GOLF SWING ANALYSIS

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ABSTRACT

A method of analyzing golf swings. A video camera assembly is used to record videos of the golf swings of a golfer and analyze his/her golf swing. The recorded video is first reduced to minimum required time of useful video data. This useful data is then divided into a plurality of frames. A plurality of key locations are identified in each frame and an analysis is conducted on various aspects of the golf swing by processing the video at each relevant frame. The faults in the swings are highlighted in each frame based on the plurality of key locations. The results are shown instantly to the user on the camera assembly. The user is also provided with recommendations to rectify the faults and can compare his/her swings with those performed by professional golfers. The videos are downloaded into a computer system and sent to a server, which also includes all the necessary software applications to automatically perform the analysis. The user can access a hosting website to review the results while playing the video.
GOLF SWING ANALYSIS
CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to provisional application Ser. No. 60/677,134 filed on May 3, 2005.
FEDERALLY SPONSORED RESEARCH

[0002] Not Applicable
SEQUENCE LISTING OR PROGRAM

[0003] Not Applicable
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BACKGROUND

[0005] The present invention relates in general to methods of analyzing golfing skills, and more particularly to a method of automatically analyzing golf swings, and getting analysis and feedback instantly or on the Internet.

[0006] Providing visual aida instructions is the best way for most people to learn golf. The lack of visual aida sometimes leaves a big gap between what the instructor is saying and what the student is interpreting. For an average golfer, what he/she is doing during the golf swing and what he/she thinks they are doing are sometimes totally different. It is also tougher for an average golfer to communicate his swing faults using correct golf terminology. A simple video picture of the golfer’s swing breaks the interpretation gap and provides a very effective communication tool.

[0007] Several methods and systems have been developed in the art for improving golfing skills. For example, U.S. Pub. No. 20050272517 to Funk discloses a method and device to teach and simulate swing mechanics. A camera assembly is coupled to a computer such that frames including an image of a golfer swinging a golf club may be captured. A key part of the image is identified by the computer in sequential frames captured from the camera assembly and the image is compared to swing mechanics of a known standard golfer. The position of the known standard golfer is capable of following the natural swing of a student golfer, and the method and device are capable of providing real-time feedback to the student golfer during the golfer’s swing. A marker attachment may be used to assist in tracking and analyzing the swing mechanics of the images.

[0008] U.S. Pat. No. 5,823,878 to Welch discloses a golf analysis apparatus and method which uses videotaping equipment to capture golf swing motions from at least two different angles, and video processing equipment to isolate video frames for global, three-dimensional orientation of chosen points on the test subject. The points are compiled and used to calculate such parameters as clubhead lag and resultant clubhead velocity, body segment rotations, joint range of motion, spine angle, and center of mass versus center of pressure. Velocity data is used to calculate acceleration data. Such velocity and parameter data is then plotted simultaneously as part of an analysis method to determine and optimize the kinetic link between various body parts. Inefficiencies in each body segment motion can be addressed and corrected until an optimum kinetic link is achieved.

[0009] U.S. Pat. No. 6,565,448 to Cameron discloses an apparatus and method for analyzing a golfer’s individual swing attributes and determining, based on that analysis, a suitable golf club configuration for that golfer. The swing analysis apparatus include video camera assemblies for obtaining video images of a golfer swinging a golf club, such as a putter, at a golf ball. Images obtained from the video camera assemblies may then be analyzed to determine what golf club dimensions will provide improved results in combination with the golfer’s individual swing characteristics. The apparatus may also include a method for confirming the dimensions that it believes will provide a golfer with improved swing results.

[0010] Although the above applications are related to analysis of golf swings, the type of analysis and methods involved in performing the analysis in the present invention are different. The present invention also aims at providing feedback and recommendations based on the results of the analysis.

[0011] Therefore, it is an object of the present invention to provide an improved method of analyzing golf swings, which uses recorded golf swings and automatically selects relevant frames in the videos to perform the analysis.

[0012] A further object is to provide an improved method of analyzing golf swings, which quantifies the swing faults by assessing the key locations associated with the golfer during golfer swings.

[0013] A further object is to provide an improved method of analyzing golf swings, which provides an instantaneous feedback of a golf swing.

[0014] A further object is to provide an improved method of analyzing golf swings, which provides a detailed feedback over the Internet.

[0015] Finally, it is an object of the present invention to provide an improved method of analyzing golf swings, which provides recommendations to rectify swing faults. These and other objects of the present invention will become better understood with reference to the appended Summary, Description, and Claims.

SUMMARY

[0016] The present invention is a method of analyzing golf swings. A video camera assembly will be provided to a user. The camera assembly can be mounted to a tripod or to a pole of a golf cart and the user records his/her golf swings in front and side view at the golf facility. The golf swing is analyzed and the results are provided to the user after recording of each golf swing. The user is allowed to repeat this process as many times as he wishes during his time for usage. At completion of the session, the camera assembly is dismounted and interfaced with a computer system to download the recorded swings. The downloaded videos are transferred to a server via the Internet. The server allows user to
view his recorded swings, review analysis and get recommendation towards improvement from the hosting website.

[0017] The software applications provide automatic and instant analysis of the customer's golf swing. The analysis is conducted as the video is played. The video is automatically stopped at relevant frames and reference lines are used to assess and compare various aspects of the golf swing. The head, ball, and hand positions, the lateral shift of hip/legs and head during back swing, head movement, and final posture upon completion of the swing are determined in different frames of the front view videos. The angle of the spine, head movement, position of the hands and swing planes during backswing and downswing are determined in the frames of the side view videos. To help with the analysis, a plurality of key locations are to be identified with markers. For example, by placing colored stickers on the club shaft, hat and hip/leg, wearing colored gloves, and choosing a specific colored ball. The reference lines are associated with the key locations to highlight major swing flaws.

[0018] Once the analysis is complete, the user can get instant feedback on results or access a hosting website to review the results. The user can then view his/her swing faults. The user is also provided with recommendations on how to fix swing faults. These recommendations will be on a short video, given by a professional golf player or a prominent golf coach, showing the problem, cause(s) of the problem, results due to the problem and practical practice drills to fix the problem. A live professional golfer will also be available on-line if the user desires to speak with him/her.

BRIEF DESCRIPTION OF THE FIGURES

[0019] FIG. 1 shows the procedures involved in fitting an actual video in a standard template of a frame in the front view video.

[0020] FIG. 2 shows the procedures involved in fitting an actual video in a standard template of a frame in the side view video.

[0021] FIG. 3 shows a template for identifying the stickers and gloves in a frame of the front view video.

[0022] FIG. 4 shows a template for identifying the stickers and gloves in a frame of the side view video.

[0023] FIG. 5 shows the swing zone created in a frame.

[0024] FIG. 6 shows a frame with reference lines for analyzing the head and the golf ball position.

[0025] FIG. 7 shows a frame for analyzing the position of the hands.

[0026] FIG. 8 shows frames with reference lines for measuring lateral shift of hips/legs during the entire back swing.

[0027] FIG. 9 shows frames with reference lines for measuring lateral shift of the head during back swing.

[0028] FIG. 10 shows a frame during backswing when the glove has reached same height as the hip/leg sticker.

[0029] FIG. 11 shows the frame at the highest point in the backswing.

[0030] FIG. 12 shows frames for measuring the up/down movement of head from start of swing through impact of golf ball.

[0031] FIG. 13 shows the last frame, i.e. the completion of a swing.

[0032] FIG. 14 shows a frame in the side view video for measuring the spine angle.

[0033] FIG. 15 shows a frame in the side view video for analyzing the hands position.

[0034] FIG. 16 shows various frames during a swing with the swing plane lines.

[0035] FIG. 17 shows the compact camera assembly mounted to a pole.

[0036] FIG. 18 shows an LCD display.

[0037] FIG. 19 shows an alternative camera assembly mounted to a tripod.

FIGURES—REFERENCE NUMERALS

[0038] 11A . . . Fixed Zone corresponding to the Golf Ball

[0039] 11B . . . Fixed Zone corresponding to the Head

[0040] 12 . . . Sticker on the Hip/leg

[0041] 13 . . . Sticker on the Hat

[0042] 14 . . . Glove

[0043] 15 . . . Shoulder Marker

[0044] 16 . . . Swing Zone

[0045] 17 . . . Vertical Reference Lines

[0046] 18 . . . Horizontal Reference Lines

[0047] 19 . . . Swing Plane Lines

[0048] 20 . . . Golf Ball

[0049] 21 . . . Zone for Identifying the Stickers and Gloves

[0050] 22 . . . Club

[0051] 23 . . . Video Camera Lens

[0052] 24 . . . Video Camera Assembly

[0053] 25 . . . Swivel Arm

[0054] 26 . . . Universal Joint

[0055] 27 . . . Clamping Assembly

[0056] 28 . . . Pole of a Golf Cart

[0057] 29 . . . Display Screen

[0058] 30 . . . Marker on Golf Club

DETAILED DESCRIPTION

[0059] Referring to the drawings, the preferred embodiment of a method to analyze and provide feedback for golf swings is described. A user is provided with a camera assembly 24 for recording his/her golf swings. The camera assembly 24 contains all necessary software application to perform golf swing analysis. The user can rent the camera assembly 24 from a store employing the present invention. A computer system is located in a kiosk with all the necessary software applications to rent out the camera assembly 24 and to also transfer the golf swing data to the internet. The user has the option to either have an analysis of his/her individual golf swings, small group golf swings,
or large group such as an outing golf swings and make purchase accordingly. For the analysis, the user selects a right-handed or left-handed option and the color of the golf ball 20. A variety of colors can be used for the golf ball 20, for example, yellow, white, or orange. The user is provided with an orange glove 14 and at least one orange stickers. A first sticker 13 is to be placed on the middle of the user’s hat and the second sticker 12 on the hip/leg and the third sticker on the golf club shaft. The camera assembly 24 is initialized and pre-set for the selected option. Many other color combinations are possible for the golf ball 20, gloves 14 and stickers 12, 13, and 30, the main criterion being that they should be fairly unique and easily noticeable to assist in performing the analysis.

[0060] A high resolution video camera assembly 24 with a display screen, storage for storing video recordings, processor, memory, rechargeable battery, automatic focusing, buttons or touch screen options, 30 and 15 frames per second and high and low resolution recording capability is used with the present invention. The camera assembly 24 can be constructed in different sizes and shapes, integrated into one unit or attachment of unique electronic components. The video camera assembly 24 is adapted to be interfaced with the computer system for downloading golf swing videos from the camera assembly 24 and uploading video or software updates to the camera assembly 24. The video camera assembly 24, contains pre-recorded instructions for use at the golf facility, pre-recorded swing fault practice drills, and pre-recorded golf swing tips by a prominent golf instructor. When in use, the user will be able to get immediate playback of his recorded golf swing in slow motion, get swing analysis results, prioritized swing faults, practice drills on how to fix user’s swing faults, and shot making tips such as how to hit a driver, how to hit out of the sand, and the like.

[0061] The camera assembly 24 and lens 23 can be enclosed in a housing that is integrated with a swivel arm 25 with a universal joint 26. The swivel arm 25 is associated to a clamping assembly 27, which is mounted to a pole 28 of a golf cart.

[0062] For the analysis of the golf swing, the user must wear a hat and has to make sure that the color of his/her clothing or apparel is not the same as the color of the stickers. The tripod or the golf cart is then placed to get either the front view or the side view of the user while performing a golf swing. Following which, the front view or the side view option is selected on the camera assembly 24. The user has to make sure that the stickers 12, 13 and the golf ball 20 are visible from the camera assembly 24. Alternatively, instead of the display screen of the camera assembly 24, a separate visual aide may be provided by an LCD screen 29 already located on the cart, provided by the golf course (not shown). Once the record button is pressed, the user will have 45 seconds to go through his pre-shot routine and complete his golf shot. Once the golf swing is completed, the customer will be able to get instantaneous analysis of his golf swing on the camera assembly 24 or on the golf cart LCD 29. This process is repeated for the next golf shot and a plurality of swings can be recorded depending on the storage capacity of the camera assembly 24.

[0063] During the golf swing recording option, the camera assembly 24 shows ball position guide on its display screen at all times. The ball position guide is modified for front view recording versus the side view recording. [0064] After recording the golf swing, other relevant user data such as right-handed versus left-handed, video recorded in front view or side view, and brief description of swing is also stored for each golf swing. The camera assembly 24 then performs automatic and instantaneous golf swing analysis. The results are immediately available to the user. At the end of usage, the camera assembly 24 is interfaced with the computer system and all the recorded videos are downloaded and transferred to servers over the internet. The user may log onto a hosting website and see the results of the analysis.

[0065] The following description explains the detailed steps involved in performing automatic analysis. First, the 45 seconds video data of a golf swing is reduced to around 3 seconds of useful data, i.e. approximately the time required to complete a golf stroke. An algorithm for the front end of the video comprises: starting from end, the video is scanned frame by frame until the golf ball is found in the prescribed box 11A. Assuming this frame as frame ‘1’, 60 frames are stored before it (i.e. 60) and 30 frames after it (i.e. 30), and the others are discarded. From the start of the 3 seconds video, the video is forwarded to a frame ‘x’ (x=25). The glove 14 on the hand is located and its position is compared to frame ‘x-1’. If there is delta, the glove 14 at frame ‘x-1’ is compared to frame ‘x-2’. The above step is continued until delta is close to zero, where it is determined as the start of the golf swing and is considered as the first frame and all the earlier frames are discarded.

[0066] For the side view, frames are played from start until the golf ball 20 is fully or partially covered. Following which, frames are continuously played until the golf ball 20 is clearly identified and the glove 14 on the hand is above the shoulder marker 15. The shoulder marker 15 is mathematically computed by drawing a straight line from the hip/leg marker 12 to the hat marker 13 and by marking upwards 60% of the distance from the hip/leg marker 12. Assuming this frame as frame ‘1’, 45 frames are stored before it (i.e. 45) and 45 frames after it (i.e. 45), and the others are discarded. From the start of the 3 seconds video, the video is forwarded until the ball 20 is fully recognized. Following which, the video is moved back 10 frames. This is the first frame.

[0067] Referring to FIGS. 1 and 2, the video is zoomed in or out to fit in a standard template. The standard template includes fixed zones 11A corresponding to the golf ball 20 and head of the user 11B. First, the golf ball 20 in the video is overlaid on the golf ball zone 11A, and then the frame is zoomed to fit the sticker on the hat 13 in the head zone 11B of the standard template. The video is then cropped. Similar procedure is used for the side view, with zones corresponding to stickers on the hip/leg 12 and the golf ball 11A.

[0068] Referring to FIGS. 3 and 4, the template of each frame includes a plurality of zones, namely, for example, a box 21 for identifying the orange stickers 12, 13 and glove 14. The first frame of the front view is shown in FIG. 3, which is the position of the user just before the golf swing. The sticker on the hat 13 and the glove 14 appear in the boxes 21. Similar procedure is adopted for the first frame of the side view, except that the shoulder marker 15 is mathematically created in this case, as described above. In addition to the boxes 21, a swing zone 16 is created by taking various data points of the gloves 14 during backswing and downswing. The swing zone 16 is shown in FIG. 5. The data points are so selected such that the orange glove on the hand stays in the created swing zone, irrespective of the users. This procedure speeds up the video processing and makes the algorithm more efficient.
The analysis is conducted as the video is played. The video will automatically stop at relevant frames and reference lines are used to assess various aspects of the golf swing, such as described hereinafter. The golf swing can be analyzed at any frame of the golf swing in the front view video. The key frames comprise the stance before starting the swing, an intermediate position in the back swing, at ⅛ of the back swing, top of swing, start of downswing from the top, before impact, at impact, post impact and the final finish position.

The head, ball and hand positions are determined in the front view of the stance. The ball position varies with the type of club, but the head should always stay behind the ball. A first vertical reference line 17A is drawn from the center of the sticker on the hat 13 and the horizontal distance between the first vertical line 17A and the center of the golf ball 20 is measured, as shown in FIG. 6. The correct position or the severity of the faults is determined depending on the measured horizontal distance. Referring to FIG. 7, a second line 17B is drawn from the centers of the sticker on the hat 13 and golf ball 20. The horizontal distance between the lines 14 and the second line is measured. In an ideal position, the center of the lines 14 should be on or ahead of the second line towards the golf ball 20. The severity of the faulty hand position is determined based on the measured distance.

Referring to FIG. 8, to measure the lateral shift of the hip/legs during backswing, a vertical line 17C is drawn at a prescribed distance from the sticker on the hip/leg 12. The horizontal distance between the vertical line 17C and the center of the sticker on the hip/leg 12 is then determined. If the sticker on the hip/leg 12 moves laterally on to the line and to the left of the line, the shift is too excessive. Similarly, a fourth vertical line 17D is drawn at a prescribed distance from the sticker on the hat and same methodology is used to determine excessive lateral head movement, as shown in FIG. 9.

Referring to FIG. 10, a first horizontal line 18A is drawn from the sticker on the hip/leg 12. A frame during backswing is used when the lines 14 meet this first horizontal line 18A. This analysis is only for reference for user to check his club head position.

Referring to FIG. 11, a second horizontal line 18B is drawn at the highest point of the lines 14 and its coordinates are noted. If the sticker on the club shaft 30 moves lower than the second horizontal line 18B, i.e. continuing the back swing further, then it is determined as a faulty move for iron golf clubs and not for driver golf club.

Referring to FIG. 12, for analyzing the up and down head movement, a third horizontal line 18C is drawn from the sticker on the hat 13 at the start of the swing, i.e. on the first frame. A fourth horizontal line 18D is drawn from the sticker on the hat 13 at the highest point during the swing or at any point from start of swing through impact. If the vertical distance between the third and fourth horizontal lines 18C, 18D is greater than a prescribed distance, then it is determined as a faulty move.

Referring to FIG. 13, a fifth vertical line 17E is drawn from the sticker on the hat 13 in the last frame, i.e. at the completion of the swing. This frame is used to verify aspects such as whether the head is over the leading foot, the trailing foot toes are on the ground, and the like. If the hip/leg marker is left of the vertical line 17E, then it is determined as a faulty finish position.

The angle of the spine, head movement, position of the hands and swing planes during backswing and downswing are determined in the frames of the side view videos. To determine the spine angle for reference purposes, the first frame of the side view is used, as shown in FIG. 14. A line 17F is drawn connecting the stickers on the hat 13 and hip/leg 12. The line 17F is offset by a prescribed amount in positive “Y” direction, for example, 6 inches.

Referring to FIG. 15, a vertical line 17G is drawn from the center of the sticker on the hat 13. The line 17G is then offset by 3 inches in negative “X” direction. The relative position between the lines 14 and the offset vertical line 17G is determined. If the lines are on the line 17G or on the right side of the line 17G, then it is determined as a faulty set-up position.

Referring to FIG. 16, two swing plane lines 19 are drawn in all frames from start of swing through impact. The lower swing plane line is drawn from small offset, towards the golfer, from the golf ball through the lower hand facing the camera. The upper swing plane line is drawn from the middle of the golf ball 20 through the shoulder marker 15. The position of the lines 14 is determined in the frames and should stay within the two lines 19 from start of the swing through impact. The swing is faulty when the hands or the club head move out of the swing plane line, and if the club head is not inside the circle when the golf club is parallel to the ground. The circle is drawn around the hands at this position. Algorithm draws an extended line from the golf glove through the golf club marker and determines if the club head is inside the swing plane from start of swing through impact. A swing fault is noted if the club head is out of the swing plane lines in relevant frames.

As cited previously, all the above analyses are performed while the video is played. When stopped at a frame, all the reference lines relevant to that frame are superimposed and the fault zones for various aspects are created. After the full analysis, the video is ready to be viewed for seeing results of the analysis. When the video is played by the user, the video stops automatically at the relevant frames. The user can now view his/her swing faults by viewing the relevant marker in the fault zones. This analysis video is available immediately after recording of the golf swing, on the camera assembly 24, and also can be later accessed from the hosting website.

The user is also provided with recommendations on how to fix swing faults. These recommendations will be on a short video, given by a professional golf player or a prominent golf coach, showing the problem, cause(s) of the problem, results due to the problem and practical practice drills to fix the problem. The user also has options to compare his/her swings from different sessions. The user can get help on other possible swing flaws, via preprogrammed video instructions and be able to purchase training aides on-line, as recommended by an instructor. The user can also compare his/her swings to professional golfer’s swings to identify major variations, get qualitative feedback from comparison to a professional player’s swing regarding hip/leg position, head positions, hands position, body position at impact, and the like.

The user is also provided with drawing tools for his/her own analysis. The video data may also be taken by a wireless video camera, a phone camera, hand held PDA,
or the like and sent to the hosting web site for processing. The user can be provided with various subscription options, depending on which previous swing analyses can be accessed and the user can sign up for product upgrades.

[0082] All features disclosed in this specification, including any accompanying claims, abstract, and drawings, may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0083] Any element in a claim that does not explicitly state “means for” performing a specified function, or “step for” performing a specific function, is not to be interpreted as a “means” or “step” clause as specified in 35 U.S.C. § 112, paragraph 6. In particular, the use of “step of” in the claims herein is not intended to invoke the provisions of 35 U.S.C. § 112, paragraph 6.

[0084] Although preferred embodiments of the present invention have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustration and not limitation.

What is claimed is:

1. A method of analyzing and providing feedback about golf swing, comprising:
   - recording the golf swings of a golfer with a video camera assembly;
   - allowing the golfer to review recorded golf swings;
   - normalizing all the golfers to fit in a same window;
   - identifying a plurality of key locations on the videos;
   - conducting an analysis of various aspects of the golf swing by processing the video at each relevant frame and highlighting faults in the frame based on the plurality of key locations on the frame;
   - reporting the results of the analysis;
   - providing recommendations to rectify the faults;
   - providing comparisons of the golfer's swing with the golf swings performed by professional golfers or the golf swings performed previously by the golfer by downloading videos of the golf swings recorded in the video camera assembly to a computer system;
   - uploading the stored swings to the hosting website.

2. The method of claim 1, wherein the step of normalizing the golfers includes zooming of the golfer to fit in a standard template.

3. The method of claim 1, the step of identifying the key locations includes using standard templates with zones corresponding to the key locations relevant to a particular frame in the golf swing.

4. The method of claim 1, wherein a swing zone is created to locate the golfer's hand, which is one of the key locations, to speed up processing, the swing zone being created by taking various data points of the golfer's hand during the complete swing.

5. The method of claim 1, the step of analyzing the golf swing includes comparing the position of the key locations in each frame to a standard position of the key locations in that frame and quantifying the deviation between the actual and standard positions of the key locations.

6. The method of claim 1, wherein a visual aid is provided on the camera assembly to review the recorded golf swings.

7. The method of claim 1, wherein the recorded video of a user's golf swing is instantly and automatically analyzed using proprietary software applications.

8. The method of claim 1, wherein the user logs onto a hosting web site to review the results of the analysis.

9. The method of claim 1, wherein the downloaded videos can be recorded on a CD, DVD, or other memory device for the golfer's personal review.

10. The method of claim 1, wherein the video camera assembly contains pre-recorded instructions and golf shot tips by a prominent golf instructor.

11. The method of claim 1 further comprising: getting qualitative feedback from comparison with a professional player's swing such as hip/leg position, head positions, hands position during downswing, body position at impact, and the like; providing an option to the customer for the automatic computer analysis or a manual analysis done by the golfer.

12. The method of claim 11 further comprising: providing drawing and video tools for manual analysis.

13. The method of claim 1, wherein the video camera assembly includes an option to record videos for the golf swing analysis or to record videos in a CD or DVD.

14. The method of claim 1, wherein colored markers associated with the golfer and golf ball used by the golfer serve as the plurality of key locations.

15. The method of claim 1, wherein colored golf glove, a first colored marker on a hat worn by the golfer, a second colored marker on the hip/leg of the golfer, a third colored marker on the golf club shaft, and golf ball serve as the plurality of key locations.

16. The method of claim 1, wherein the analysis is done for front and side views of the golfer performing the golf swing.

17. The method of claim 16, wherein a first frame of the front view comprises an initial position of the golfer before the golf swing, the analysis for the head and hands position being made in the first frame.

18. The method of claim 17, wherein the position of the hands with respect to ball, lateral shift of hip/legs and head during back swing, and position of the head, club, and final posture at the end of the golf swing are analyzed in the subsequent frames.

19. The method of claim 16, wherein a first frame of the side view comprises an initial position of the golfer before the golf swing, where the analysis of the spine angle is made.

20. The method of claim 19, wherein the position of head and the position of the hands and club head in the backswing and downswing are analyzed in the subsequent frames.