the plurality of cameras simultaneously. Preferably the videos from each of the plurality of cameras are synchronized to play at the same time and show the same kinetic motion from different angles at the same time.
Store video image data obtained from plurality of cameras

Access stored video image data

Simultaneously display video image data from plurality of cameras

Provide user interface for controlling display of video image data

FIG. 3
KINETIC MOTION ANALYZER

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to an apparatus for evaluating kinetic motion, and more particularly relates to an apparatus for evaluating the motion of a sports performance.

BACKGROUND OF THE INVENTION

[0002] Analyzing motion to aid in developing maximum efficiency, to identify faults in the motion, and to view the effects of motion has been utilized in many fields, such as automobile crash testing, sports performance evaluation, animation, and the like. For example, in the context of sports performances, analysis of captured images can serve as an instructional tool to teach and demonstrate play characteristics. Sports that may derive benefit from motion sequence analysis include, but are not limited to, golf, tennis, baseball, football, skiing, track and field, soccer, martial arts, and bowling.

[0003] An example of the use of visual recording in sports is disclosed in U.S. Pat. No. 5,797,805, wherein a system and method for producing a personal golf lesson videotape from a visual recording of a person’s golf swing and a partially prerecorded instructional golf lesson videotape is disclosed. The partially prerecorded golf lesson videotape has gaps in predetermined locations into which are inserted the full motion video of the person’s golf swing and selected still frames. The system contains two cameras for recording a player’s golf swing from the back and side, a computer connected to the cameras for digitally capturing and storing the recorded golf swing, and a computer-controlled recording device for copying the selected video and still frames of the recorded golf swing into the gaps of the prerecorded videotape golf lesson. The still frames are selected to match the player’s position to the position of the professional golfer in corresponding still frames so that a split screen, side-by-side view can be produced showing the player’s and professional’s positions at various points along a golf swing.

[0004] Another sports technique video training device is disclosed in U.S. Patent Application Publication No. US20020064764. A multimedia analysis system for capturing and comparing sports performances of a player is provided that includes at least one video camera for acquiring a plurality of sets of video data of player performances, with the location of the at least one video camera being substantially the same when acquiring each set of video data. For example, the baseball swing of a particular player may be taken at different times during the season to identify changes in the swing. The system mixes two of the sets of video data, and displays them in a substantially synchronized and superimposed manner.

[0005] Despite these developments, there exists a need for an improved analysis system. In order to fully evaluate an action, it is desirable to view the action from different angles. For example, attempts have been made to record a baseball player’s swing from multiple angles by having the baseball player repeat his or her swing, and recording the different swings from different angles. It is virtually impossible, however, to exactly duplicate baseball swings from one swing to another. Therefore, any evaluation of baseball swings taken at different times and different angles has the inherent problem that the swings are actually different. These differences, especially in actions such as a baseball swing, where the impact of the ball with the bat lasts only a fraction of a second, can have significant effects on the outcome.

[0006] Accordingly, to get an accurate assessment of a particular action, such as a baseball swing, it is desired to view the same action from multiple angles. In order to fully evaluate the action, it is also desired to view the multiple angles of the action at the same time. The present invention provides an apparatus capable of providing these improvements.

SUMMARY OF THE INVENTION

[0007] An apparatus for analyzing kinetic motion is provided. The apparatus includes a plurality of video capture devices, such as digital video cameras, a device for storing video image data obtained by the video cameras, a video display device, and a computer.

[0008] The actor of the kinetic motion to be analyzed may be any person or object in motion. For example, a person’s motion, such as a golf swing, baseball swing, baseball pitcher’s motion, tennis serve and the like, may be analyzed. Alternatively, objects such as automobiles and animals may also be videoed and analyzed.

[0009] Preferably, the apparatus includes at least four video capture devices, which are positioned to collect video image data from a variety of perspectives. A camera can also be mounted on the subject being analyzed. For example, a camera can be mounted on a batter’s helmet in order to obtain video image data of the viewpoint of the baseball player.

[0010] The device for storing the videos may be any known means for storing video information, such as a video cassette recorder, a digital video recorder, a computer readable memory, and the like. Preferably, the recorded video stream is in a digital format which is stored in a computer readable memory. Alternatively, the video data can be recorded in an analog format and then converted to a digital format for storage in a computer readable memory.

[0011] The computer, which is controlled by computer executable code stored therein, is operatedly connected to a display device such as a computer monitor or television. The computer executable code enables the computer to access the stored video image data obtained from each of the plurality of cameras and display them simultaneously on a single screen. Preferably the video playback from each of the plurality of cameras are synchronized and show the same action from different angles such that the start, finish, and all points of time in between of the playback of video data obtained from one camera matches the playback of the video data from the other cameras. The display of the stored video data may also be individually controlled by the user through a user interface provided by the computer. For instance, the user may decide to advance the stored video data obtained from one camera while pausing other views. Other controls available to the user for each individual video, or all the videos synchronously include frame by frame advance, reverse, slow motion, fast forward, and zoom. The user interface can be by any means such as a dialog box with a mouse pointer, a touch screen, keyboard, touch pad and stylus, voice command or the like.
In the drawings,

- FIG. 1 is a schematic illustration of an apparatus in accordance with the invention;
- FIG. 2 is a schematic illustration of a video display in accordance with the embodiment of the invention of FIG. 1;
- FIG. 3 is a flowchart illustrating the main functions of the computer program of the present invention;
- FIG. 4 is a schematic illustration of an alternate embodiment of an apparatus in accordance with the invention; and
- FIG. 5 is a schematic illustration of a video display in accordance with the embodiment of the invention of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

The invention disclosed herein is, of course, susceptible of being embodied in many different forms. Shown in the drawings and described herein below in detail are preferred embodiments of the invention. It is to be understood, however, that the present disclosure is an exemplification of the principles of the invention and does not limit the invention to the illustrated embodiments.

The following embodiments of the present invention are described in the context of viewing the action of a sport, in particular, a baseball swing. It will be recognized by those skilled in the art that the disclosed apparatus is readily adaptable for broader application.

FIG. 1 illustrates a kinetic motion analysis apparatus 10 according to one exemplary embodiment of the invention. The apparatus includes four digital video cameras 20, 22, 24, and 26. Each of the cameras is operatively connected to computer 28, such that images taken by cameras 20, 22, 24, and 26 are stored on the hard drive of computer 28.

In the particular embodiment shown in FIG. 1, camera 20 is a front view camera, camera 22 is a side view camera, camera 24 is a rear view camera, and camera 26 is a top view camera. Each camera is preferably positioned near batter 30 using any suitable support (not shown), but is sufficiently spaced from batter 30 so as not to interfere with the swing of batter 30. Each camera is also uniquely positioned to record the kinetic motion from a perspective different than the other cameras.

Cameras 20, 22, 24, and 26 are preferably digital video cameras, such as Sanyo model VCC 3512T, Uniq model 610, and Sony Digital Camcorders. For most applications, such as evaluating a baseball or golf swing, cameras which are capable of filing at speeds of about 30 to about 110 frames per second are sufficient. In some applications, however, higher speed cameras capable of recording at about 500 frames per second to about 8000 frames per second, such as sold under the trade name Basler, are desired.

Computer 28, which includes standard computer elements, such as a monitor 32, a keyboard 34, and a mouse 36, is also included in kinetic motion analysis apparatus 10. Preferably, digital video cameras 20, 22, 24, and 26 are operatively connected to computer 28 such that video image data obtained from video cameras 20, 22, 24, and 26 is stored directly in a memory device associated with computer 28, such as a computer hard drive, or the like. Alternatively, the outputs of the video cameras can be connected to other devices suitable for recording video image data, such as a video cassette recorder, a DVD recorder, a compact disc recorder, the video camera's own recorder, or the like. In such an embodiment, the digital video data from each camera is transferred to and stored on a memory device associated with computer 28.

The cameras can be activated by manually activating the cameras, preferably via a user interface provided by the computer. For example, a control button provided with the user interface is record button 70 (FIG. 2), which activates the cameras and the obtaining of video image data. Alternatively, the analyzer can include an infrared or other motion sensitive detector operatively connected to the computer to activate the cameras to obtain video image data. For example, an infrared sensor can be positioned such that when the batter enters a predetermined area, the computer is notified of this fact and the cameras are activated and obtain video image data for a desired time span. This enables more efficient use of the device by a single user.

The computer system for the present invention preferably is a standard personal computer. For example, computer 28 includes a processing unit, such as a central processing unit, or CPU. Parallel processing may be employed, such as with multiple or distributed processors. As discussed, storage devices are included, such as a hard disk, CD ROM, magneto-optical (optical) drive, tape drive or other suitable storage device, and are operatively connected to the processing unit. In addition, a primary memory device is included, and has random access memory (RAM) for storing programming instructions and data for processes operating on the central processing unit. The primary memory device further includes read only memory (ROM) that stores basic operating instructions, data and objects used by the computer to perform its functions. Computer 28 also includes one or more input/output sources, such as keyboard 34, mouse 36, stylus (not shown), and/or other suitable device. Furthermore, a network connection may be provided. Those skilled in the art will also contemplate other configurations of computer 28 and associated technology, which are readily usable with the present development.

Computer 28 is also suitable for playback of stored video image data. The computer program, i.e., computer readable code, causes the computer to access the video image data stored in computer memory and display the stored video image data from each of the plurality of cameras simultaneously on the computer monitor 32. In other words, video image data obtained by each of the four video cameras 20, 22, 24, and 26 is shown in the computer monitor at the same time. For example, as shown in FIG. 2, the monitor 32 shows image data obtained from video cameras 20, 22, 24, and 26 as playback screens 40, 42, 44, and 46 respectively, and the four different perspective views of actor 30 are displayed simultaneously, or at the same time. Preferably, the computer program will also cause the computer 28 to synchronously display the video image data obtained by each of the four video cameras 20, 22, 24, and
26, such that all points in time of the video image data from one camera match the points in time of the video image data from all other cameras. The computer program can be based on any suitable video editing or management software, which is customized to provide the desired user interface, such as that provided by Epix, Inc. and sold under the name Pixci.

[0027] The computer program also causes the computer to display on the computer monitor 32 a user interface 48, including a variety of buttons for controlling the display of the video image data. Included among the control buttons shown in FIG. 2 is a play button 50, pause button 52, fast forward button 53, reverse button 54, stop button 55, and a speed control button 56. These particular controls are merely examples. Depending on the particular needs of the user, fewer or more controls, such as zoom, rotate, etc. can be provided by the computer by customizing the computer program to provide the desired controls. Using the control button buttons, the user controls the playback of the image data from each of the video cameras 20, 22, 24, and 26 (FIG. 1), such that the stored video image data from each of video cameras 20, 22, 24, and 26 is displayed at the same time on playback screens 40, 42, 44, and 46, respectively. For example, by taking the mouse 36 and positioning the mouse pointer 37 over the play button 50, the user can activate the play function and cause the video image on playback screens 40, 42, 44, and 46 to advance. Where the playback is synchronized, the beginning, end, and points in between of the videos played back on screens 40, 42, 44, and 46 are matched to one another.

[0028] This synchronization of the video data obtained from the plurality of cameras enhances the analysis of the magnetic force. In the example of a baseball swing, the particular motion of the baseball player is viewed from multiple angles, and the videos of the multiple angles are shown with the same time index. As such, the stored video image data from top view camera 26 will show whether the player is leaning forward or back during the swing, and thereby creating a loss of balance. At the same time, the stored video image data from the side view camera 22 will show whether the baseball player is pivoting his hips during the same time frame of the swing. Also synchronized with the playback of the stored video image data from cameras 22 and 26 is the playback of the stored video image data from front view camera 20, which will show whether the baseball player is properly shifting his weight. This collection of video data images from multiple angles and simultaneous playback of the multiple angles of enables a complete analysis of the kinetic motion by viewing the actor’s weight shift, pivoting, head movements, hand movements, body sway, etc.

[0029] A further feature of the present apparatus is for a user interface that enables the user to control the display of the stored video data from an individual camera. For example, a set of control buttons for playback on individual screens 40, 42, 44, and 46 is provided. Individual screen control buttons 58, 60, 62, and 64 are used to control the playback on screens 40, 42, 44, and 46, respectively. In one embodiment, by using mouse 36 (FIG. 1) and mouse pointer 37 the user controls the video playback. For example, by clicking with the left mouse button 38 with the mouse pointer 37 over control button 58, the video image on screen 40 is advanced frame-by-frame. By clicking on the right mouse button 39 with the mouse pointer 37 over control button 58, the video image on screen 40 is reversed frame-by-frame. Similarly, by clicking the left mouse button 38 with the mouse pointer 37 over control buttons 60, 62, or 64, the video image on screens 42, 44, and 46 are advanced frame-by-frame, respectively. All of the video images on screens 40, 42, 44, and 46 can also be advanced or reversed frame-by-frame in a synchronized manner by clicking control button 66 with the mouse pointer 37.

[0030] The playback of a particular screen is also possible. For example, by holding left mouse button 38 down while the mouse pointer 37 is over control button 58 causes the video image on screen 40 to play. Likewise, by holding right mouse button 39 down while the mouse pointer 37 is over control button 58 causes the video image on screen 40 to play in reverse.

[0031] A print button 68 is also provided to print still images shown on screens 40, 42, 44, and 46. In an alternative embodiment, which is not shown, additional buttons can be included in the user interface such that prints of still images from individual screens can be made.

[0032] A flowchart illustrating the main functions of the present invention is provided as FIG. 3. As described above, the video image data obtained from, in this embodiment, the four video cameras is stored in computer readable memory, such as a computer hard drive. This is shown as box 80. When the user desires to view and analyze the videoed action, the computer, as shown in box 82, accesses the stored video image data. After the stored video image data is accessed, the computer simultaneously displays the video image data from the plurality of cameras as stated in box 84. The computer, as stated in box 86, also provides a user interface which the user can use to control the display of the video image data.

[0033] An alternate embodiment of the present invention for recording and analyzing the motion of actor 130 provided by kinetic motion analysis apparatus 110 is illustrated in FIG. 4. The apparatus 110 includes eight digital video cameras 120, 121, 122, 123, 124, 125, 126, and 127. Each of the cameras is operatively connected to computer 128, such that images taken by cameras 120, 121, 122, 123, 124, 125, 126, and 127 are stored on the hard drive of computer 128, which includes two monitors 132 and 133. Each camera records a different perspective of the actor. For example, camera 120 may obtain video from a front view, whereas, camera 121 obtains a close up or zoom in front view and camera 122 obtains a side view. Stored video image data from cameras 120, 121, 122, and 123 are displayed on monitor 132, while stored video image data from cameras 124, 125, 126, and 127 are displayed on monitor 133. While in this embodiment monitors 132 and 133 are used because displaying eight separate images on a standard size computer display would result in too small of images, it is contemplated that with larger computer monitors or digital televisions that the display of stored video images from all eight cameras can be displayed on a single monitor.

[0034] As with the embodiment illustrated in FIGS. 1 and 2, computer 128 further includes standard computer elements, such as a keyboard 134 and a mouse 136.

[0035] A user interface 148 appropriate for this alternate embodiment is shown in FIG. 5. The user interface 148
includes buttons similar to the previous embodiment, such as a play button 150, pause button 152, fast forward button 153, reverse button 154, stop button 155, and a speed control button 156. By taking the mouse 136 and positioning the mouse pointer 137 over the play button 150, the play function is activated and causes the video image on playback screens 140, 141, 142, 143, 144, 145, and 146 to advance. Where the playback is synchronized, the beginning, end, and points in between of the videos played back on the screens are matched to one another.

[0036] In order to control the display of the stored video data from an individual camera control buttons 158, 159, 160, 161, 162, 163, 164, and 165 are also provided in the user interface 148. Individual screen control buttons 158, 159, 160, 161, 162, 163, 164, and 165 are used to control the playback on screens 140, 141, 142, 143, 144, 145, and 146, respectively. By clicking with the left mouse button with the mouse pointer 137 over control button 158, the video image on screen 140 is advanced frame-by-frame. By clicking on the right mouse button with the mouse pointer 137 over control button 158, the video image on screen 140 is reversed frame-by-frame. Similarly, by clicking the left mouse button 138 with the mouse pointer 137 over control buttons 160, 162, 164, 142, 144, and 146 are advanced frame-by-frame, respectively. All of the video images on screens 140, 141, 142, 143, 144, 145, and 146 can also be advanced or reversed frame-by-frame in a synchronized manner by clicking control button 166 with the mouse pointer 137.

[0037] Similar to the previous embodiment, playback on a particular playback screen can be accomplished by holding left mouse button 138 down while the mouse pointer 137 is over control button 158 thereby causing the video image on screen 140 to play. Holding right mouse button 139 down while the mouse pointer 137 is over control button 158 causes the video image on screen 140 to play in reverse. A print button 168 and a record button 170 may also be provided in user interface 148.

[0038] While the embodiments shown utilize cameras that are connected to the computer by cables, it is contemplated that the analyzer can utilize cameras which are in wireless communication with the computer. For example, a wireless transmitter and receiver such as sold under the name Clover CVL9900 can be utilized.

[0039] The computer software may also be capable of increasing the effective number of frames per second recorded. For example, in typical digital video camcorder type camera, odd and even numbered lines are recorded at different times, i.e., odd numbered lines are recorded and then even numbered lines are recorded. The computer software of the present invention enables the computer to separate video image data of odd numbered lines from video image data of even numbered lines and to display odd then even numbered lines in sequence. This effectively doubles the frames per second recorded.

[0040] The foregoing description is to be taken as illustrative, but not limiting. Still other variants within the spirit and scope of the present invention will readily present themselves to those skilled in the art.

I claim:

1. An apparatus for viewing and analyzing kinetic motion, the apparatus comprising:

   at least four video capture devices for obtaining video image data of an actor in motion wherein each of the at least four video capture devices obtains the video image data of the actor from an unique perspective;

   at least one video image data storage device communicatively connected to each of the at least four video capture devices and for receiving and storing the video image data of the actor in motion;

   a display device for displaying the images stored by the at least one video image data storage device;

   a computer having computer executable code, the computer operatively connected to the display device; and

   wherein the computer provides a user interface for controlling the simultaneous display of the video image data.

2. The apparatus of claim 1, wherein the images from each of the video capture devices is displayed synchronously.

3. The apparatus of claim 1, wherein the user interface includes at least one playback control.

4. The apparatus of claim 3, wherein the playback control includes at least one frame by frame control button.

5. The apparatus of claim 3, wherein the playback control includes a reverse button.

6. The apparatus of claim 3, wherein the playback control includes at least one individual camera control.

7. The apparatus of claim 3, wherein the playback control includes a playback speed control button.

8. The apparatus of claim 1, wherein the user interface includes a record button.

9. The apparatus of claim 1, wherein the user interface includes a print button.

10. The apparatus of claim 1, further including a camera mounted on the actor.

11. An apparatus for viewing and analyzing kinetic motion, the apparatus comprising:

   at least four video cameras directed at an actor for obtaining video images of the actor in motion, and wherein each of the digital video cameras obtains video images of the actor in motion from a different perspective.

   a computer having a computer memory for storing the video images of the actor in motion obtained by the at least four video cameras;

   a display device operatively connected to the computer for simultaneously displaying the video images of the actor in motion obtained by the at least four video cameras; and

   the computer providing a user interface for controlling the simultaneous display of the video images of the actor in motion obtained by the at least four video cameras.

12. The apparatus of claim 11, wherein the video images of the actor in motion images are displayed synchronously.

13. The apparatus of claim 11, wherein the user interface includes at least one playback control.
14. The apparatus of claim 13, wherein the playback control includes at least one frame by frame control button.
15. The apparatus of claim 13, wherein the playback control includes a reverse button.
16. The apparatus of claim 13, wherein the playback control includes at least one individual camera control.
17. The apparatus of claim 13, wherein the playback control includes a playback speed control button.
18. The apparatus of claim 11, wherein the user interface includes a record button.
19. The apparatus of claim 11, wherein the user interface includes a print button.
20. The apparatus of claim 11, further including a camera mounted on the actor.