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(54) ## A self-learning golf diagnosis apparatus and method

(57) A self-learning golf diagnosis apparatus comprising an evaluation unit for evaluating a quality of a stroke of a golf player based on a predetermined quality criteria, a determining unit for determining a parameter related to the stroke, and a correlation unit for determining a correlation between the parameter related to the stroke and the evaluated quality of the stroke.

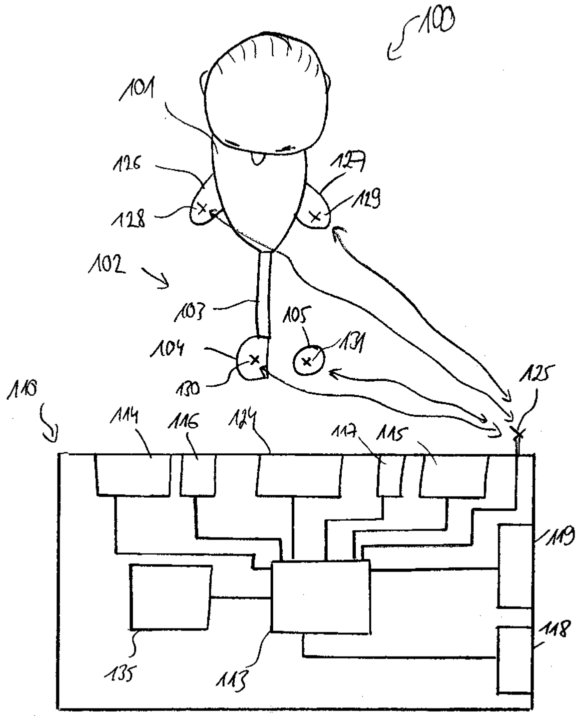

Fig. 1

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Description

[0001] The invention relates to a self-learning golf diagnosis apparatus.
The invention further relates to a self-learning golf diagnosis method.
Moreover, the invention relates to a program element.
Further, the invention relates to a computer-readable medium.

[0002] US 2005/0026710 A1 discloses a video image acquisition apparatus having one or multiple digital cameras taking images of a flying golf ball created by at least two flashes or strobes of light on continuous video mode at a predetermined frame rate. Each image frame is then subtracted from the background and compared to determine the existence of the ball image in flight. Furthermore, another video image acquisition apparatus is also disclosed in US 2005/0026710 A1 that consists of at least two video cameras taking images of flying golf balls created by at least two flashes or strobes of light at predetermined time intervals. The apparatus then applies triangulate calculation of the two camera images to determine the exact physical locations of the flying golf balls in space at a given time of flight.

[0003] However, conventional golf diagnosis systems suffer from the fact that they do not produce reliable results.

[0004] It is an object of the invention to allow for a reliable golf diagnosis system.

[0005] In order to achieve the object defined above, a self-learning golf diagnosis apparatus, a self-learning golf diagnosis method, a program element, and a computer-readable medium according to the independent claims are provided.

[0006] According to an exemplary embodiment of the invention, a self-learning golf diagnosis apparatus is provided comprising an evaluation unit for evaluating a quality of a stroke of a golf player based on a predetermined quality criteria, a determining unit for determining a parameter (more particularly a value of a parameter) related to the stroke, and a correlation unit for determining a correlation between the parameter (more particularly the value) of the parameter related to the stroke and the evaluated quality of the stroke.

[0007] According to another exemplary embodiment of the invention, a self-learning golf diagnosis method is provided, the method comprising evaluating a quality of a stroke of a golf player based on a predetermined quality criteria, determining at least one parameter related to the stroke, and determining a correlation between the at least parameter related to the stroke and the evaluated quality of the stroke.

[0008] According to still another exemplary embodiment of the invention, a program element is provided, which, when being executed by a processor, is adapted to control or carry out a self-learning golf diagnosis method having the above mentioned features.

[0009] According to yet another exemplary embodiment of the invention, a computer-readable medium is provided, in which a computer program is stored which, when being executed by a processor, is adapted to control or carry out a self-learning golf diagnosis method having the above mentioned features.

[0010] The self-learning golf diagnosis scheme according to embodiments of the invention can be realized by a computer program, that is by software, or by using one or more special electronic optimization circuits, that is in hardware, or in hybrid form, that is by software components and hardware components.

[0011] In the context of this application, the term "stroke" may particularly denote the entire procedure or a part of the procedure including a swing with the golf club, a hit between golf club and golf ball, and the flight of the golf ball until the ball rests.

[0012] In the context of this application, the term "stroke distance" may particularly denote the distance between a resting position of the golf ball before a stroke and after the stroke.

[0013] According to an exemplary embodiment of the invention, an adaptive or a self-learning golf diagnosis apparatus may be provided which may allow to monitor a stroke of a golf player, to evaluate the quality of this stroke and to determine, for instance on a statistical basis obtained from a plurality of previous strokes, which stroke parameters, for instance which body positions of a golfer, yielded in the past proper results.

[0014] Such a golf diagnosis apparatus may comprise a self-learning mechanism, for instance implementing instruments of artificial intelligence, like neural networks, so that the system may learn automatically to distinguish between good strokes and bad strokes and to analyze which stroke strategies yield good strokes and which stroke strategies yield bad strokes. This may be determined based on an experience made by the golf player in the past, and may allow to distinguish a good stroke from a bad stroke, and may allow to correlate parameters according to the stroke to be desirable or non-desirable, etc.

[0015] By taking such measures, the self-learning golf diagnosis apparatus may become a "friend for a golfer", i.e. an automatic golf trainer providing the golfer with proposals or suggestions as to how to improve the performance. This may include statements like "turn your shoulder approximately five degrees more to the left immediately before the stroke" or "distribute the body weight onto the front part of the foot when swinging the golf club".

[0016] In the context of such a golf diagnosis system, it may be possible that a camera or the like takes images of the golfer before, during or after hitting the ball. From such images, quality-related parameters like the flight distance of the ball, and its angular direction, etc. can be derived. Furthermore, parameters related to the stroke like a body position of a golfer, a weight distribution on the feet of the golfer, etc. may be determined automatically. By comparing such parameters (or parameter values) to one or more predetermined quality criteria (like "a good stroke yields a distance of at least 150 metres") allows to automatically classify the stroke to be good or not that good. Such a quality of the stroke may then be analyzed in connection with further stroke-related parameters, particularly golfer-related parameters, like body positions or the like. By repeating such a procedure and by storing such correlations in a database, the system may learn to distinguish between good and bad strikes, and to correlate golfer positions to quality results.

[0017] For instance, the system may determine statistically significantly that particular golfer positions have been, in many cases in the past, being correlated to a good stroke, so that on this basis proposals or suggestions for improving the performance of a golfer may be performed. Thus, the self-learning golf diagnosis apparatus may substitute or support/ supplement a conventional (human) golf teacher.

[0018] According to an exemplary embodiment of the invention, a self-learning golf diagnosis device may be provided. Such a golf diagnosis device may simultaneously measure the golf ball flight parameters and/or the motion of the golf club and/or the golfer at the moment at which the golf club hits the golf ball. It is also possible to measure such parameters before or after having hit the golf ball. Then, an adaptive, statistical evaluation of such measurement results may allow to determine an optimum or improved position of the golfer at the position of hitting the ball, in order to achieve an improved or optimum trajectory of the golf ball. It is also possible to simultaneously measure the flight parameters of the golf ball and/or of the golfer in the moment at which the golf club hits the golf ball.

[0019] In such a context, a launch monitor may measure the ball flight parameters and optionally the motion parameters of the golf club. At the moment of a collision of the golf club and the golf ball, additionally a whole body image of the golfer may be taken. Such a procedure may be repeated a plurality of times (for instance 30 times). It is possible to define, by the golfer or automatically, one or more quality criteria for a desired way of playing. Such quality criteria may be the distance of a golf ball, an angle of a golf stroke versus target line, a back spin or combinations of such parameters. Using statistical methods, it is possible to determine advantageous body positions and dynamics of the golfer, which body positions repeatedly resulted in the past in golf strokes in which the defined quality criteria could be achieved.

[0020] Thus, launch monitors estimating flight parameters can be combined with a video camera. It is also possible to determine the golf club trajectory with such systems. It may be particularly advantageous to combine such data for a self-learning evaluation.

[0021] Particularly, in the context of such a self-learning golf diagnosis device, the position of the legs of the golfer may be used for deriving information about the quality of a stroke and particularly the correlation of such a quality with the body position and dynamics of the golfer. Therefore, it is possible to simultaneously measure the golf ball flight parameters and/or the golf club motion and/or the position of the legs and/or the position of the feet of the golfer at the moment at which the golf club hits the ball and positioning motions before the stroke. Furthermore, it is possible to simultaneously measure the golf ball flight parameters and/or the golf club motion and/or the distribution of the weight to the legs and/or to the front and/or back portion of the feet of the golfer, for instance in a moment at which the club hits the golf ball. Then, it may be determined using an adaptive statistical evaluation, to evaluate an improved or optimum weight distribution of the golfer at the moment of the collision, in order to achieve an improved or optimized trajectory of the golf ball.

[0022] Thus, a launch monitor may measure the ball flight parameters and optionally the motion parameters of the club. At the moment at which the club hits the ball, the weight distribution and/or the position of the legs and/or the position of the feet of the golfer may be estimated during the swing. After having monitored such a procedure a plurality of times, the success of a stroke may be correlated to monitored properties. Repeating such a procedure a plurality of times (for instance 30 times) and defining a quality criteria for the desired golf performance, it may be possible to define desired positions and/or weight distributions and/or leg or feet positions which, in the past, in the statistical average yielded proper golf results, that is to say strokes which successfully achieved the defined quality criteria.

[0023] Parameters like the weight distribution may be measured by pressure sensors. According to an exemplary embodiment of the invention, corresponding pressure sensor data may be used in the context of an adaptive evaluation.

[0024] According to an exemplary embodiment of the invention, it is possible to perform a self calibration of the distance between the golf diagnosis system, particularly between launch monitor, and the golf ball. When evaluating an image of the golf ball and/or of the golf club and/or of the golf player, for instance by using methods of automatic image processing, the automatic calculation of the motion and/or positional parameters requires a set of information as a basis for the calculation. For instance, knowing the distance between the ball and the camera may allow to derive other information with respect to the trajectory of the golf ball and/or the body motion of the golfer when carrying out such a stroke. According to an exemplary embodiment, such a distance between the camera/the launch monitor and the golfer may be self-calibrated, that is to say estimated automatically.

[0025] In such a scenario, it may be necessary or advantageous to estimate the flight parameters of the hit golf ball. The flight parameters may be velocity, direction (horizontal and/or vertical to the direction of the aimed goal) and the spin of the ball. After the golf club has hit the golf ball and the golf ball has entirely left the golf club, at least two single pictures of the flying golf ball may be taken with a camera separated by a defined time interval. The distance between the camera and the golf ball, which may be estimated by a self-calibration method, is a parameter which influences the evaluation of the parameters.

[0026] In the following, different options are explained how to estimate the distance of the camera to the ball with such a self-calibration method.

[0027] According to a first option, the moment at which the golf club hits the ball is measured by a light barrier and by a microphone, which may be positioned relatively close or attached to the camera. From the time difference between the optical detection and the acoustical detection, it is possible to calculate the distance, for each hit individually.

[0028] According to another option, the moment at which the club hits the ball may be measured by a microphone which may be positioned relatively close to the camera, or which may be attached thereto. From the distance between the ball position measured by the camera at the time at which the microphone detects the acoustic waves and the rest position of the ball it is possible to calculate back to the propagation time of the acoustic waves.

[0029] A further option is to pre-store the real size/dimension of the ball in the device, and to calculate the distance from the detected size of the resting ball (before it is hit by the club) as visible on the image.

[0030] According to still another option, a calibration body with known geometrical dimensions may be captured by an image acquisition device at or close to the position at which the ball shall be hit. From the apparent size of the calibration body, the distance may be estimated.

[0031] According to yet another option, the above-mentioned options may be carried out with the measure that, instead of observing the size of the ball, the size of markers or patterns are evaluated which can be attached to the ball or may be provided as colour marks at the ball.

[0032] According to exemplary of embodiments of the invention, launch monitors with one or more cameras may be implemented to automatically calibrating the distance between camera and ball so as to simplify the use of the system to achieve a user-friendly device.

[0033] According to an exemplary embodiment, size or distance information may be encoded in markers or patterns. Particularly, such markers may be provided not only at a golf ball, but may also be provided at a golf equipment device (like a golf bag, a golf caddy, a golf cart, a golf glove, a golf shoe, a golf suit, a golf cap, a golf club or a golf ball). In order to allow an automatic detection/localisation of such golf equipment devices by a launch monitor, it is possible to attach one or more different markers or patterns to such golf equipment devices.

[0034] In order to evaluate golf strokes, launch monitors or golf simulators may be employed. Depending on the technology of such measurement devices, the information with which kind of golf club (iron, wood, manufacturer, etc.) the stroke has been performed, may be necessary or advantageous for an evaluation (for instance a statistics with respect to the success of strokes in dependence on the used golf club). Using markers foreseen at the golf club, which markers may be detected or recognized electronically, the information with which club the stroke has been performed may be used for evaluating the stroke. Examples for such encoding items are colour markers which may be recognized by an optical sensor, patterns which may be recognized by an optical camera and an image processing system, a bar code, or emitted electromagnetic radiation (for instance using an infrared detector or an RFID tag).

[0035] Next, further exemplary embodiments of the invention will be explained. In the following, further exemplary embodiments of the self-learning golf diagnosis apparatus will be explained. However, these embodiments also apply for the self-learning golf diagnosis method, for the computer-readable medium, and for the program element.

[0036] The predetermined quality criteria may comprise a stroke distance. The quality criteria may also be the number of strokes which were required by a user to finish a hole. One or a plurality of quality criteria may be defined. Such a definition may be performed by a user, for instance by inputting a quality criteria or by selecting one or more criteria ? from a menu. It is also possible that the system automatically determines or defines one or more quality criteria.

[0037] The stroke related parameter which the determining unit may determine may be related to a golfer-related property during the stroke. Thus, the parameter may be indicative of what a golfer did or how the golfer hit the ball in this particular stroke. Such a parameter may be related to a position of the golfer's body during the stroke, an orientation of the golfer's body during the stroke, a position of particular body parts of the golfer, like legs, feet, the bottom, the shoulders, the arms, etc. Also parameters which are indirectly related to a body position of the golfer may be evaluated as the parameter. This includes a swing angle or other swing parameters of the golf club operated or actuated by the golfer. By examining which parameter values/body positions yielded good results with respect to the achievement of the quality criteria in the past, valuable information for a golfer may be derived as to how to improve her or his skills.

[0038] The self-learning golf diagnosis apparatus may comprise a storage unit adapted to store (pre-)determined correlations between the value of the parameter related to the stroke and the evaluated quality of the stroke. Such a storage unit may be a volatile or a non-volatile storage unit, like an EPROM or an EEPROM, a hard disk, a memory card, a USB stick, or the like. The storage unit may be rewritable so as to allow to update the information. In the storage unit, under the control of a central control unit like a CPU (central processing unit), long-term experiences between successful/non-successful strokes and corresponding body positions may be stored. Thus, the storage unit may be a (golfer-related/personal) database in which a large number of hits and the corresponding correlations between quality and parameter values are stored. Thus, on the basis of such information, the CPU may perform a statistical analysis and may determine which parameter values resulted in the past in a statistically significant manner in successful strokes.

[0039] The correlation unit may be adapted for determining the correlation between the value of the parameter related to the stroke and the evaluated quality of the stroke using correlations stored in the storage unit. Thus, the correlation unit may make use of such prestored data sets. In this context, the correlation unit may apply statistical methods, like generation of histograms, calculation of expected value and variants/co-variants, etc. It is possible to calculate distribution functions.

[0040] Furthermore, a neural network may be fed with such empiric information to train the neurons so as to allow the trained neural network to generate meaningful statements or predictions with respect to a correlation of parameter values and a success of a stroke. Expert rules may be applied in this context. Thus, artificial neural networks may be implemented in a golf diagnosis apparatus.

[0041] The self-learning golf diagnosis apparatus may comprise an image acquisition device for capturing an image of the stroke of the golf player. As an example for such an image acquisition device, a camera, for example a CCD (charge coupled device) camera, may be used. It is possible to use one or more image acquisition devices. Using a single image acquisition device may allow to manufacture a low cost and low dimensioned self-learning golf diagnosis apparatus. Using a plurality of image acquisition devices may for example allow to capture, simultaneously, images of the golfer from different positions so as to broaden the basis of information for generating an analysis.

[0042] Such an image acquisition device may work in a single picture mode in which individual images may be taken. Alternatively, such an image acquisition device may work in a continuous video mode for acquiring a film/movie of a golf stroke.

[0043] The image acquisition device may be adapted for capturing an image of at least a part of at least one of the group consisting of a golf ball, a golf club, and the golf player. For example, it is possible to capture various images of the golf ball at different moments of time. This may be done by combining the function of a camera with one or more strobes emitting light pulses defining the points of time at which images of the golf ball are taken. Additionally or alternatively, images of the golf club may be taken at one or more points of time. From the same image or from another image, particularly from an image with a smaller scale, images of the golf player may be taken from one or several body positions so as to obtain further information.

[0044] The image acquisition device may be adapted for capturing an image of the stroke of the golf player at a time corresponding to at least one of the group consisting of before the stroke, during the stroke, and after the stroke. For instance, swing parameters of the golf player and the golf club before and after the stroke may be meaningful. With respect to the hit of the ball and the club, images essentially during the stroke may be meaningful. Furthermore, images of the ball after the stroke may be a source of valuable information for deriving proposals for improving the performance of a golfer.

[0045] The self-learning golf diagnosis apparatus may comprise an image processing unit, particularly an image recognition unit, for processing the image captured by the image acquisition device so as to derive information indicative of the quality of the stroke and/or to derive the value of the parameter related to the stroke. Such image recognition methods which may be used by the image processing unit may allow to derive a position of a ball for instance based on a predetermined (round) shape of the ball.

[0046] It is also possible to support the function of the image recognition unit by markers provided on the ball. In other words, abstract information may be extracted by the image processing unit from the actual image which allows to determine golf stroke related parameters.

[0047] The self-learning golf diagnosis apparatus may comprise a user interface for allowing a user to determine the quality parameter(s). Via the user interface, the user may input one or more quality parameters or criteria which shall be used by the system. Such a user interface may comprise graphical elements, when a graphical user interface (GUI) is implemented, like an LCD display, a TFT display, an OLED (organic LED) based display, a plasma device or the like. Furthermore, such a user device may include input elements such as a keypad, a joystick, a trackball, or a microphone of a voice recognition system.

[0048] The self-learning golf diagnosis device may further comprise an output unit for outputting a determined correlation between the value of the parameter related to the stroke and the evaluated quality of the stroke. Such an output may be performed in an audible, visual, or audiovisual manner. It is also possible that a hard copy of the result is printed on a piece of paper, using a printer (which may be externally connected to or integrated in the golf diagnosis system). The output unit may also display statistical information or may show graphical illustrations of the parameters of the stroke.

[0049] The output unit may particularly be adapted for outputting a proposal to a user as to explain the user how to modify the parameter related to the stroke so as to improve the quality of the strokes. Thus, the output unit may, in a manner perceivable by a human being, provide the golfer with information as to how to improve the stroke, for instance which values of the parameter should be selected to obtain better results. For instance, such proposals may include instructions like "the turning angle between the shoulders and the feet should be increased, particularly by essentially five degrees".

[0050] The self-learning golf diagnosis apparatus may further comprise a sensor unit adapted to sense at least one sensor parameter related to the stroke of the golf player. Thus, in addition to the pure image information of the image acquisition device, further sensor parameters may be acquired. This may include position sensors, which may for instance be implemented in the golf ball and/or in the golf club so that a trajectory of such golf equipment devices may be retraced. Furthermore, such sensors may include pressure sensors which may for instance be provided on the golf ball, in the soles of a golf shoe, in the golf equipment, etc. Such pressure information may allow to derive parameters like a weight distribution of the golfer during the stroke, etc.

[0051] Particularly, the sensor unit may be adapted to sense a weight distribution acting on the feet of the golf player during carrying out the stroke and/or a weight distribution acting on different portions (for instance a front portion and a back portion) of a foot of the golf player carrying out the stroke. Positioning the sensor unit in the sole for insertion into a golf shoe is a cheap and efficient way of measuring the weight distribution of the golfer.

[0052] A communication between such senor units and the central processing unit may be performed in a wireless manner, for instance via Bluetooth, infrared communication or wireless LAN (WLAN). For instance, the sensor components in the sole may be connected to a central processing unit via an RFID tag based communication.

[0053] The sensor unit may further be adapted for providing at least one sensor parameter via a wireless communication path. However, it is also possible to provide a wired connection between sensors and evaluation units, for instance via a conventional cable or optical fibres.

[0054] The self-learning golf diagnosis apparatus may further comprise a self-calibration unit for automatically determining a distance between the image acquisition device and a golf ball before the stroke. By automatically determining this distance, a calibration may be performed to obtain a meaningful parameter as a basis for the image recognition and the determination of motion rates. Thus, the basis of information may be broadened and the obtained results with respect to the performance of the golf stroke may be improved with respect to accuracy.

[0055] The self-calibration unit may comprise a combined light barrier and acoustic detection unit. When the ball or the club interrupts the light barrier, a timer may be started. The point of time at which the acoustic signals are detected may then be taken, together with the velocity of sound in the surrounding medium, to calculate the distance.

[0056] Alternatively, a combined optical detection unit and acoustic detection unit may be performed. Due to the difference between the velocity of sound and the velocity of light, the propagation time difference between optical waves and acoustic waves may be taken as a basis for calculating the distance.

[0057] Furthermore, a predetermined golf ball size information may be used to detect the distance by comparing the predetermined golf ball size information with a measured/apparent/actual golf ball size. The further the golf ball being dislocated from the camera, the smaller the apparent size of the ball.

[0058] It is also possible to use predetermined marker size information. For instance, a strip or an arrow with a known size may be provided at golf equipment or at a golf ball or at a golf club. Measuring the actual or apparent size may then allow to measure or calculate or compute the distance between ball and detector.

[0059] Furthermore, calibration bodies may be used with known geometry parameters so as to detect the distance.

[0060] The golf diagnosis apparatus may comprise an adapter adapted for connecting at least one additional component. Such additional components may be, for instance, additional image acquisition devices, an additional sensor unit, an additional flashlight unit, and an additional stroboscope unit. Thus, a modular system is provided which can be extended, or even retrofitted, so that the performance and the functionality of the system may be extended step by step. Thus, a very flexible system may be provided.

[0061] Such an adapter or user port may particularly be an electric adapter like a connection plug board. Such an adapter may include support structures, clips, stand arms, etc., at which auxiliary equipment may be fastened. For example, it may be possible to use a connection to a battery of a golf cart or a golf caddy, connect it to an intermediate piece like a T-piece and use this specially designed/shaped T-piece as a connector for one or a plurality of additional equipment items.

[0062] According to an exemplary embodiment, expert rules may be combined with the self-learning feature. That is, "golf rules" derived from experience may be input in the device and may be consulted to evaluate a quality of a stroke. For instance, a rule like "relatively slowly performing a swing results in many cases in a proper stroke", may be considered for evaluating the quality of the stroke.

[0063] The aspects defined above and further aspects of the invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to these examples of embodiment.

[0064] The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

[0065] Figure 1 shows a golf diagnosis system according to an exemplary embodiment of the invention.

[0066] Figure 2 illustrates a calculation scheme for deriving parameter information from a captured image of a golf ball related to a golf stroke according to an exemplary embodiment of the invention.

[0067] Figures 3 and 4 illustrate a calculation scheme for deriving parameter information from a captured image of a golf club related to a golf stroke according to an exemplary embodiment of the invention.

[0068] Figures 5 and 6 illustrate a calculation scheme for deriving parameter information from a captured image of a golf club and a golf ball related to a golf stroke according to an exemplary embodiment of the invention.

[0069] Figure 7 shows a sole for a golf shoe as a part of a golf diagnosis system according to an exemplary embodiment of the invention.

[0070] The illustration in the drawing is schematically. In different drawings, similar or identical elements are provided with the same reference signs.

[0071] In the following, referring to **Fig. 1**, a golf diagnosis system 100 according to an exemplary embodiment of the invention will be described.

[0072] As shown in Fig. 1, a golfer 101 carries a golf club 102 including a shaft 103 and a club head 104. A golf ball 105 is positioned on a tee (not shown).

[0073] Furthermore, Fig. 1 shows a golf diagnosis apparatus 110. Embedded in the golf diagnosis apparatus 110 are a plurality of components as will be explained in the following.

[0074] The golf diagnosis apparatus 110 comprises a central processing unit (CPU) 113 which includes processing resources and storage resources. The CPU 113 is the control system over the entire golf diagnosis apparatus 110. The CPU 113 is electrically coupled to a first CCD camera 114 and to a second CCD camera 115. Instead of providing two CCD cameras 114, 115, it is also possible that only a single camera is provided, or a number of cameras which is larger than two. It may be particularly advantageous to provide only a single camera, since this may allow to manufacture the device with low costs and in small size. The provision of two cameras in Fig. 1 is thus not to be understood as a limiting feature for the invention. Particularly, the second camera 115 is merely optional, and a performance with only the first camera 114 is sufficient. The CCD cameras 114, 115 are adapted to monitor the golf player 101 from different views so as to derive complementary information for evaluating a stroke of the golfer 101.

[0075] Furthermore, a first flash 116 and a second flash 117 are provided. The flashes 116, 117 can be positioned at any desired position of the golf diagnosis apparatus 110, particularly attached to a casing of the golf diagnosis apparatus 110. The flashes 116, 117 may emit light flashes so as to define points of time at which images of the golf club 102, of the golf ball 105 and of the golf player 101 are captured by the cameras 114, 115. As an alternative for the flashes 116, 117, strobes may be provided. It is possible to implement such light flash sources using LEDs, particularly OLEDs. Instead of using two flashes, it is possible to use only one flash or at least three flashes. For example, each of the two flashes 116, 117 can emit a single flash, or a single flash may emit two flashes. Also the number of light pulses may vary, and can be larger or smaller than two.

[0076] Moreover, the CPU 113 is coupled to an LCD display 118 as an optical output unit or optical display unit for displaying results of the golf diagnosis.

[0077] Furthermore, the CPU 113 is coupled to a graphical user interface 119 like a keypad, a joystick, a touch screen so as to provide the CPU 113 with control information. Particularly, the user may input, via the input/output device 119, quality parameters on the basis of which a stroke of the user 10 1 shall be evaluated. Furthermore, the golfer may input, via the input/output device 119, golf equipment information like information with respect to the club 102 which shall be used for the strike, so as to provide the system 110 with the required information needed to evaluate the stroke.

[0078] Each of the components 114 to 119 may be connected to interfaces of the golf diagnosis apparatus 110 so that individual components may be retrofitted, substituted, or replaced. Thus, a modular system may be provided.

[0079] Although not shown in Fig. 1, a battery is housed in the golf diagnosis apparatus 110 so as to supply the various components of the golf diagnosis apparatus 110 with electrical energy. However, the golf diagnosis apparatus 110 may also be powered by solar cells or the like.

[0080] As further shown in Fig. 1, a microphone 124 is provided for detecting acoustic waves resulting from a hit between the golf club head 104 and the ball 105.

[0081] Furthermore, a Bluetooth communication interface 125 is provided at the golf diagnosis apparatus 110 and is coupled to the CPU 113. Via the Bluetooth communication interface 125, wireless communication with sensors 128, 129 provided in both shoes 126, 127 of the golfer 101 is possible. Furthermore, wireless communication with a sensor 130 provided in the golf club head 104 and with a sensor 131 provided in the golf ball 105 is possible.

[0082] In the following, the functionality of the system 100 will be explained in more detail.

[0083] When the golf player 101 has actuated the golf club 102 so that the club head 104 hits the ball 105, acoustic waves are generated. These are detected by the microphone 124 so that the flashes 116, 117 are triggered to emit light pulses. Points of times are defined by these flashes at which points of time the cameras 114, 115 detect images of the hit ball 105, the moving club 102 and the moving golf player 101 before, during or after the hit. Furthermore, sensor information sensed by the sensors 128 to 131 are transmitted to the Bluetooth communication interface 125. All these items of information are used by the CPU 113 to derive golf diagnosis information, like angle information, velocity information, distance information, etc. A result of such an evaluation may be output via the display unit 118 so as to be perceivable by the golfer 101. The CPU 113 may be implemented inside the golf diagnosis apparatus 110 so that the latter can be operated in an autarkic manner as a self-contained device. Alternatively, the CPU 113 may be implemented outside the golf diagnosis apparatus 110 for instance in a laptop so that the golf diagnosis apparatus 110 can be operated in combination with a detachably connectable laptop.

[0084] Furthermore, the user may input certain quality criteria which define the quality of a stroke. Such quality criteria may be a striking angle, a striking distance, etc. The CPU 113 detects, based on a comparison of the defined quality criteria with the derived parameters from the stroke, whether the actual stroke has been successful or not. Credits (for example a number of points between zero and ten) may be calculated for such a stroke. Furthermore, from the image data acquired by the CCDs 114, 115, golfer-related properties of the stroke may be derived like arm positions, leg positions, turning properties, swing amplitude, etc. The values of the parameters related to the quality criteria may be compared to the golf player related parameters. Based on this comparison, a correlation may be found between body positions of the golfer 101 and the success of the stroke. Such data items may be stored in the storage unit 135 which is an EEPROM. Thus, with each strike, the amount of data provided in the database 135 is increased so that the data basis for a statistical evaluation of the correlation between quality and golfer body positions can be increased successively. Therefore, a self-learning system is provided which refines the correlation between body position and quality of the stroke with each new item stored in the EEPROM 135. A neural network controlled by the CPU 113 may be trained with this information so as to become able to distinguish between good and bad strokes. As result of this, it becomes possible to formulate recommendations for improving the performance of the golfer 10 1 which may be output for a visual inspection by the user at the output display 118.

[0085] Referring to Fig. 1, the golf diagnosis apparatus 110 is adapted for evaluating a stroke of the golf player 101 captured by the cameras 114, 115. The golf pressure sensors 128, 129 allow to sense weight distributions of the golfer 101 during the hit, which may be used for evaluating a stroke. Position sensors 130, 131 may allow to derive position information of club 102 and ball 105 during the stroke.

[0086] Next, the self-learning golf diagnosis function of the system 110 will be explained in more detail.

[0087] Various functional sections may be provided within the CPU 113. An evaluation section evaluates a quality of a stroke of the golf player 103 based on the quality criteria defined by the user 101 via the input interface 119. A determining section in the CPU 113 determines a value of a parameter related to the stroke. For instance, such a stroke-related parameter or golfer-related parameter may be indicative of a body position of the golfer 101 when carrying out the stroke. When the CPU 113 has determined the quality of the stroke and the value of the parameter, a correlation section in the CPU 113, which may make use of the prestored historical information in the EEPROM 135, may determine correlations between the estimated quality and the estimated parameter indicative of the body position of the golfer 101. As a result, the system may provide the information that a particular body position of the golfer 101 has yielded statistically significantly, proper stroke results.

[0088] For instance, the quality criteria which may be input by the user 101 or which may be used automatically by the system 110 may be the stroke distance, a stroke angle, a stroke velocity, a stroke acceleration or a stroke spin. The parameters derived from the images captured by the CCDs 114, 115 and of the sensors 128 to 131 may be related to a golfer-related property during the stroke. Such parameters may include position information of the actuating golfer, body orientation, particularly orientation, motion and position of legs and feet of the golfer, and also the orientation of the club 102 during the stroke.

[0089] The storage unit 135 may store determined correlations between the parameter values related to the stroke and the evaluated stroke quality.

[0090] For performing such a correlation, statistical methods or other algorithms, image recognition features, etc. may be applied, and use may be made of the correlations stored in the storage unit 135. The cameras 114, 115 may have focussing optical elements so as to selectively capture only specific portions of the system formed by the golfer 101, the club 102 and the ball 105. It is also possible that one of the cameras 114, 115 captures a detailed view of a portion, for instance only the initial portion of the golf ball 105 motion after the hit, and the other one of the cameras 114, 115 may capture the entire image.

[0091] The microphone 124, in combination with the cameras 114, 115 and the performance of the CPU 113 may allow to automatically determine a distance between the CCDs 114, 115 and the golf ball 105 before the stroke. When the player 101 actuates the club 102 and hits the ball 105, corresponding acoustic waves are emitted to the microphone 124 and to the cameras 114, 115. Thus, optically and acoustically, the hit can be detected. Due to the different velocities of sound and of light, the detection of the hit occurs at different points of time at the position of the microphone 124 (detecting the acoustic waves) and at the position of the cameras 114, 115 (detecting the electromagnetic light waves). This allows to calculate a distance between the cameras 114, 115 and the ball 105 which may be taken as a basis for the calculation of the quality-related parameters of the stroke.

[0092] In the following, referring to **Fig. 2**, an illustration 200 will be explained related to the three-dimensional evaluation of the trajectory of the golf ball 105.

[0093] In Fig. 2, the golf ball 105 is shown at a first position A at which it rests on a tee (not shown), and on a second position B during the motion after a hit. Furthermore, a pin or hole 201 is shown. Beyond this, a camera 114 is illustrated in Fig. 2.

[0094] According to an exemplary embodiment, a three-dimensional evaluation of the trajectory of the golf ball 105 is possible. In the embodiment shown in Fig. 2, trajectory parameters of the ball 105 are evaluated using a single camera

114, considering the monitoring angle. Furthermore, the spherical contour of the ball 105 is used. Moreover, marks or patterns (not shown) which may be provided on the ball 105 or may be provided as a coloured portion of the ball 105 may be evaluated as well.

[0095] The flight parameters of the hit golf ball shall be estimated. The flight parameters are particularly the velocity, the direction (horizontal and vertical to the direction of the goal 201) and the spin of the ball 105. Subject of the illustration in Fig. 2 is the measurement of the horizontal deviation of the direction.

[0096] After the golf club 102 has hit the ball 105, and the ball 105 has left the club 102 completely, at least two images are captured by the camera 114 with a defined time interval. In order to measure the deviation of the actual from the desired direction of the golf ball 105, the dimension of the image of the golf ball 105, that is to say the monitoring angle, may be used. When the ball 105 is closer to the camera 114 at the second image, then the ball 105 will cover a larger area on the second image. If the ball is further away, it will appear to be smaller. From this size difference, from the distance of the positions of the ball 105 in the different images, and based on the apparent dimensional difference, the angle between the camera plane and the trajectory of the ball 105 may be estimated. In case that the camera plane is parallel to the desired flight direction of the ball 105, it may be possible to estimate the angle of deviation from a goal 201 in a given distance.

[0097] The exemplary embodiment of Fig. 2 may have the advantage that the use of a single camera 115 is sufficient, which allows to manufacture the corresponding golf diagnosis apparatus with low costs.

[0098] In the following, referring to **Fig. 3** and **Fig. 4**, another exemplary embodiment of the invention will be explained in which the golf club trajectory during the stroke is evaluated to derive three-dimensional information.

[0099] According to the exemplary embodiment of Fig. 3 and Fig. 4, a motion of a golf club 102 when hitting a golf ball 105 is evaluated. As can be taken from Fig. 3, when swinging 300 the golf club 102 from an initial position 301 to a final position 302, the motion of the golf club 102 can be captured (for instance using a stroboscope) before, during and after hitting the golf ball 105 with a camera 114 using the monitoring angle. The contour of the club head 104 can be taken into account for such an evaluation. The club shaft 103 can be evaluated. Furthermore, marks or patterns which may be provided at the club head 104 and/or at the club shaft 103 may be evaluated.

[0100] The motion of the golf club head 104 before and/or after hitting the golf ball 105 shall be estimated. In this context, important trajectory parameters are the velocity and/or the direction (horizontal and vertical to the direction of the goal).

[0101] At least two images are made from the golf club head 104 by a camera 114 with a defined time interval. From the positional information derived from these images, the velocity and the direction may be derived.

[0102] Furthermore, it may be possible to measure the deviation in the horizontal direction:

[0103] In order to measure the horizontal angle between the plane in which the golf club 102 is moved and the desired direction of the golf ball 105, the size of the image of the club head 104 and/or of the club shaft 103, that is to say the monitoring angle, may be used. When the club head 104 and/or the club shaft 103 is/are closer to the camera 114 at the second image, it will cover a larger area in the image. If it is further away, it will appear to be smaller. From this difference in sizes, from the distance of the positions of the club 102 at the different images, and from the apparent size difference, the angle between the camera plane and the ball trajectory may be estimated. When the camera plane is aligned parallel to the desired flight direction of the ball, this angle denotes also the horizontal deviation from the desired direction of the ball trajectory. Particularly, with such a launch monitor, the motion of the golf club 102 may be taken into account for the analysis.

[0104] As can be taken from Fig. 3, it is possible to determine the trajectory of the golf club 102 from the positions of the club head 104.

[0105] As indicated by reference numeral 400 in Fig. 4, the club shaft 103, a marker, or a front area of the club 102 may be used. A camera 114 may detect the various images. From the size of the image, the motion of the club 102 in direction of the camera 114 may be derived.

[0106] Next, referring to **Fig. 5** and **Fig. 6,** a method of back-calculation of a golf club trajectory according to an exemplary embodiment of the invention will be explained.

[0107] This embodiment intends to conclude from the situation after a hit between a golf club and a golf ball to the situation before the hit, thereby calculating back the motion of the club 102 before hitting the golf ball 105 from measured parameters of the motion of the golf ball 105 and of the club 102 after the hit. For this purpose, the contour of the golf ball 105 may be evaluated. Furthermore, the contour of the club head 104 and/or of the club shaft 103 may be evaluated. Beyond this, markers or patterns (not shown in the figures) attached to the golf ball 105 may be evaluated. Beyond this, markers or patterns attached to the club head 104 and/or to the club shaft 103 may be evaluated.

[0108] The motion of the club head 102 and of the golf ball 105 may be estimated after hitting the golf ball 105. From the trajectory parameters of the ball (like velocity, flight direction, spin and position of the spin axis direction) and of the club head 104 (velocity, direction of motion) after the collision, the motion of the club head 104 before hitting the ball 105 and the angle of the club head 104 at the moment of hitting the resting ball 105 may be calculated.

[0109] For the calculation, the system formed of golf ball 105 and club head 104 may be modelled by an analog system of two balls. The club head 104 may be substituted for the calculation by the sphere of an identical mass. The angle of the club head 104 with respect to the motion direction of the club head can be simulated by a non-central collision (see Fig. 5). The contact point of the sphere with the ball 105 shall be the same at which the ball 105 is hit by the club head 104. It is assumed, for the sake of simplicity, that elastic impact are involved and that the club head 104 moves linearly to the ball 105 (thus neglecting spin effects).

[0110] The ball 105 with the mass m' rests (velocity v'=0). The club 104 (the mass of the club head 104 is denoted as m) moves, as shown in Fig. 5, to the ball 105 with the velocity v. A collision occurs. After that, the ball 105 moves with the velocity u', and the club head 104 moves with a velocity u.

[0111] By the launch monitor, the direction and the absolute value of the velocities u and u' are measured. Using the laws of impulse conservation and energy conservation, from the absolute values of the velocity and the scatter angle between the motion directions, first of all the effective ratio of the masses of the club head 104 and of the ball 105, namely m/m', is estimated. Using impulse conservation, it is subsequently possible to estimate the absolute value and the direction of the velocity v of the club head 104.

[0112] The direction of the golf ball 105 may be described by a horizontal angle ϑ_h and is a vertical angle ϑ_V, respectively, as defined relatively to the axis of the goal 201.

[0113] The direction of the club head 104 may be described by a horizontal angle relative to the axis to the target line 201 (before the collision ϑ_P, after the collision ϑ_S).

[0114] The following equations illustrate the calculation scheme according to the described embodiments. It is understood that a plurality of alternative calculation schemes are possible to derive information before the collision from parameters measured after the collision.

[0115] The velocities are displayed as vectors. Equation (1) illustrates impulse conservation. Equation (3) illustrates energy conservation. Equations (8) and (9) illustrate results from a vector addition. Equation (10) is based on an approximation for the angle ϑ_B, by which the club head 104 deviates from the vertical in the horizontal direction of $\vec{v}$ vector.

$$m\vec{v} = m\vec{u} + m'\vec{u}' \qquad (1)$$

$$mv^2 = mu^2 + \frac{m'^2}{m}u'^2 + 2m'\vec{u}\vec{u}' \qquad (2)$$

$$mv^2 = mu^2 + m'u'^2 \qquad (3)$$

$$m'u'^2 = \frac{m'^2}{m}u'^2 + 2m'\vec{u}\vec{u}' \qquad (4)$$

$$\frac{m'}{m} = \frac{u'^2 - 2\vec{u}\vec{u}'}{u'^2} \qquad (5)$$

$$\frac{m'}{m} = \frac{|\vec{u}'| - 2|\vec{u}|\cos\varphi}{|\vec{u}'|} \qquad (6)$$

$$\vec{v} = \vec{u} + \frac{m'}{m}\vec{u}' \qquad (7)$$

$$\vartheta_P = \arctan\left(\frac{\frac{m'}{m}|\vec{u}'|\sin\vartheta_h + |\vec{u}|\sin\vartheta_S}{\frac{m'}{m}|\vec{u}'|\cos\vartheta_h + |\vec{u}|\cos\vartheta_S}\right) \qquad (8)$$

$$|\vec{v}| = \sqrt{\left(\frac{m'}{m}|\vec{u}'|\sin\vartheta_h + |\vec{u}|\sin\vartheta_S\right)^2 + \left(\frac{m'}{m}|\vec{u}'|\cos\vartheta_h + |\vec{u}|\cos\vartheta_S\right)^2} \qquad (9)$$

$$\vartheta_B = \frac{\vartheta_P - \vartheta_H}{2} \qquad (10)$$

[0116] In the following, an example will be given for the case that the ball 105 is hit in a bad manner, and flies without rising 20° away from the goal 201.

[0117] The ball 105 has a velocity |u'|=40m/s. The vertical angle ϑ_V=0°. The horizontal angle ϑ_h=20°.

[0118] What concerns the club head 104, |u|=25m/s. ϑ_s=-30°, which is the horizontal angle after the hit.

[0119] The scatter angle φ=50°. This yields the following results:

$$\frac{m'}{m} = \frac{40 - 2 * 25\cos 50^\circ}{50} = 0.2 \qquad (11)$$

$$\vartheta_P = \arctan\left(\frac{\frac{m'}{m}40 * \sin(-30^\circ) + 25 * \sin(-30^\circ)}{\frac{m'}{m}40 * \cos(20^\circ) + 25 * \cos(-30^\circ)}\right) = -18.5^\circ \qquad (12)$$

[0120] The result of the vector addition is that the club head 104 moves approximately 18.5° deviating from the goal 201.

[0121] With regard to **Fig. 7**, a sole 700 is illustrated for insertion into a golf shoe.

[0122] The sole 700 comprises a first pressure sensor 701 and a second pressure sensor 702. The first pressure sensor 701 is provided at a back portion of the sole 700, whereas the second sensor 702 is provided at a front portion of the sole 700. Although not shown in Fig. 7, RFID tags are provided so that the sensor information from the sensors 701, 702 may be transmitted to a remote destination 8 for instance to the CPU 113.

[0123] It should be noted that the term "comprising" does not exclude other elements or features and the "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined.

[0124] It should also be noted that reference signs in the claims shall not be construed as limiting the scope of the claims.

Claims

1. A self-learning golf diagnosis apparatus, comprising

   an evaluation unit for evaluating a quality of a stroke of a golf player based on a predetermined quality criteria;
   a determining unit for determining a parameter related to the stroke;
   a correlation unit for determining a correlation between the parameter related to the stroke and the evaluated quality of the stroke.

2. The self-learning golf diagnosis apparatus of claim 1, wherein the predetermined quality criteria comprises at least one of the group consisting of a golf ball flight distance, a stroke angle, a stroke velocity, a stroke acceleration, and a stroke spin.

3. The self-learning golf diagnosis apparatus of claim 1 or 2, wherein the parameter is indicative of a golfer-related property with regard to the stroke.

4. The self-learning golf diagnosis apparatus of any one of claims 1 to 3, wherein the parameter is related to at least one of the group consisting of a position of a body of the golfer during the stroke, an orientation of a body of the golfer during the stroke, a position of legs of the golfer during the stroke, an orientation of legs of the golfer during the stroke, a position of a club operated by the golfer during the stroke, and an orientation of a club operated by the golfer during the stroke.

5. The self-learning golf diagnosis apparatus of any one of claims 1 to 4, comprising a storage unit adapted to store determined correlations between the parameter related to the stroke and the evaluated quality of the stroke.

6. The self-learning golf diagnosis apparatus of claim 5, wherein the correlation unit is adapted for determining the correlation between the value of the parameter, particularly a ball parameter, related to the stroke and the evaluated quality of the stroke using correlations stored in the storage unit.

7. The self-learning golf diagnosis apparatus of any one of claims 1 to 6, wherein the correlation unit is adapted for determining the correlation between the value of the parameter related to the stroke and the evaluated quality of the stroke by performing a statistical analysis.

8. The self-learning golf diagnosis apparatus of any one of claims 1 to 7, comprising an image acquisition device for capturing an image of the stroke of the golf player.

9. The self-learning golf diagnosis apparatus of claim 8, wherein the image acquisition device is adapted for capturing an image of at least one of the group consisting of a golf ball, at least a part of a golf club, and at least a part of the golf player.

10. The self-learning golf diagnosis apparatus of claim 8 or 9, wherein the image acquisition device is adapted for capturing an image of the stroke of the golf player at a time corresponding to at least one of the group consisting of before the stroke, during the stroke, and after the stroke.

11. The self-learning golf diagnosis apparatus of any one of claims 8 to 10, comprising an image processing unit, particularly an image recognition unit, for processing the image captured by the image acquisition device so as to derive at least one of the group consisting of information indicative of the quality of the stroke and the parameter related to the stroke.

12. The self-learning golf diagnosis apparatus of any one of claims 1 to 11, comprising a user interface for allowing a user to determine the quality criteria.

13. The self-learning golf diagnosis apparatus of any one of claims 1 to 12, comprising an output unit for outputting a determined correlation between the parameter related to the stroke and the evaluated quality of the stroke.

14. The self-learning golf diagnosis apparatus of claim 13,
wherein the output unit is adapted for outputting a proposal to a user as to how to modify the parameter related to the stroke so as to improve quality of the stroke.

15. The self-learning golf diagnosis apparatus of any one of claims 1 to 14,
comprising a sensor unit adapted to sense at least one sensor parameter related to the stroke of the golf player.

16. The self-learning golf diagnosis apparatus of claim 15,
wherein the sensor unit is adapted to sense at least one of the group consisting of a weight distribution acting on the feet of the golf player carrying out the stroke, and a weight distribution acting on different portions of a foot of the golf player carrying out the stroke.

17. The self-learning golf diagnosis apparatus of claim 15 or 16,
wherein the sensor unit is provided in a sole for insertion into a golf shoe.

18. The self-learning golf diagnosis apparatus of any one of claims 15 to 17,
wherein the sensor unit is adapted for sensing the parameter related to the stroke.

19. The self-learning golf diagnosis apparatus of any one of claims 15 to 18,
wherein the sensor unit is adapted for providing the at least one sensor parameter via a wireless communication path.

20. The self-learning golf diagnosis apparatus of any one of claims 1 to 19,
comprising a self-calibration unit adapted for automatically determining a distance between the self-learning golf diagnosis apparatus and a golf ball before the stroke.

21. The self-learning golf diagnosis apparatus of claim 20,
wherein the self-calibration unit comprises at least one of the group consisting of a combined light barrier and acoustic detection unit, a combined optical detection unit and acoustic detection unit, predetermined golf ball size information, predetermined marker size information, and predetermined calibration body size information.

22. The self-learning golf diagnosis apparatus of any one of claims 1 to 21,
comprising an adapter for connecting at least one additional component.

23. The self-learning golf diagnosis apparatus of claim 22,
wherein the adapter is adapted for connecting, as the at least one additional component, at least one of the group consisting of an additional image acquisition device, an additional sensor unit, and an additional stroboscope unit.

24. The self-learning golf diagnosis apparatus of any one of claims 1 to 23,
wherein the determining unit is adapted for determining a plurality of parameters related to the stroke;
wherein the correlation unit is adapted for determining a correlation between the plurality of parameters related to the stroke and the evaluated quality of the stroke.

25. A self-learning golf diagnosis method, comprising

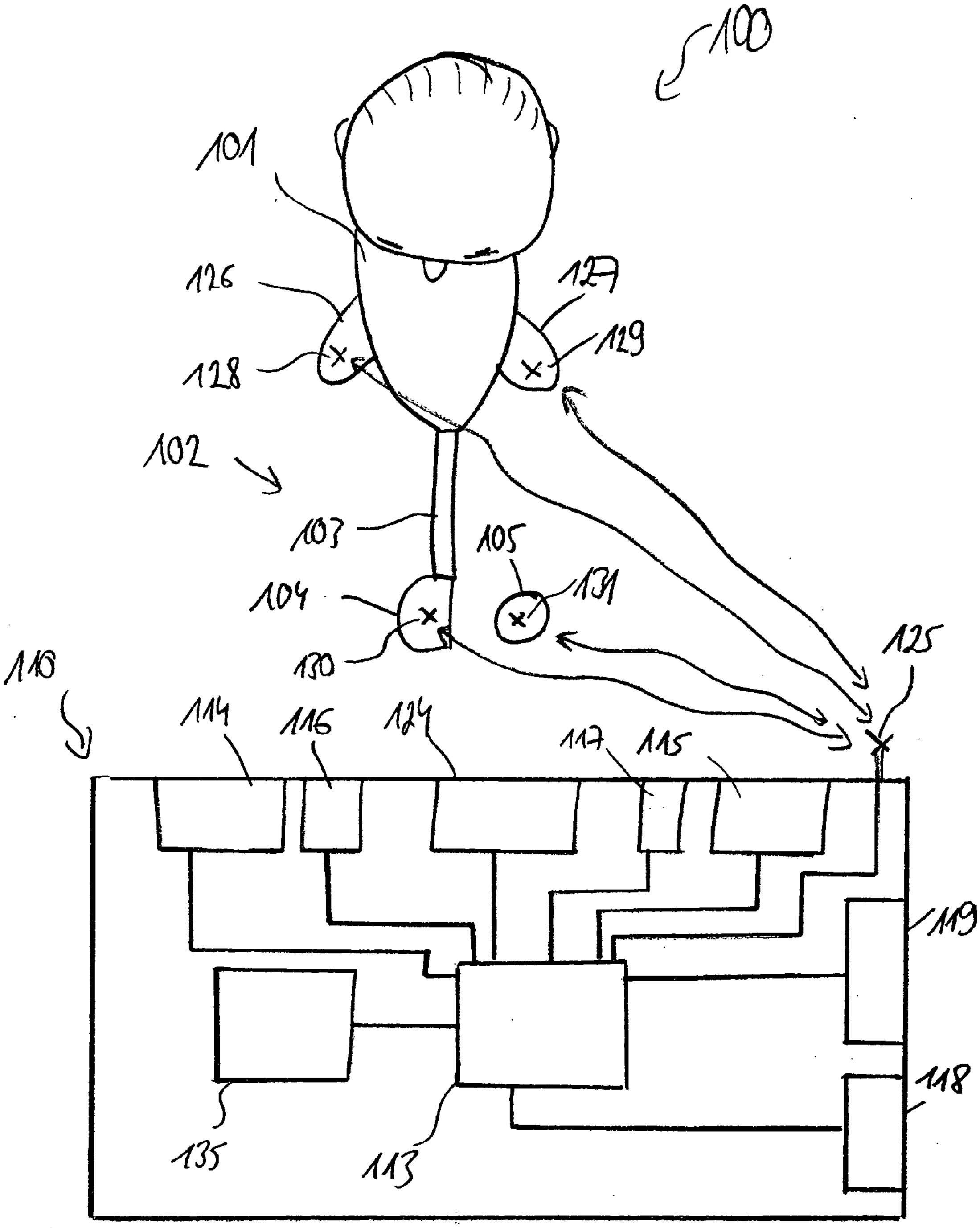
evaluating a quality of a stroke of a golf player based on a predetermined quality criteria;
determining a parameter related to the stroke;
determining a correlation between the parameter related to the stroke and the evaluated quality of the stroke.

26. A program element, which, when being executed by a processor, is adapted to control or carry out a self-learning golf diagnosis method comprising:

evaluating a quality of a stroke of a golf player based on a predetermined quality criteria;
determining a parameter related to the stroke;
determining a correlation between the parameter related to the stroke and the evaluated quality of the stroke.

27. A computer-readable medium, in which a computer program is stored which, when being executed by a processor, is adapted to control or carry out a self-learning golf diagnosis method comprising:

evaluating a quality of a stroke of a golf player based on a predetermined quality criteria;
determining a parameter related to the stroke;
determining a correlation between the parameter related to the stroke and the evaluated quality of the stroke.


100
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126
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128
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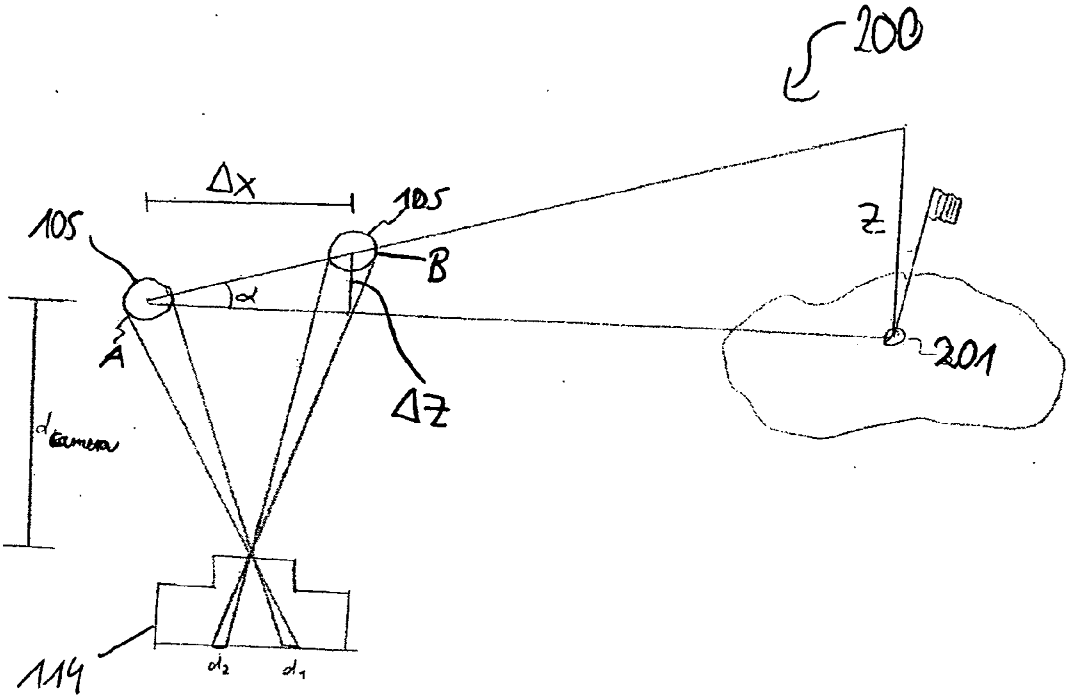
135
113

Fig. 1



$$\Delta d = d_1 - d_2$$

$$\Delta Z = \Delta d \cdot \frac{d_{camera}}{d_2}$$

$$\tan\alpha \approx \frac{\Delta Z}{\Delta x}$$

Fig 2

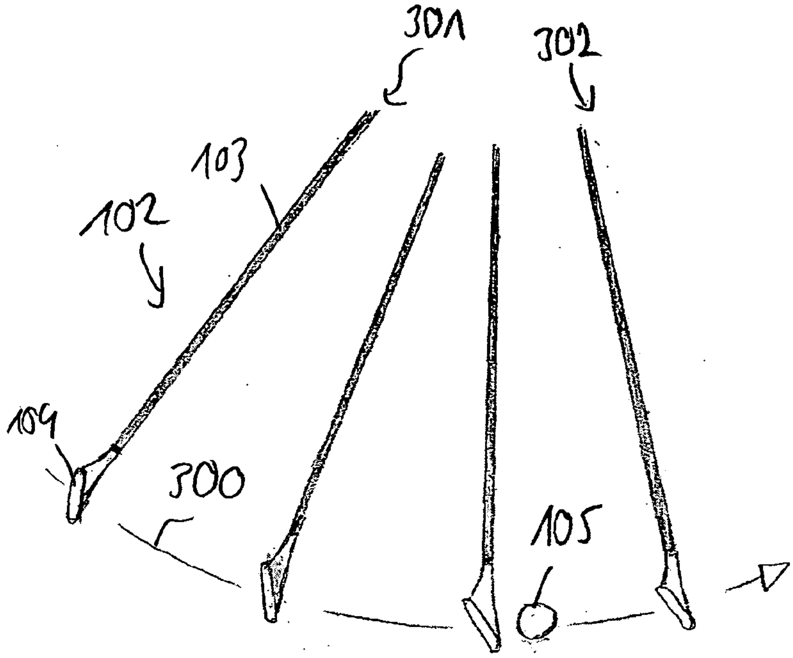
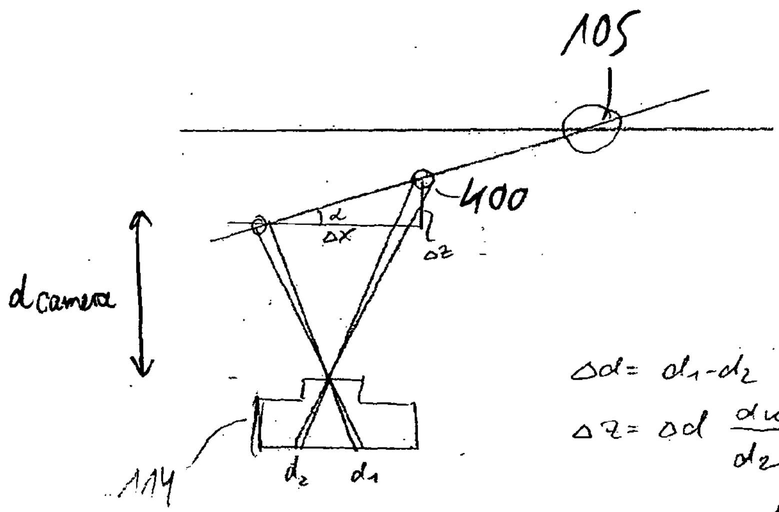


Fig.3



$\Delta d = d_1 - d_2$

$\Delta z = \Delta d \, \frac{d_{camera}}{d_2}$

Fig.4

$\tan\alpha \approx \frac{\Delta z}{\Delta x}$

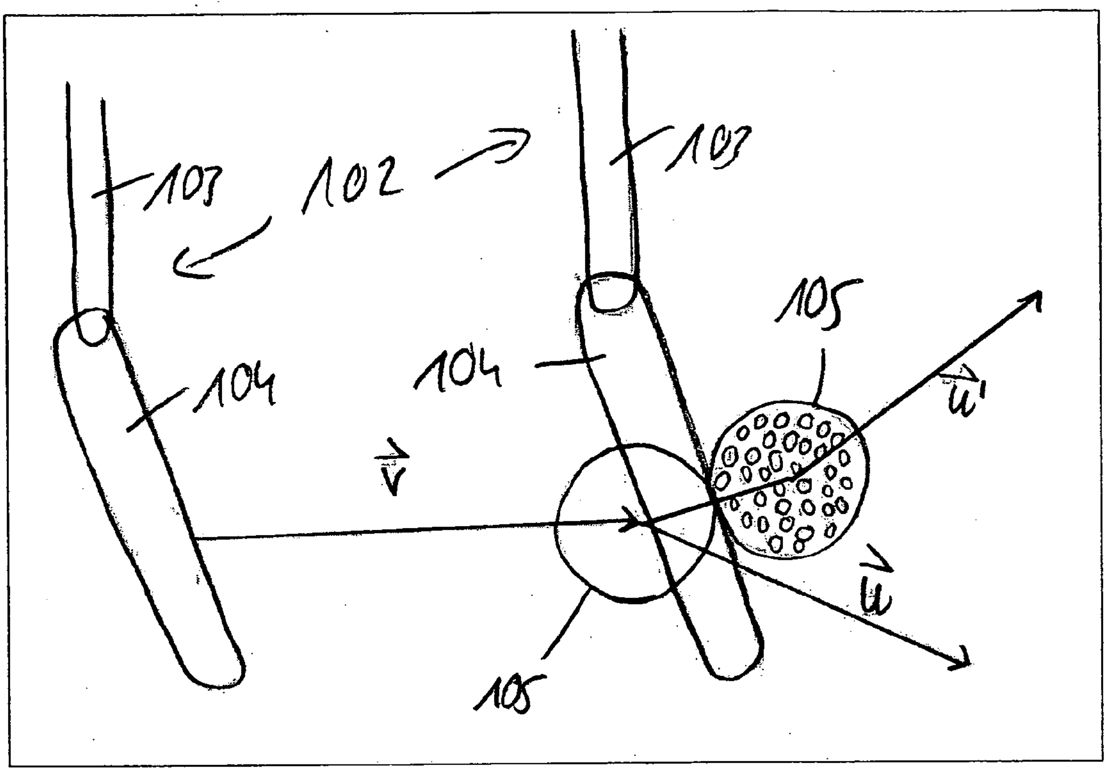


Fig. 5

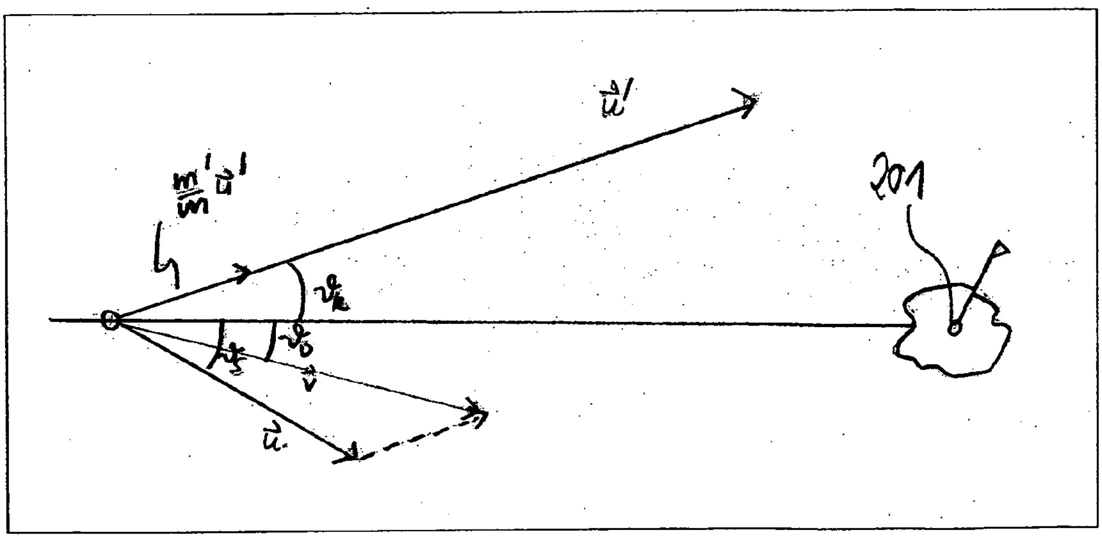


Fig. 6

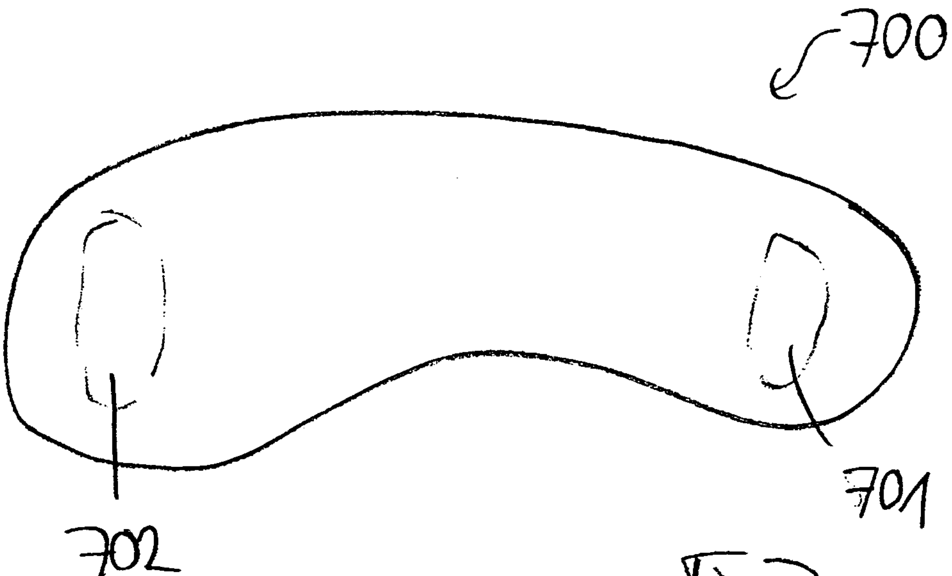


Fig. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 00 5266

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 111 410 A (NAKAYAMA MIZUO [JP] ET AL) 5 May 1992 (1992-05-05) * column 2, lines 30-34 - column 3, lines 52-67 * * column 5, lines 44-66 - column 6, lines 2-49 * * column 13, lines 8-68; figures *	1-27	INV. A63B69/36 A63B24/00
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X A	US 2004/106460 A1 (LEE NATHAN J [US] ET AL) 3 June 2004 (2004-06-03) * paragraphs [0004], [0017], [0020], [0030], [0078], [0079] *	1-12, 25-27 13-24	
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TECHNICAL FIELDS SEARCHED (IPC)

A63B
G06T
G09B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 April 2007	Teissier,Sara

CATEGORY OF CITED DOCUMENTS

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26-04-2007

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