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(54) **MOTION ANALYSIS DEVICE, MOTION ANALYSIS METHOD, MOTION ANALYSIS SYSTEM, AND DISPLAY METHOD**

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(57) **ABSTRACT**

A swing analysis device analyzing a swing using a golf club, includes a data acquisition portion acquiring position information, and motion information output from an inertial sensor, a processor generating first analysis information obtained by analyzing a swing on the basis of motion information corresponding to a plurality of the swings at first position information and second analysis information obtained by analyzing a swing on the basis of motion information corresponding to a plurality of the swings at second position information, and a display outputting a first region image based on the first analysis information and a second region image based on the second analysis information.

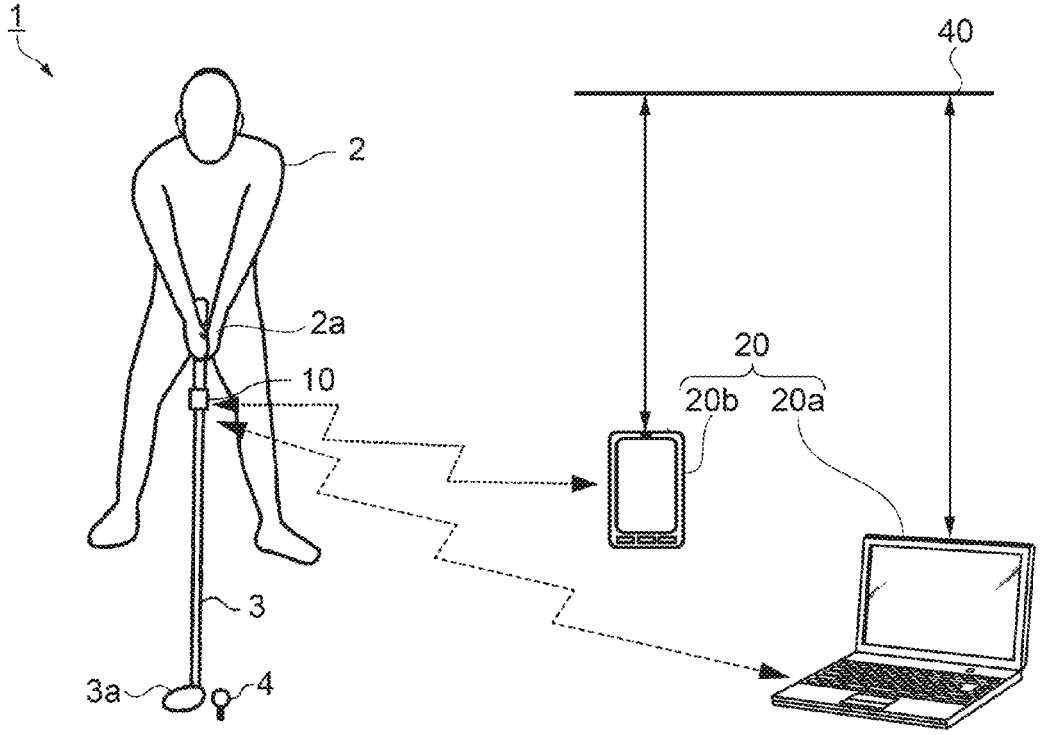


FIG. 1

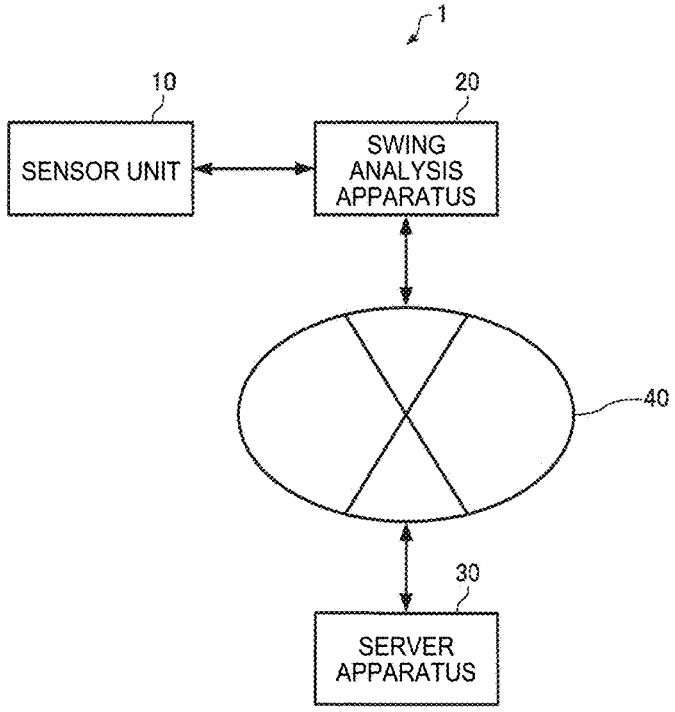
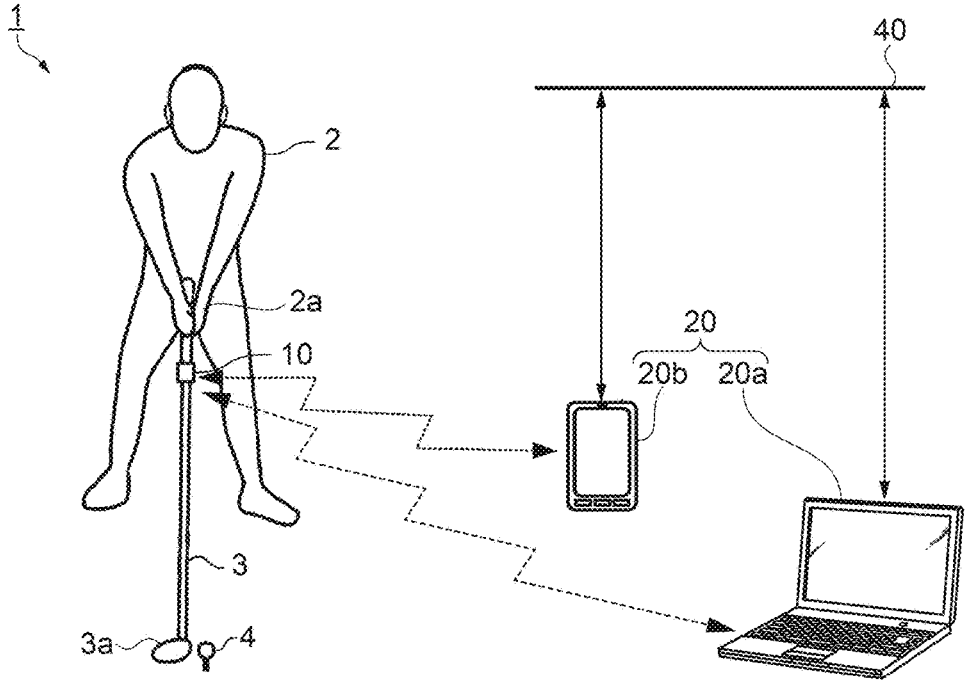

1
10
20
SENSOR UNIT
SWING ANALYSIS APPARATUS
40
30
SERVER APPARATUS

FIG. 2


1
40
2
2a
10
20
20b
20a
3
3a
4

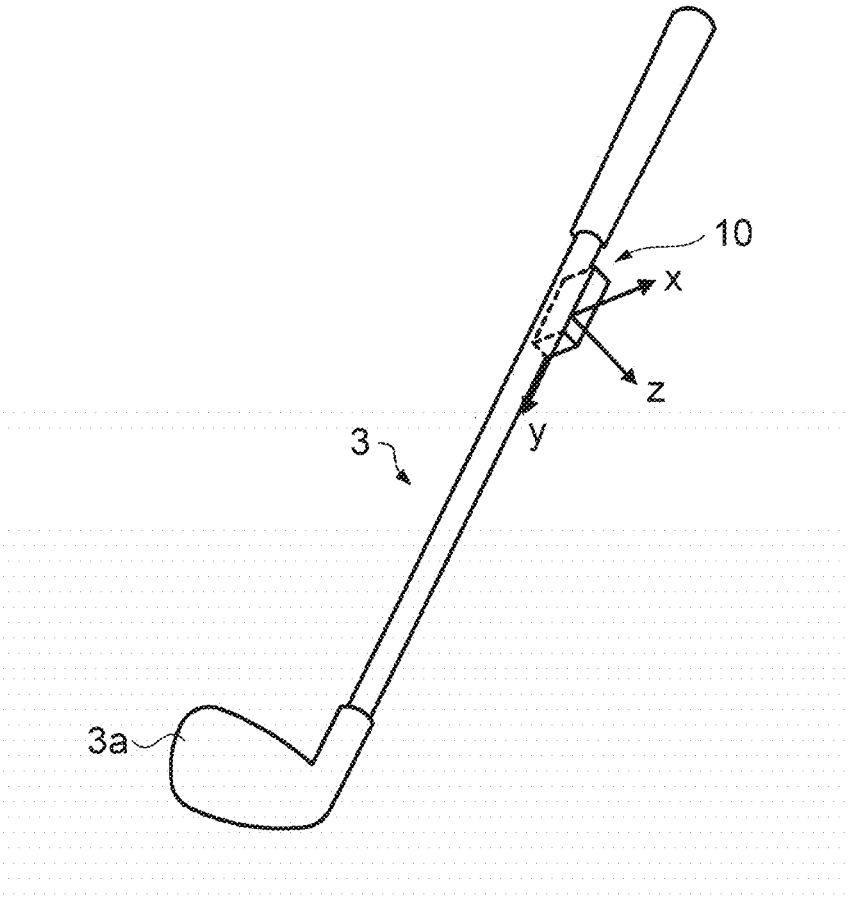


FIG. 3

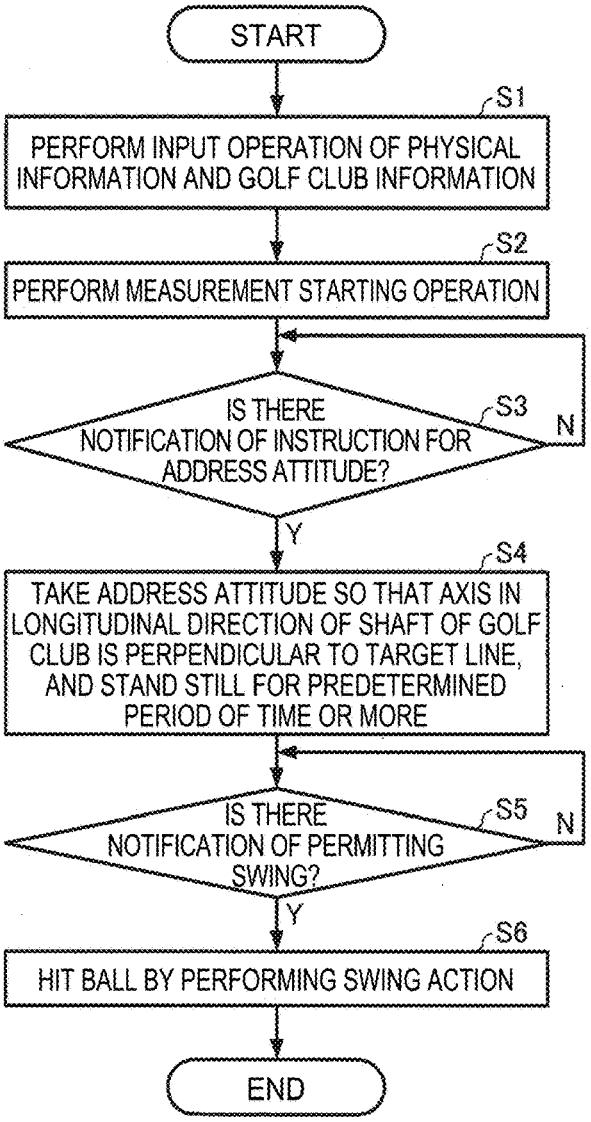

START
S1
PERFORM INPUT OPERATION OF PHYSICAL INFORMATION AND GOLF CLUB INFORMATION
S2
PERFORM MEASUREMENT STARTING OPERATION
S3
IS THERE NOTIFICATION OF INSTRUCTION FOR ADDRESS ATTITUDE?
N
Y
S4
TAKE ADDRESS ATTITUDE SO THAT AXIS IN LONGITUDINAL DIRECTION OF SHAFT OF GOLF CLUB IS PERPENDICULAR TO TARGET LINE, AND STAND STILL FOR PREDETERMINED PERIOD OF TIME OR MORE
S5
IS THERE NOTIFICATION OF PERMITTING SWING?
N
Y
S6
HIT BALL BY PERFORMING SWING ACTION
END

FIG. 4

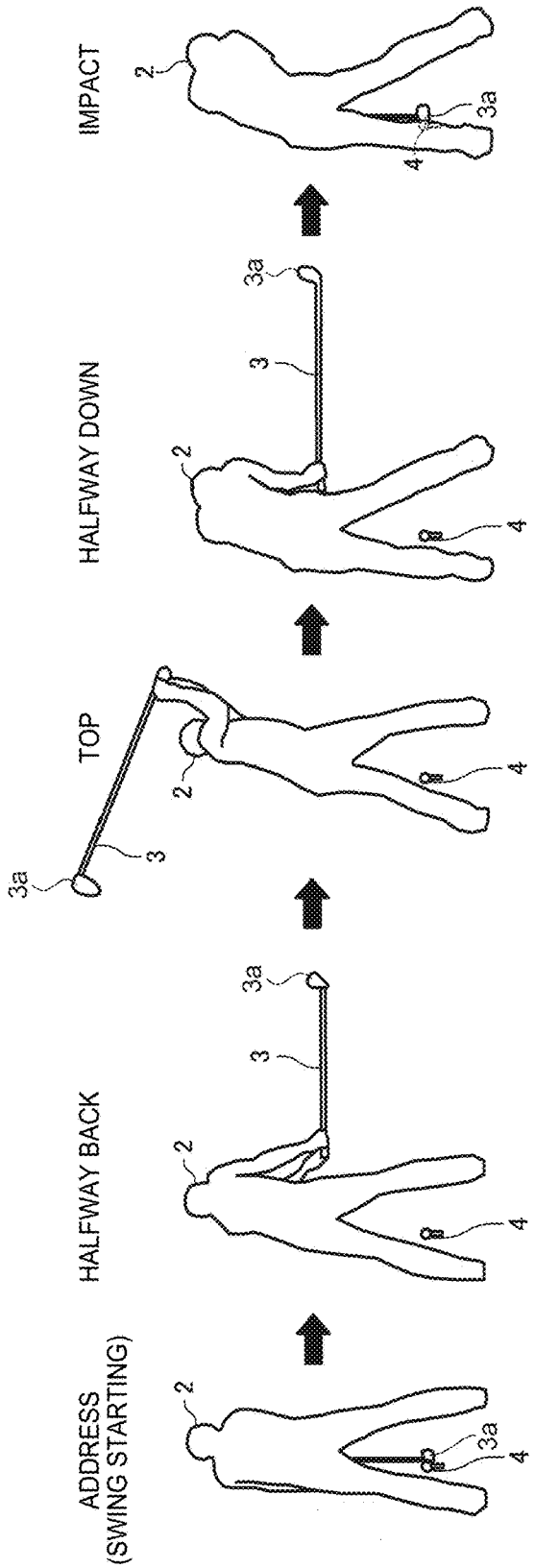

ADDRESS
(SWING STARTING)
HALFWAY BACK
TOP
HALFWAY DOWN
IMPACT
2
3
3a
4

FIG. 5

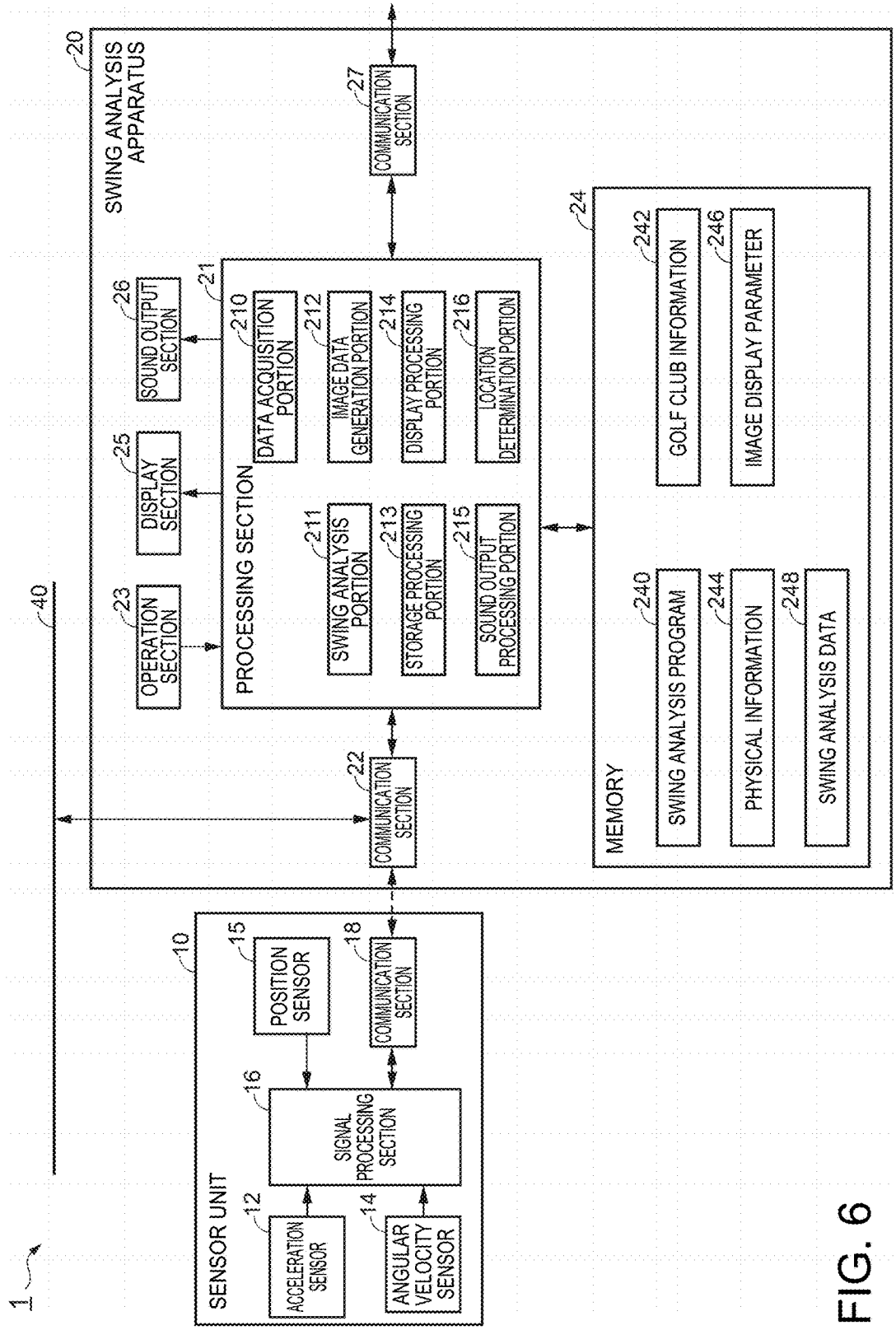

1
40
SENSOR UNIT
10
ACCELERATION SENSOR
12
ANGULAR VELOCITY SENSOR
14
SIGNAL PROCESSING SECTION
16
POSITION SENSOR
15
COMMUNICATION SECTION
18
SWING ANALYSIS APPARATUS
20
OPERATION SECTION
23
DISPLAY SECTION
25
SOUND OUTPUT SECTION
26
PROCESSING SECTION
21
DATA ACQUISITION PORTION
210
IMAGE DATA GENERATION PORTION
212
DISPLAY PROCESSING PORTION
214
LOCATION DETERMINATION PORTION
216
SWING ANALYSIS PORTION
211
STORAGE PROCESSING PORTION
213
SOUND OUTPUT PROCESSING PORTION
215
COMMUNICATION SECTION
22
COMMUNICATION SECTION
27
MEMORY
24
SWING ANALYSIS PROGRAM
240
GOLF CLUB INFORMATION
242
PHYSICAL INFORMATION
244
IMAGE DISPLAY PARAMETER
246
SWING ANALYSIS DATA
248

FIG. 6

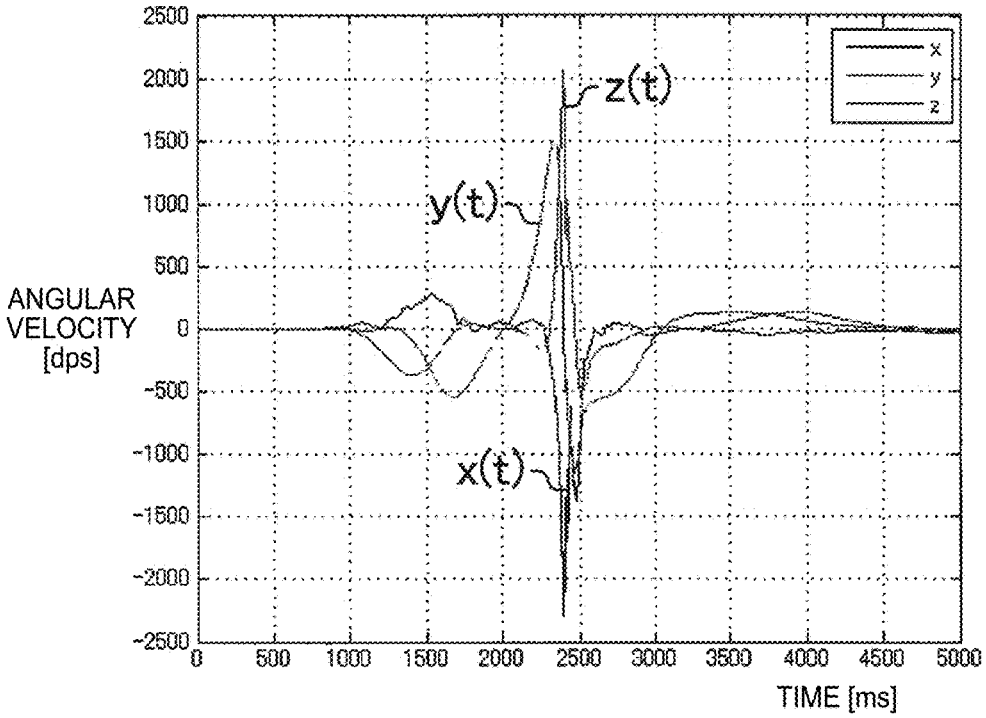

2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
ANGULAR VELOCITY [dps]
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
TIME [ms]
z(t)
y(t)
x(t)
x
y
z

FIG. 7

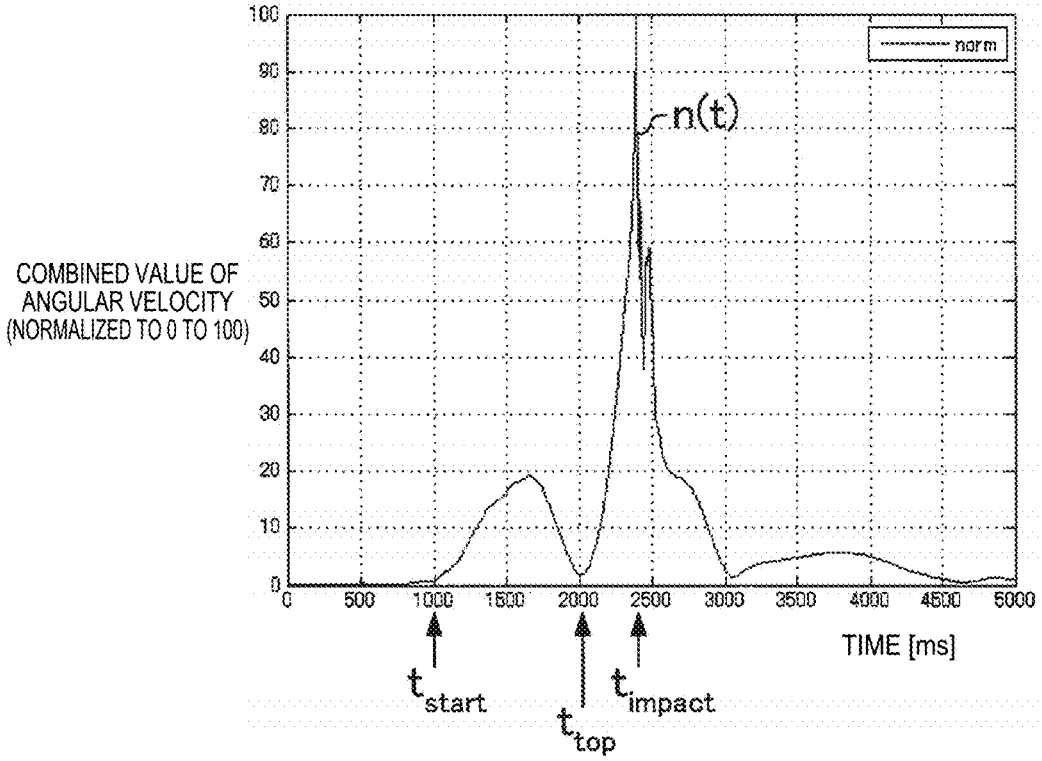

norm
n(t)
COMBINED VALUE OF ANGULAR VELOCITY (NORMALIZED TO 0 TO 100)
TIME [ms]
t_{start}
t_{top}
t_{impact}

FIG. 8

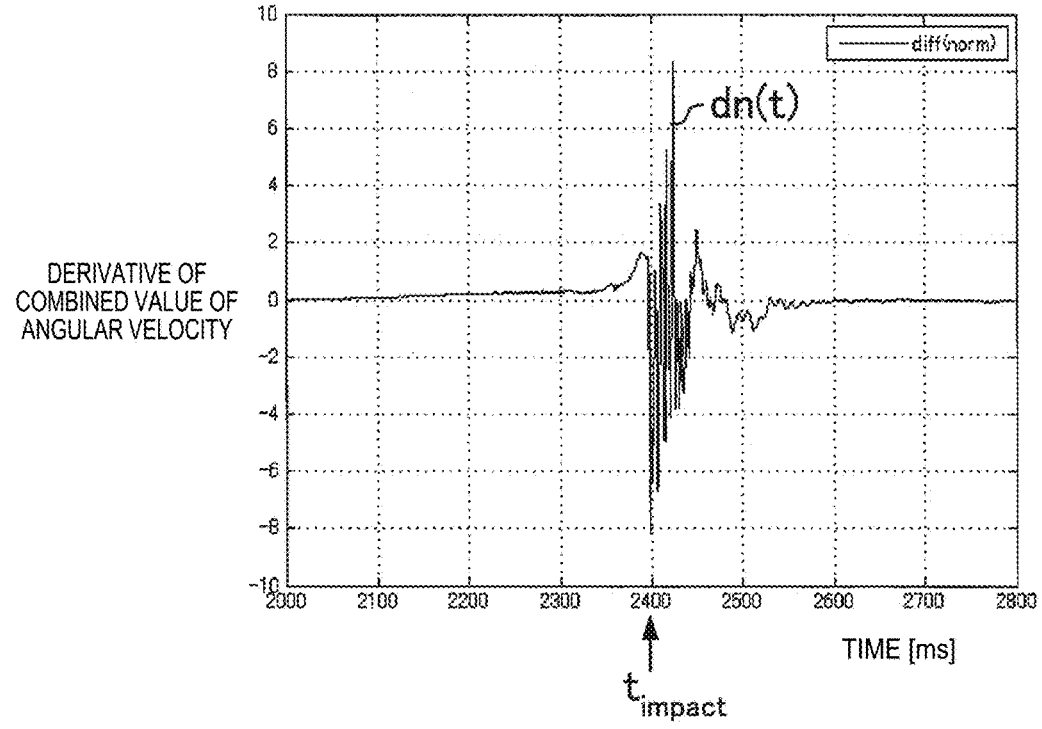

diff(norm)
dn(t)
DERIVATIVE OF COMBINED VALUE OF ANGULAR VELOCITY
TIME [ms]
t_{impact}

FIG. 9

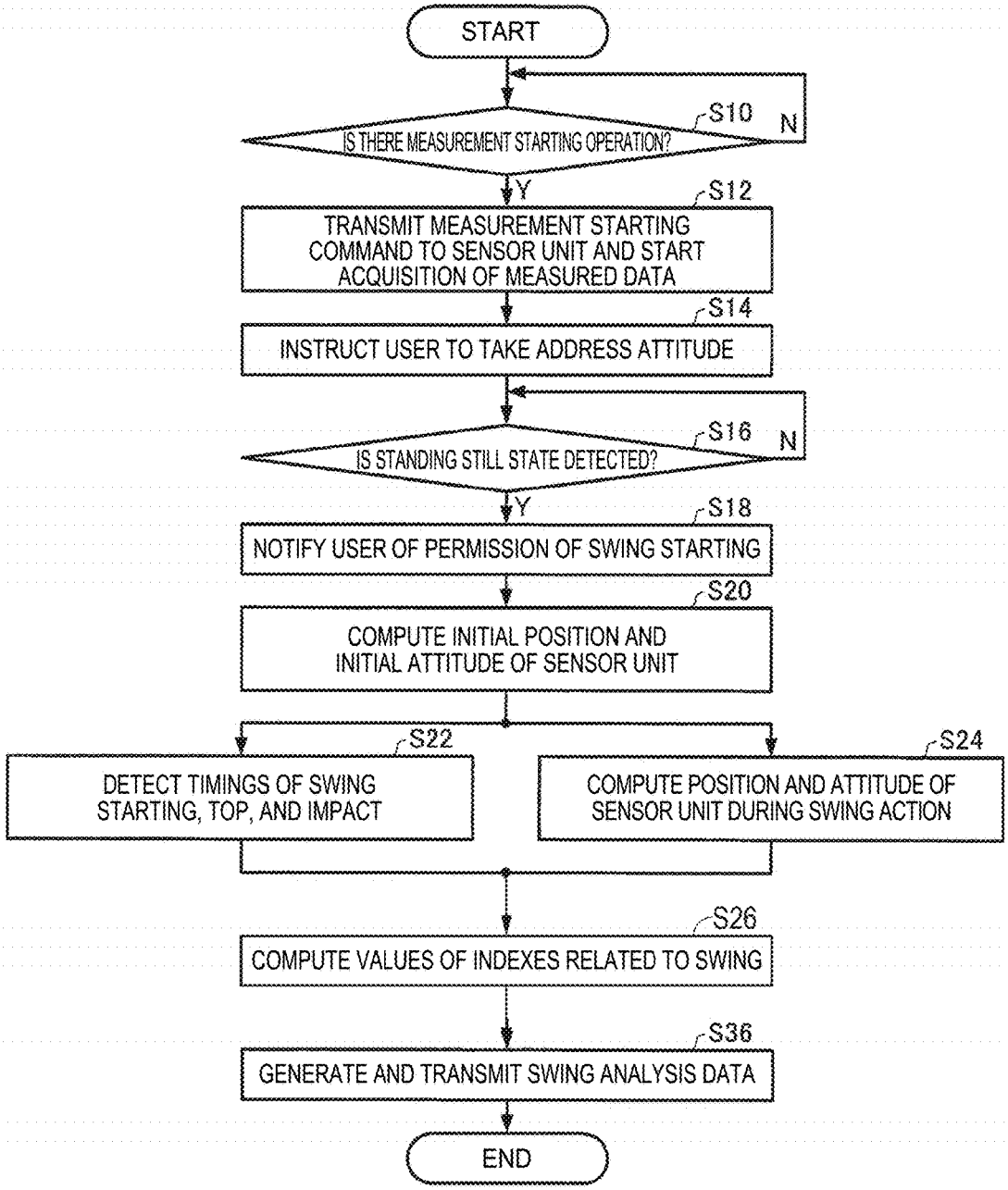

START
S10
IS THERE MEASUREMENT STARTING OPERATION?
N
Y
S12
TRANSMIT MEASUREMENT STARTING COMMAND TO SENSOR UNIT AND START ACQUISITION OF MEASURED DATA
S14
INSTRUCT USER TO TAKE ADDRESS ATTITUDE
S16
IS STANDING STILL STATE DETECTED?
N
Y
S18
NOTIFY USER OF PERMISSION OF SWING STARTING
S20
COMPUTE INITIAL POSITION AND INITIAL ATTITUDE OF SENSOR UNIT
S22
DETECT TIMINGS OF SWING STARTING, TOP, AND IMPACT
S24
COMPUTE POSITION AND ATTITUDE OF SENSOR UNIT DURING SWING ACTION
S26
COMPUTE VALUES OF INDEXES RELATED TO SWING
S36
GENERATE AND TRANSMIT SWING ANALYSIS DATA
END

FIG. 10

FIG. 11

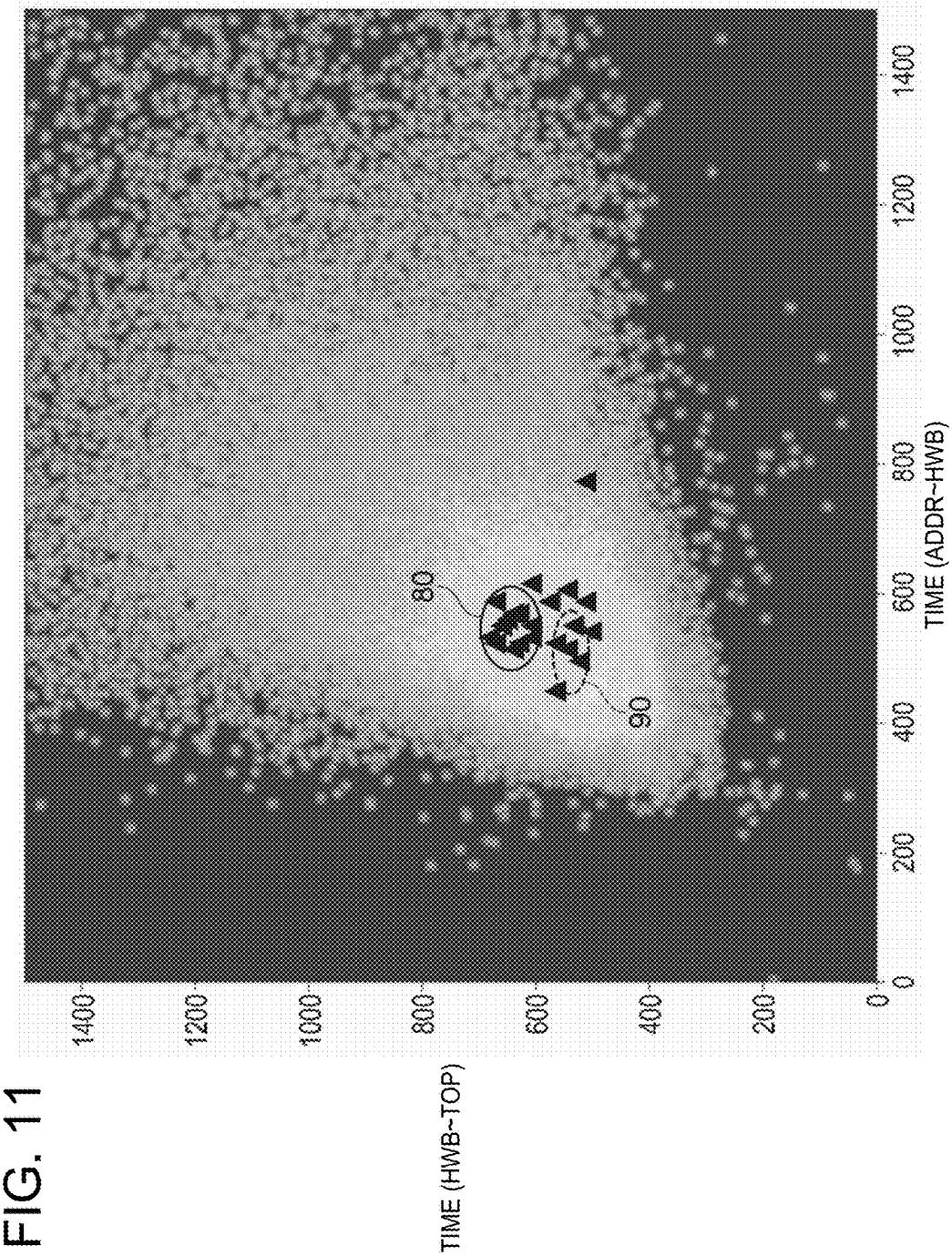

80
90
TIME (HWB~TOP)
TIME (ADDR~HWB)
0
200
400
600
800
1000
1200
1400

FIG. 12

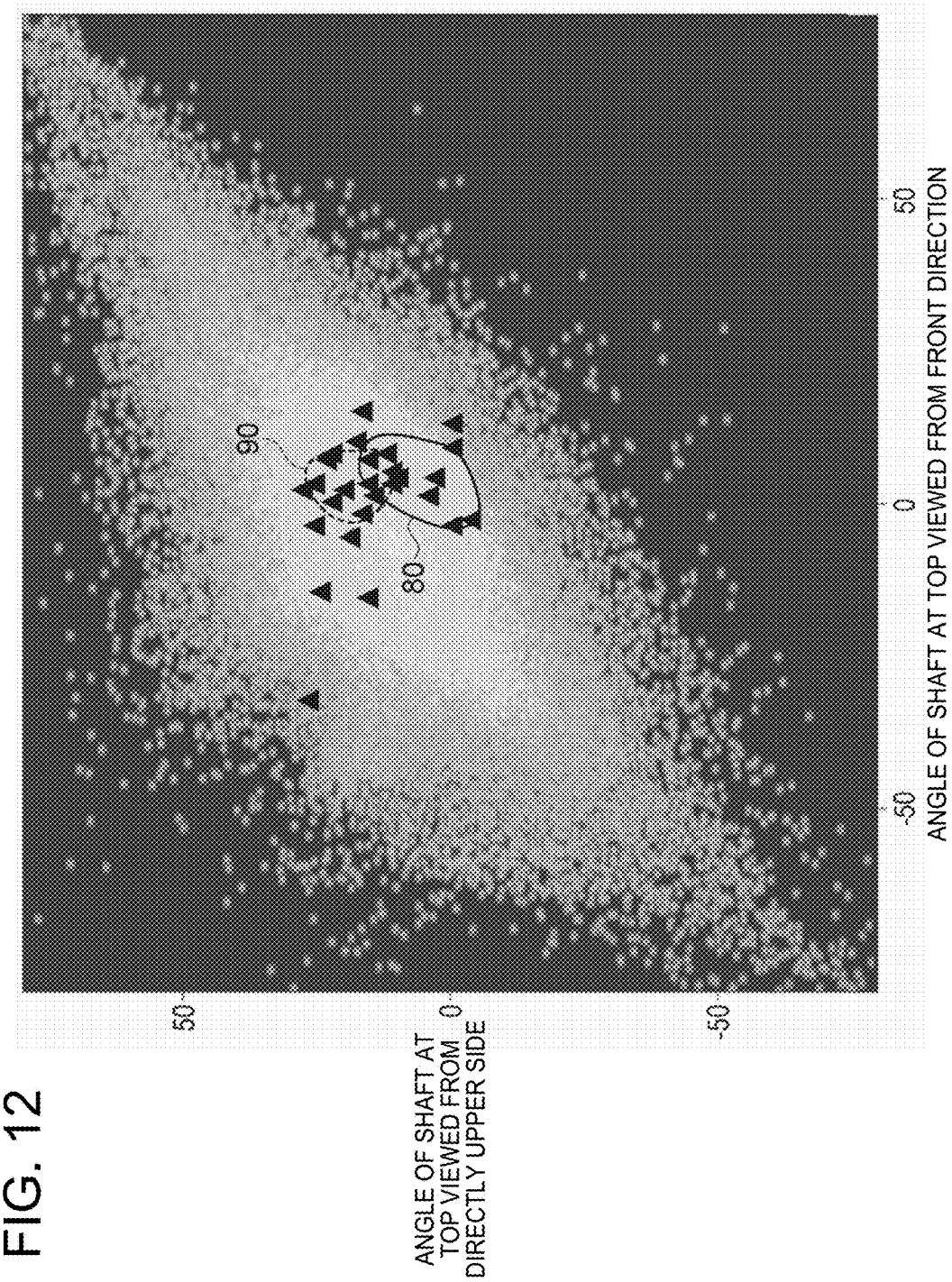

90
80
50
0
-50
ANGLE OF SHAFT AT TOP VIEWED FROM DIRECTLY UPPER SIDE
50
0
-50
ANGLE OF SHAFT AT TOP VIEWED FROM FRONT DIRECTION

FIG. 13

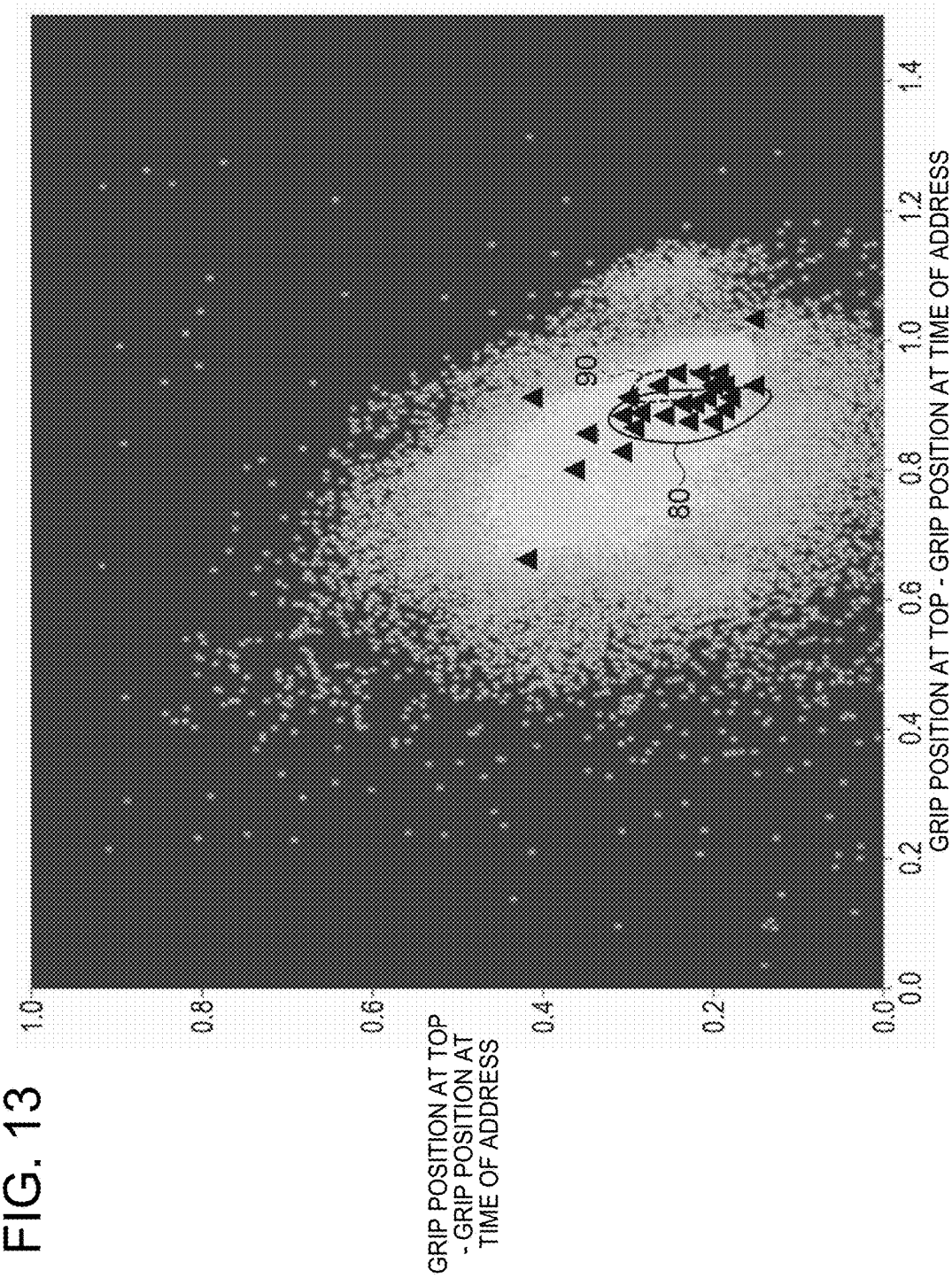
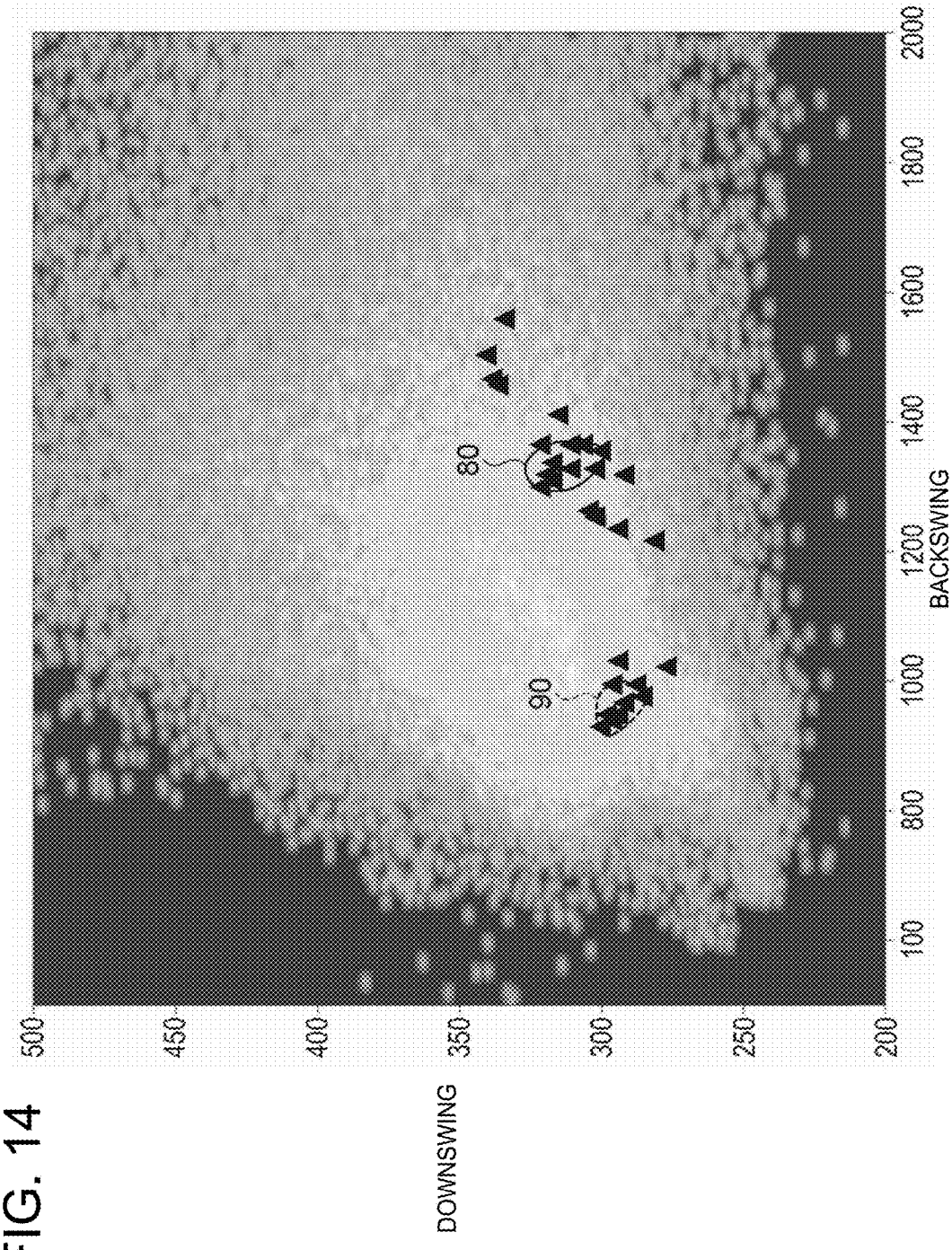

GRIP POSITION AT TOP - GRIP POSITION AT TIME OF ADDRESS
GRIP POSITION AT TOP - GRIP POSITION AT TIME OF ADDRESS
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.0
0.2
0.4
0.6
0.8
1.0
90
80

FIG. 14


DOWNSWING
500
450
400
350
300
250
200
100
800
1000
1200
1400
1600
1800
2000
BACKSWING
80
90

MOTION ANALYSIS DEVICE, MOTION ANALYSIS METHOD, MOTION ANALYSIS SYSTEM, AND DISPLAY METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Japanese patent application JP 2017-040155 filed Mar. 3, 2017, which is incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present invention relates to a motion analysis device, a motion analysis method, a motion analysis system, and a display method.

2. Related Art

[0003] In the related art, there is a technique in which a swing trajectory of a golf club, a racket, or a bat as an exercise equipment in sports such as golf, tennis, or baseball is analyzed, and an athletic ability of a player is enhanced by improving a swing trajectory. As an example of such a technique, for example, JP-A-2013-31529 discloses an analysis apparatus in which an inertial sensor is attached to a golf club, and swing analysis is performed on the basis of a motion signal which is output in a case where a golf ball is hit through a swing of the golf club.

[0004] A user attaches an analysis apparatus to a golf club in a golf course or a golf practice range, and can improve a swing of the user or select an appropriate golf club by performing swing analysis.

[0005] However, as well known, since, in a sport such as golf, there is a difference in performance between the time of practice in a golf practice range and the time of playing golf in a golf course, there is the need for an analysis apparatus which can divide such a difference in performance depending on situations in which a swing is performed, and can perform swing analysis according to each situation.

SUMMARY

[0006] An advantage of some aspects of the invention is to perform swing analysis according to a location where a swing is performed.

[0007] The invention can be implemented as the following forms or application examples.

Application Example 1

[0008] A motion analysis device according to this application example analyzes a swing using a golf club, and includes an acquisition portion acquiring position information, and motion information output from an inertial information obtained by analyzing a plurality of the swings at first position information and second analysis information obtained by analyzing a plurality of the swings at second position information; and an output portion outputting a first region image based on the first analysis information and a second region image based on the second analysis information.

[0009] According to this configuration, since a swing is analyzed on the basis of motion information corresponding to each of a swing at the first position information and a swing at the second position information, it is possible to perform swing analysis corresponding to a swing position.

[0010] According to this configuration, it is possible to output the first region image based on the first analysis information and the second region image based on the second analysis information, obtained through analysis.

Application Example 2

[0011] It is preferable that the motion analysis device according to the application example includes a display that displays outputs from the output portion.

[0012] According to this configuration, it is possible to visually recognize analysis images related to the first analysis information and the second analysis information.

Application Example 3

[0013] In the motion analysis device according to the application example, it is preferable that the first region image and the second region image are displayed in a coordinate system having two indexes respectively related to the first analysis information and the second analysis information as axes.

[0014] According to this configuration, the first region image and the second region image can be displayed in a coordinate system having two indexes respectively related to the first analysis information and the second analysis information as axes.

Application Example 4

[0015] In the motion analysis device according to the application example, the first analysis information may include information related to at least one of a movement distance or a movement time of a head of the golf club from address to halfway back and from the halfway back to top, angles of a shaft of the golf club viewed from a front side and an upper side of the golf club at top, a movement distance of a grip of the golf club at the time of address in a height direction or a rear direction at top, and times required for a backswing and a downswing.

Application Example 5

[0016] In the motion analysis device according to the application example, the first position information may indicate a golf course, and the second position information may indicate a golf practice range.

Application Example 6

[0017] It is preferable that the motion analysis device according to the application example further includes a communication section that performs communication with a server apparatus via a network, the communication section transmits the motion information to the server apparatus, and receives a swing analysis result transmitted from the server apparatus, and the analysis portion generates the first analysis information and the second analysis information on the basis of the swing analysis result.

[0018] According to this configuration, since motion information is transmitted to the server apparatus, and a swing analysis result is acquired from the server apparatus, it is possible to reduce a burden on the motion analysis device required for swing analysis.

Application Example 7

[0019] In the motion analysis device according to the application example, the inertial sensor may detect at least one of acceleration and angular velocity.

Application Example 8

[0020] In the motion analysis device according to the application example, the position information may be calculated on the basis of a satellite signal transmitted from a positioning satellite.

Application Example 9

[0021] A motion analysis method according to this application example is a motion analysis method of analyzing a swing using a golf club, the method including acquiring position information, and motion information output from an inertial sensor; generating first analysis information obtained by analyzing the swing on the basis of the motion information corresponding to a plurality of the swings at first position information; generating second analysis information obtained by analyzing the swing on the basis of the motion information corresponding to a plurality of the swings at second position information; and outputting a first region image based on the first analysis information and a second region image based on the second analysis information.

[0022] According to the method, since a swing is analyzed on the basis of motion information corresponding to each of a swing at the first position information and a swing at the second position information, it is possible to perform swing analysis corresponding to a swing position.

[0023] According to the method, it is possible to output the first region image based on the first analysis information and the second region image based on the second analysis information, obtained through analysis.

Application Example 10

[0024] A motion analysis system according to this application example is a motion analysis system analyzing a swing using a golf club, the system including an acquisition portion as apart of a processor acquiring position information, and motion information output from an inertial sensor; an analysis portion as a part of the processor generating first analysis information obtained by analyzing the swing on the basis of the motion information corresponding to a plurality of the swings at first position information; generating second analysis information obtained by analyzing the swing on the basis of the motion information corresponding to a plurality of the swings at second position information; and a display outputting a first region image based on the first analysis information and a second region image based on the second analysis information.

[0025] According to this configuration, since a swing is analyzed on the basis of motion information corresponding to each of a swing at the first position information and a swing at the second position information, it is possible to perform swing analysis corresponding to a swing position.

[0026] According to this configuration, it is possible to output the first region image based on the first position information and the second region image based on the second position information, obtained through analysis.

Application Example 11

[0027] It is preferable that a display method according to this application example includes generating first analysis information obtained by analyzing a plurality of the swings at first position information and second analysis information obtained by analyzing a plurality of the swings at second position information on the basis of position information, and motion information output from an inertial sensor; generating a first region image based on the first analysis information and a second region image based on the second analysis information; and displaying the first region image and the second region image in a coordinate system having at least two indexes as axes.

[0028] According to the display method, since a swing is analyzed on the basis of motion information corresponding to each of a swing at the first analysis information and a swing at the second analysis information, it is possible to perform swing analysis corresponding to a swing position.

[0029] According to the display method, the first region image and the second region image can be displayed in a coordinate system having two indexes respectively related to the first analysis information and the second analysis information as axes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

[0031] FIG. **1** is a diagram illustrating a configuration example of a motion analysis system according to the present embodiment.

[0032] FIG. **2** is a diagram illustrating a sensor unit and a swing analysis apparatus.

[0033] FIG. **3** is a diagram illustrating examples of a position at which and a direction in which the sensor unit is attached.

[0034] FIG. **4** is a diagram illustrating procedures of actions performed by a user until the user hits a ball.

[0035] FIG. **5** is a diagram illustrating a swing action.

[0036] FIG. **6** is a diagram illustrating configuration examples of the sensor unit and a swing analysis apparatus.

[0037] FIG. **7** is a graph illustrating examples of temporal changes of three-axis angular velocities.

[0038] FIG. **8** is a graph illustrating a temporal change of a combined value of the three-axis angular velocities.

[0039] FIG. **9** is a graph illustrating a temporal change of a derivative of the combined value.

[0040] FIG. **10** is a flowchart illustrating examples of procedures of a swing analysis process.

[0041] FIG. **11** is a diagram illustrating an example of an analysis image.

[0042] FIG. **12** is a diagram illustrating an example of an analysis image.

[0043] FIG. **13** is a diagram illustrating an example of an analysis image.

[0044] FIG. **14** is a diagram illustrating an example of an analysis image.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0045] Hereinafter, an embodiment of the invention will be described with reference to the drawings.

Embodiment

[0046] 1. Motion Analysis System

[0047] 1-1. Configuration of motion analysis system

[0048] Hereinafter, analysis of a golf swing will be described as an example of motion analysis. FIG. **1** is a diagram illustrating a configuration example of the motion analysis system **1** according to the present embodiment. As illustrated in FIG. **1**, a motion analysis system (swing analysis system) **1** of the present embodiment includes a sensor unit (an example of an inertial sensor) **10**, a swing analysis apparatus (an example of a motion analysis device) **20**, and a server apparatus **30**. Communication between the sensor unit **10** and the swing analysis apparatus **20** may be wireless communication, and may be wired communication. As illustrated in FIG. **2**, the swing analysis apparatus **20** is implemented by various information terminals (client terminals) including not only a personal computer **20***a*, but also a portable apparatus **20***b* such as a smart phone or a tablet PC, or a wearable terminal such as head mounted display (HMD) or a wrist apparatus.

[0049] The swing analysis apparatus **20** and the server apparatus **30** are connected to each other via a network **40**. The network **40** maybe a wide area network (WAN) such as the Internet, and may be a local area network (LAN). The swing analysis apparatus **20** and the server apparatus **30** may communicate with each other through, for example, near field communication or wired communication, without using the network **40**.

[0050] In the present embodiment, the motion analysis system (swing analysis system) **1** is configured to include the server apparatus **30** separately from the swing analysis apparatus **20**, and is not limited thereto. For example, the swing analysis apparatus **20** may have a function of the server apparatus **30**.

[0051] As illustrated in FIG. **2**, the sensor unit **10** can measure, for example, acceleration in each axial direction of three axes orthogonal to each other and, for example, angular velocity about each of the three axes orthogonal to each other, and is attached to, for example, a golf club **3** as an exercise equipment.

[0052] As illustrated in FIG. **3**, the sensor unit **10** is attached to the golf club **3** (an example of an exercise equipment) so as to match three detection axes (an x axis, a y axis, and a z axis) intersecting (ideally, orthogonal to) each other. In FIG. **3**, the sensor unit **10** is attached to a part of a shaft so that, for example, the y axis matches a longitudinal direction of the shaft of the golf club **3** (a longitudinal direction of the golf club **3**), and, for example, the x axis matches a target direction of a hit ball (target hitting direction). Preferably, the sensor unit **10** is attached to a position close to a grip to which impact during ball hitting is hardly forwarded and a centrifugal force is not applied during a swing. The shaft is a shaft portion other than a head (ball hitting portion) **3***a* of the golf club **3** and also includes the grip. However, the sensor unit **10** may be attached to a part (for example, the hand **2***a* or a glove) of the user **2**, and may be attached to an accessory such as a wristwatch.

[0053] The user **2** performs a swing action for hitting a golf ball **4** or a swing action through a practice swing according to predefined procedures. FIG. **4** is a diagram illustrating procedures of actions performed by the user **2** until the user hits the ball in the present embodiment. As illustrated in FIG. **4**, first, the user **2** performs an input operation of physical information (the height, the sex, and the age) of the user **2**, information (golf club information; a club length (a length of the shaft), a type number) regarding the golf club **3** used by the user **2**, and the like via the swing analysis apparatus **20** (step S**1**).

[0054] Next, the user **2** performs a measurement starting operation (an operation for starting measurement in the sensor unit **10**) via the swing analysis apparatus **20** (step S**2**). After receiving a notification (for example, a notification using a voice) of giving an instruction for taking an address attitude (a basic attitude before starting a swing) from the swing analysis apparatus **20** (Y in step S**3**), the user **2** takes an address attitude so that the axis in the longitudinal direction of the shaft of the golf club **3** is perpendicular to a target line (target hit ball direction), and stands still (step S**4**). Next, the user **2** receives a notification (for example, a notification using a voice) of permitting a swing from the swing analysis apparatus **20** (Y in step S**5**), and then hits the golf ball **4** by performing a swing action (step S**6**). The present embodiment is not necessarily limited to ball hitting, and is also applicable to a practice swing, and may have a function of detecting a timing corresponding to ball hitting.

[0055] If the user **2** performs the measurement starting operation in step S**2** in FIG. **4**, the swing analysis apparatus **20** transmits a measurement starting command to the sensor unit **10**, and the sensor unit **10** receives the measurement starting command and starts measurement of three-axis accelerations and three-axis angular velocities. The sensor unit **10** measures three-axis accelerations and three-axis angular velocities in a predetermined cycle (for example, 1 ms), and sequentially transmits the measured data to the swing analysis apparatus **20**.

[0056] The swing analysis apparatus **20** notifies the user **2** of permission of swing starting, shown in step S**5** in FIG. **4**, and then analyzes the swing action (step S**6** in FIG. **4**) in which the user **2** has hit the ball by using the golf club **3** on the basis of measured data from the sensor unit **10**.

[0057] As illustrated in FIG. **5**, the swing action performed by the user **2** in step S**6** in FIG. **4** includes an action reaching impact (ball hitting) at which the golf ball **4** is hit from an address (ADDR) attitude (standing still state) through respective states of halfway back (HWB) at which the shaft of the golf club **3** becomes horizontal during a backswing after starting a swing (backswing), a top at which the swing changes from the backswing to a downswing, and halfway down (HWD) at which the shaft of the golf club **3** becomes horizontal during the downswing.

[0058] The swing analysis apparatus **20** generates swing analysis data **248** including information regarding a location (position information) or a time point (date and time) at which the swing is performed, identification information or the sex of the user **2**, the type of golf club **3**, and an analysis result of the swing action, and transmits the swing analysis data to the server apparatus **30** via the network **40** (refer to FIG. **1**).

[0059] The server apparatus **30** receives the swing analysis data **248** transmitted by the swing analysis apparatus **20** via the network **40**, and preserves the swing analysis data. Therefore, when the user **2** performs a swing action according to the procedures illustrated in FIG. **4**, the swing analysis data **248** generated by the swing analysis apparatus **20** is preserved in the server apparatus **30**.

[0060] The server apparatus **30** has a swing diagnosis function of diagnosing a swing on the basis of the swing analysis data **248**. The user **2** may request the server appa-

ratus **30** to perform swing analysis via an operation section **23** (refer to FIG. **6**) of the swing analysis apparatus **20**. In the swing diagnosis function, various analyses with respect to a swing are performed on the basis of the preserved swing analysis data **248**, and a swing analysis result is transmitted to the swing analysis apparatus **20**.

[0061] In the present embodiment, in the swing diagnosis function of the server apparatus **30**, a movement distance and a movement time of the head **3***a* from an address attitude to top through halfway back, an angle (attitude) of the shaft viewed from the front or the top of the golf club **3** at top, a movement distance of the grip at the time of address in a height direction or a rear direction at top, a rhythm of a backswing or a downswing, and the like are calculated on the basis of the preserved swing analysis data **248**, and are stored in correlation with information regarding a position where a swing is performed. The calculated information is transmitted to the swing analysis apparatus **20** as a swing analysis result in correlation with the position information in response to a request from the swing analysis apparatus **20**.

[0062] The information calculated in the swing diagnosis function is not limited to the above-described items. For example, a position of the head **3***a* at halfway back, a position of the head **3***a* at halfway down, and a shaft axis rotation angle, a face angle, a grip deceleration ratio, a grip deceleration time ratio, a club path (incidence angle), and a relative face angle at top may be calculated.

[0063] The swing analysis apparatus **20** receives analysis information of levels of a plurality of items related to a plurality of swings in different locations as in a case of a golf course or a golf practice range, generates each piece of analysis information on the basis of a plurality of pieces of information (data), and generates an analysis image including a plurality of region images on the basis of the generated analysis information. The swing analysis apparatus **20** may display the plurality of region images (illustrated in FIGS. **11** to **14** and will be described later) in a coordinate system having at least two indexes as axes together. In the plurality of region images, a size of a region surrounded by an outer circumferential line indicating the region displays a size corresponding to a variation among a plurality of pieces of data related to a plurality of swings. In other words, a large area of the region image indicates a large variation.

[0064] 1-2. Configurations of Sensor Unit and Swing Analysis Apparatus

[0065] FIG. **6** is a diagram illustrating configuration examples of the sensor unit **10** and the swing analysis apparatus **20**. As illustrated in FIG. **6**, in the present embodiment, the sensor unit **10** is configured to include a position sensor **15**, a signal processing section **16**, and a communication section **18** in addition to an acceleration sensor **12** and an angular velocity sensor **14** which are inertial sensors. However, the sensor unit **10** may have a configuration in which some of the constituent elements are deleted or changed as appropriate, or may have a configuration in which other constituent elements are added thereto.

[0066] The acceleration sensor **12** measures respective accelerations in three axial directions which intersect (ideally, orthogonal to) each other, and outputs motion information (acceleration data) corresponding to magnitudes and directions of the measured accelerations in the three axial directions.

[0067] The angular velocity sensor **14** measures respective angular velocities in three axial directions which intersect (ideally, orthogonal to) each other, and outputs motion information (angular velocity data) corresponding to magnitudes and directions of the measured angular velocities in the three axial directions.

[0068] The position sensor **15** outputs position information regarding a position where the sensor unit **10** is located. A method of detecting position information may employ a method of detecting a position on the earth by receiving satellite signals (GPS signals) from a plurality of GPS satellites which are positioning satellites.

[0069] The position sensor **15** receives, for example, GPS signals transmitted from four GPS satellites of which positions on orbits are known, and calculates the current position on the basis of a propagation time required to receive the GPS signals from transmission thereof.

[0070] As a method of detecting position information, there may be a method based on position information obtained from an access point of WiFi (registered trademark).

[0071] In a case where the position sensor **15** is disposed in a golf course, and receives an electric wave signal transmitted from an access point of which a position is known, the position sensor **15** applies a beam forming technique to the signal, and specifies a direction of the access point by using directivity of an antenna.

[0072] The position sensor **15** applies a Chronos technique to an electric wave signal transmitted from the access point, so as to calculate a distance from the access point. The position sensor **15** may detect the current position on the basis of the direction and the distance from the access point.

[0073] The position sensor **15** outputs position data indicating the detected position information. The position data is assumed to be data indicating longitude and latitude.

[0074] In the present embodiment, the position sensor **15** is assumed to be built into the sensor unit **10**, but is not limited thereto.

[0075] For example, there may be an aspect in which the position sensor **15** is provided in a wristwatch type information terminal apparatus mounted on the arm of the user **2**, and transmits information to the swing analysis apparatus **20** via short-range wireless communication.

[0076] The signal processing section **16** receives the acceleration data, the angular velocity data, and the position data from the acceleration sensor **12**, the angular velocity sensor **14**, and the position sensor **15**, respectively, adds time information thereto, stores the data in a memory section (not illustrated), adds time information to the stored data so as to generate packet data conforming to a communication format, and outputs the packet data to the communication section **18**.

[0077] Ideally, the acceleration sensor **12** and the angular velocity sensor **14** are provided in the sensor unit **10** so that the three axes thereof match three axes (an x axis, a y axis, and a z axis) of an orthogonal coordinate system (sensor coordinate system) defined for the sensor unit **10**, but, actually, errors occur in installation angles. Therefore, the signal processing section **16** performs a process of converting the acceleration data and the angular velocity data into data in the xyz coordinate system by using a correction parameter which is calculated in advance according to the installation angle errors.

[0078] The signal processing section **16** may perform a process of correcting the temperatures of the acceleration sensor **12** and the angular velocity sensor **14**. Alternatively,

the acceleration sensor **12** and the angular velocity sensor **14** may have a temperature correction function.

[0079] The acceleration sensor **12** and the angular velocity sensor **14** may output analog signals, and, in this case, the signal processing section **16** may A/D convert an output signal from the acceleration sensor **12** and an output signal from the angular velocity sensor **14** so as to generate measured data (acceleration data and angular velocity data), and may generate communication packet data by using the data.

[0080] The communication section **18** performs a process of transmitting packet data received from the signal processing section **16** to the swing analysis apparatus **20**, or a process of receiving various control commands such as a measurement start command from the swing analysis apparatus **20** and sending the control command to the signal processing section **16**. The signal processing section **16** performs various processes corresponding to control commands.

[0081] As illustrated in FIG. **6**, in the present embodiment, the swing analysis apparatus **20** is configured to include a processing section (processor) **21**, a communication section **22**, an operation section **23**, a memory section (memory) **24**, a display section (display) **25**, a sound output section **26**, and a communication section **27**. However, the swing analysis apparatus **20** may have a configuration in which some of the constituent elements are deleted or changed as appropriate, or may have a configuration in which other constituent elements are added thereto.

[0082] The communication section **22** performs a process of receiving packet data transmitted from the sensor unit **10** and sending the packet data to the processing section **21**, or a process of transmitting a control command from the processing section **21** to the sensor unit **10**.

[0083] The operation section **23** performs a process of acquiring operation data from the user **2** and sending the operation data to the processing section **21**. The operation section **23** may be, for example, a touch panel type display, a button, a key, or a microphone.

[0084] The memory section **24** is constituted of, for example, various IC memories such as a read only memory (ROM), a flash ROM, and a random access memory (RAM), or a recording medium such as a hard disk or a memory card. The memory section **24** stores a program for the processing section **21** performing various calculation processes or a control process, or various programs or data for realizing application functions.

[0085] In the present embodiment, the memory section **24** stores a swing analysis program **240** which is read by the processing section **21** and executes a swing analysis process. The swing analysis program **240** may be stored in a non-volatile recording medium (computer readable recording medium) in advance, or the swing analysis program **240** may be received from the server apparatus **30** by the processing section **21** via the network **40**, and may be stored in the memory section **24**.

[0086] In the present embodiment, the memory section **24** stores golf club information **242**, physical information **244**, image display parameters **246**, and swing analysis data **248**. For example, the user **2** may operate the operation section **23** so as to input specification information regarding the golf club **3** to be used (for example, at least some information such as information regarding a length of the shaft, a position of the centroid thereof, a lie angle, a face age, a loft angle, and the like), and the input specification information may be used as the golf club information **242**. Alternatively, in step S**1** in FIG. **4**, the user **2** may sequentially input type numbers of the golf club **3** (alternatively, selects a type number from a type number list) so that specification information for each type number is stored in the memory section **24** in advance. In this case, specification information of an input type number may be used as the golf club information **242**.

[0087] The display section **25** displays a processing result in the processing section **21** as text, a graph, a table, animation, and other images. The display section **25** may be, for example, a CRT, an LCD, a touch panel type display, and a head mounted display (HMD). A single touch panel type display may realize functions of the operation section **23** and the display section **25**.

[0088] The sound output section **26** outputs a processing result (analysis information) in the processing section **21** so as to present the processing result as a sound such as a voice or a buzzer sound. The sound output section **26** may be, for example, a speaker or a buzzer.

[0089] The display section **25** and the sound output section **26** are an aspect of a display.

[0090] The communication section **27** performs data communication with the server apparatus **30** via the network **40**. For example, the communication section **27** performs a process of receiving the swing analysis data **248** from the processing section **21** after a swing analysis process is completed, and transmitting the swing analysis data to the server apparatus **30**. The communication section **27** performs a process of receiving a swing analysis result from the server apparatus **30**.

[0091] The processing section **21** performs a process of transmitting a control command to the sensor unit **10** via the communication section **22**, or various computation processes on data which is received from the sensor unit **10** via the communication section **22**, according to various programs. The processing section **21** performs a process of reading the swing analysis data **248** from the memory section **24**, and transmitting the swing analysis data to the server apparatus **30** via the communication section **27**, according to various programs.

[0092] The processing section **21** may output analysis information via the communication section **27** on the basis of information received from the server apparatus **30** according to various programs. The processing section **21** performs other various control processes.

[0093] By executing the swing analysis program **240**, the processing section **21** functions as a data acquisition portion **210**, a swing analysis portion **211** as an analysis portion, an image data generation portion **212**, a storage processing portion **213**, a display processing portion **214**, a sound output processing portion **215**, and a location determination portion **216**.

[0094] The processing section **21** may be realized by a computer including a central processing unit (CPU) which is a calculation device, a random access memory (RAM) which is a volatile storage device, a ROM which is a nonvolatile storage device, an interface (I/F) circuit which connects the processing section **21** to other units, and a bus connecting the above-described elements to each other. The computer may include various dedicated processing circuits

such as an image processing circuit. The processing section **21** maybe realized by an application specific integrated circuit (ASIC).

[0095] The data acquisition portion **210** performs a process of receiving packet data which is received from the sensor unit by the communication section **22**, acquiring position information, time information, and measured data from the received packet data, and sending the position information, the time information, and the measured data to the storage processing portion **213**.

[0096] The storage processing portion **213** performs read/write processes of various programs or various data for the memory section **24**. The storage processing portion **213** performs a process of storing the position information, the time information, and the measured data received from the data acquisition portion **210** in the memory section **24** in correlation with each other, or a process of storing various pieces of information calculated by the swing analysis portion **211**, the swing analysis data **248**, or the like in the memory section **24**.

[0097] The swing analysis portion **211** performs a process of analyzing a swing action of the user **2** by using the measured data (the measured data stored in the memory section **24**) output from the sensor unit **10**, data which is input from the operation section **23**, or the like, so as to generate the swing analysis data **248** as analysis information including a location and a time point (date and time) at which the swing was performed, identification information or the sex of the user **2**, the type of golf club **3**, and information regarding a swing action analysis result. Particularly, in the present embodiment, the swing analysis portion **211** calculates a value of each index of the swing as at least some of the information regarding the swing action analysis result.

[0098] The swing analysis portion **211** calculates a position of the head **3***a* of the golf club **3** over time at a predetermined timing during the backswing or the downswing as an index of the swing. A position of the head **3***a* may be obtained by calculating changes in positions from an initial position in a time series by integrating acceleration data output from the sensor unit **10**. The swing analysis portion **211** may calculate a movement distance of the head **3***a* on the basis of time-series changes of positions of the head **3***a*.

[0099] As indexes of the swing, the swing analysis portion **211** may calculate an incidence angle of the head **3***a* of the golf club **3** at impact (at ball hitting), an inclination of the head **3***a* of the golf club **3** at impact (at ball hitting), a speed of the golf club **3** (head **3***a*) at impact (at ball hitting), a rotation angle about a rotation axis of the shaft of the golf club **3** at a predetermined timing between the time of starting a backswing and the time of impact (at ball hitting), and the like.

[0100] The location determination portion **216** determines a location where measured data corresponding to position information was acquired, that is, a location where the golf club **3** was swung.

[0101] In the present embodiment, the location determination portion **216** determines whether a swing location is a golf course or a golf practice range.

[0102] The location determination portion **216** collates position data indicated by position information corresponding to a swing analysis result with map information so as to determine a swing location. The map information may be stored in the memory section **24**, and may be acquired from an external server via the network **40**. In a case where locations indicated by position data are different from each other, that is, in a case where it is determined that the user performed a swing while moving, it may be determined that the swing was performed in a golf course. In a case where locations indicated by position data are substantially the same as each other, it may be determined that a swing was performed in a golf practice range. A determination result in the location determination portion **216** is correlated with a corresponding swing analysis result.

[0103] The image data generation portion **212** performs a process of generating image data corresponding to an image displayed on the display section **25**. For example, the image data generation portion **212** generates image data on the basis of various pieces of information received by the data acquisition portion **210**.

[0104] The display processing portion **214** performs a process of displaying various images (including text, symbols, and the like in addition to an image corresponding to the image data generated by the image data generation portion **212**) on the display section **25**.

[0105] The sound output processing portion **215** performs a process of outputting various sounds (including voices, buzzer sounds, and the like) from the sound output section **26**. For example, the sound output processing portion **215** may output a sound for notifying the user **2** of permission of swing starting from the sound output section **26** in step S5 in FIG. **4**. For example, the sound output processing portion **215** may output a sound or a voice indicating an analysis result in the swing analysis portion **211** from the sound output section **26** automatically or in response to an input operation performed by the user **2** after a swing action of the user **2** is completed. Alternatively, a sound output section may be provided in the sensor unit **10**, and the sound output processing portion **215** may transmit various items of sound data or voice data to the sensor unit **10** via the communication section **22**, and may output various sounds or voices from the sound output section of the sensor unit **10**.

[0106] A vibration mechanism may be provided in the swing analysis apparatus **20** or the sensor unit **10**, and various pieces of information may be converted into vibration pieces of information by the vibration mechanism so as to be presented to the user **2**.

[0107] 1-3. Swing Analysis Process

[0108] In the present embodiment, when a position of the head **3***a* of the golf club **3** at address (during standing still) is set to the origin, an XYZ coordinate system (global coordinate system) is defined which has a target line indicating a target hit ball direction as an X axis, an axis on a horizontal plane which is perpendicular to the X axis as a Y axis, and a vertically upward direction (a direction opposite to the gravitational direction) as a Z axis. In order to calculate each index value, the swing analysis portion **211** calculates a position and an attitude of the sensor unit **10** in a time series from the time of the address in the XYZ coordinate system (global coordinate system) by using measured data (acceleration data and angular velocity data) in the sensor unit **10**. The swing analysis portion **211** detects respective timings of the swing starting, the top, and the impact illustrated in FIG. **5**, by using the measured data (acceleration data or angular velocity data) in the sensor unit **10**. The swing analysis portion **211** calculates values of the respective indexes (for example, a V zone, efficiency (swing

efficiency), rotation, impact, and a down blow (or an upper blow)) of the swing by using the time series data of the position and the attitude of the sensor unit **10**, and the timings of the swing starting, the top, and the impact, so as to generate the swing analysis data **248**.

[0109] First, the swing analysis portion **211** computes an offset amount included in the measured data by using the measured data (acceleration data and angular velocity data) during standing still (at address) of the user **2**, stored in the memory section **24**. Next, the swing analysis portion **211** subtracts the offset amount from the measured data after swing starting, stored in the memory section **24**, so as to perform bias correction, and computes a position and an attitude of the sensor unit **10** during a swing action of the user **2** by using the bias-corrected measured data.

[0110] For example, the swing analysis portion **211** computes a position (initial position) of the sensor unit **10** during standing still (at address) of the user **2** in an XYZ coordinate system (a coordinate system in which a position of the ball hitting portion (head) **3***a* during standing still (at address) of the user **2** is set as the origin, a target hit ball direction is set as an X axis, an axis on a horizontal plane perpendicular to the X axis is set as a Y axis, and a vertically upward direction is set as a Z axis; hereinafter, referred to as a global coordinate system) by using the acceleration data measured by the acceleration sensor **12**, the club specification information, and the sensor attachment position information, and integrates subsequent acceleration data so as to compute a positional change from the initial position of the sensor unit **10** in a time series. The user **2** stands still at a predetermined address attitude, and an X coordinate of the initial position of the sensor unit **10** is 0.

[0111] Since the y axis of the sensor unit **10** matches the long axis direction of the shaft of the golf club **3**, and the acceleration sensor **12** measures only the gravitational acceleration during standing still of the user **2**, the swing analysis portion **211** may compute an inclined angle (an inclination relative to a horizontal plane (XY plane) or a vertical plane (XZ plane)) of the shaft by using y axis acceleration data. The swing analysis portion **211** may compute a Y coordinate and a Z coordinate of the initial position of the sensor unit **10** by using the inclined angle of the shaft, the club specification information (the length of the shaft), and the sensor attachment position information (a distance from the grip end), so as to specify the initial position of the sensor unit **10**. Alternatively, the swing analysis portion **211** may compute coordinates of an initial position of the sensor unit **10** by using coordinates of a position of the grip end of the golf club **3** and the sensor attachment position information (a distance from the grip end).

[0112] The motion analysis portion **211** computes an attitude (initial attitude) of the sensor unit **10** during standing still (at address) of the user **2** in the XYZ coordinate system (global coordinate system) by using the acceleration data measured by the acceleration sensor **12**, and computes changes in attitudes from the initial attitude of the sensor unit **10** by performing rotation calculation using angular velocity data which is subsequently measured by the angular velocity sensor **14**. An attitude of the sensor unit **10** maybe expressed by, for example, rotation angles (a roll angle, a pitch angle, and a yaw angle) around the X axis, the Y axis, and the Z axis, an Euler's angle, or a quaternion.

[0113] Since the acceleration sensor **12** measures only the gravitational acceleration during standing still of the user **2**, the swing analysis portion **211** may specify an angle formed between each of the x axis, the y axis, and the z axis of the sensor unit **10**, and the gravitational direction by using three-axis acceleration data. Since the user **2** stands still at the predetermined address attitude, and thus the y axis of the sensor unit **10** is present on the YZ plane during standing still of the user **2**, the swing analysis portion **211** can specify the initial attitude of the sensor unit **10**.

[0114] The signal processing section **16** of the sensor unit **10** may compute an offset amount of measured data so as to perform bias correction on the measured data, and the acceleration sensor **12** and the angular velocity sensor **14** may have a bias correction function. In this case, it is not necessary for the swing analysis portion **211** to perform bias correction on the measured data.

[0115] The swing analysis portion **211** defines a motion analysis model (double pendulum model) in which physical information (the height of the user **2** (the lengths of the arms)), club specification information (a length and a position of the centroid of the shaft), sensor attachment position information (a distance from the grip end), features (rigid body) of the golf club **3**, or human features (a joint bending direction, and the like) are taken into consideration, and computes a trajectory of the golf club **3** in a swing of the user **2** by using the motion analysis model, and information regarding the position and the attitude of the sensor unit **10**.

[0116] The swing analysis portion **211** detects a timing (impact timing) at which the user **2** hit the ball in a period of the swing action by using the time information and the measured data stored in the memory section **24**. In the present embodiment, the swing analysis portion **211** computes a combined value of the measured data (the acceleration data or the angular velocity data) output from the sensor unit **10**, and specifies the timing (time point) at which the user **2** hit the ball on the basis of the combined value.

[0117] The swing analysis portion **211** also generates a head speed from a backswing to follow-through, an incidence angle (club path) or a face angle during hitting of a ball, shaft rotation (a change amount of a face angle during a swing), and a deceleration rate of the golf club **3**, or information regarding a variation in these information pieces in a case where the user **2** performs a plurality of swings, by using the motion analysis model and the information regarding the position and the attitude of the sensor unit **10**.

[0118] The swing analysis portion **211** detects a series of actions (also referred to as a "rhythm") from the start of a swing to the finish of the swing, for example, the start of the swing, a backswing, a top, a downswing, impact, follow-through, and the finish of the swing by using the measured data acquired from the sensor unit **10**. Specific procedures of detecting the rhythm are not particularly limited, but, for example, the following procedures may be employed.

[0119] First, the swing analysis portion **211** computes a sum (referred to as a norm) of magnitudes of angular velocities at respective time points t by using the angular velocity data at acquisition time points t. The swing analysis portion **211** may differentiate the norm of the angular velocities at the respective time points t with time.

[0120] Here, a case is assumed in which angular velocities around the three axes (the x axis, the y axis, and the z axis) are expressed, for example, in a graph illustrated in FIG. **7**. In FIG. **7**, a transverse axis expresses time (msec), and a longitudinal axis expresses angular velocity (dps). A norm of angular velocities is illustrated in a graph as illustrated in

FIG. **8**, for example. In FIG. **8**, a transverse axis expresses time (msec), and a longitudinal axis expresses a combined value (norm) of the angular velocities. A derivative value of the norm of the angular velocities is illustrated in a graph as illustrated in FIG. **9**, for example. In FIG. **9**, a transverse axis expresses time (msec), and a longitudinal axis expresses a derivative value of the norm of the angular velocities. FIGS. **7** to **9** are drawings for better understanding of the present embodiment, and do not illustrate accurate values.

[0121] The swing analysis portion **211** detects an impact timing in the swing by using the computed norm of the angular velocities. The swing analysis portion **211** detects, for example, a timing at which the norm of the angular velocities is the maximum as the impact timing (reference sign t_{impact}). For example, of a timing at which a derivative value of the computed norm of the angular velocities is the maximum and a timing at which a derivative value thereof is minimum, the swing analysis portion **211** may detect the former timing as the impact timing (reference sign t_{impact}).

[0122] The swing analysis portion **211** detects, for example, a timing at which the computed norm of the angular velocities is the minimum before impact as a top timing in the swing (reference sign t_{top}). The swing analysis portion **211** specifies a period in which the norm of the angular velocities which is equal to or less than a first threshold value continues as a top period (a staying period around the top).

[0123] The swing analysis portion **211** detects, for example, a timing at which the norm of the angular velocities is equal to or less than a second threshold value before the top as a swing start timing (reference sign t_{start}).

[0124] The swing analysis portion **211** detects, for example, a timing at which the norm of the angular velocities is the minimum after the impact as a swing finish timing. Alternatively, the swing analysis portion **211** may detect, for example, an initial timing at which the norm of the angular velocities is equal to or less than a third threshold value after the impact as the swing finish timing. The swing analysis portion **211** specifies, for example, a period in which the norm of the angular velocities which is equal to or less than a fourth threshold value continues after the impact and around the impact timing as a finish period.

[0125] In the above-described way, the swing analysis portion **211** may detect the rhythm of the swing. The swing analysis portion **211** may specify each period during a swing (for example, a backswing period from swing start to top start, a downswing period from top finish to impact, and a follow-through period from the impact to swing finish) by detecting the rhythm.

[0126] 1-3-1. Procedures of Swing Analysis Process (Motion Analysis Method)

[0127] FIG. **10** is a flowchart illustrating examples of procedures of a swing analysis process (swing analysis method) performed by the processing section **21**. The processing section **21** performs the swing analysis process, for example, according to the procedures shown in the flowchart of FIG. **10** by executing the swing analysis program **240** stored in the memory section **24**. Hereinafter, the flowchart of FIG. **10** will be described.

[0128] First, the processing section **21** waits for the user **2** to perform a measurement starting operation (the operation in step S**2** in FIG. **4**) (N in step S**10**), transmits a measurement starting command to the sensor unit **10** if the measurement starting operation is performed (Y in step S**10**), and starts to acquire measured data from the sensor unit **10** (step S**12**).

[0129] Next, the processing section **21** instructs the user **2** to take an address attitude (step S**14**). The user **2** takes the address attitude in response to the instruction, and stands still for a predetermined period of time or more (step S**4** in FIG. **4**).

[0130] Next, if a standing still state of the user **2** is detected by using the measured data acquired from the sensor unit **10** (Y in step S**16**), the processing section **21** notifies the user **2** of permission of swing starting (step S**18**). The processing section **21** outputs, for example, a predetermined sound, or an LED is provided in the sensor unit **10**, and the LED is lighted, so that the user **2** is notified of permission of swing starting. The user **2** confirms the notification and then starts a swing action (the action in step S**6** in FIG. **4**).

[0131] Next, the processing section **21** performs processes in step S**20** and subsequent steps after completion of the swing action of the user **2**, or from before completion of the swing action.

[0132] First, the processing section **21** computes an initial position and an initial attitude of the sensor unit **10** by using the measured data (measured data during standing still (at address) of the user **2**) acquired from the sensor unit **10** (step S**20**).

[0133] Next, the processing section **21** detects a swing starting timing, a top timing, and an impact timing by using the measured data acquired from the sensor unit **10** (step S**22**).

[0134] The processing section **21** computes a position and an attitude of the sensor unit **10** during the swing action of the user **2** in parallel to the process in step S**22**, or before and after the process in step S**22** (step S**24**).

[0135] Next, in step S**26**, the processing section **21** computes values of various indexes regarding the swing by using at least some of the measured data acquired from the sensor unit **10**, the swing starting, top and impact timings detected in step S**22**, and the position and the attitude of the sensor unit **10** computed in step S**24**.

[0136] The processing section **21** generates the swing analysis data **248** by using the calculated various indexes, transmits the swing analysis data to the server apparatus **30** (step S**36**), and finishes the swing analysis process.

[0137] In the flowchart of FIG. **10**, order of the respective steps may be changed as appropriate within an allowable range, some of the steps may be omitted or changed, and other steps may be added thereto.

[0138] 1-3-2. Display Method of Swing Analysis Result

[0139] The image data generation portion **212** generates an analysis image based on a swing analysis result, for example, as in FIGS. **11** to **14**, in response to an operation performed by the user **2**, and displays the analysis image on the display section **25**.

[0140] FIG. **11** illustrates distributions in a golf course and a golf practice range in a case where a movement time of the head **3***a* from an address attitude to halfway back is expressed as a parameter (index) on a transverse axis, and a movement time of the head **3***a* from the halfway back to top is expressed as a parameter (index) on a longitudinal axis. The units for the transverse axis and the longitudinal axis in FIG. **11** are millisecond (ms).

[0141] A set of distributions of first analysis information in a golf course which is first position information is displayed in a first region image **80**, and a set of distributions of second analysis information in a golf practice range which is second position information is displayed in a second region image **90**. Consequently, even in a case where a movement distance of the head **3***a* is unclear, it is possible to visually recognize an analysis result of the amplitude.

[0142] FIG. **12** illustrates distributions in the golf course and the golf practice range in a case where, at the top, an angle of the shaft viewed from a direction of viewing the golf club **3** from the front side (a direction of viewing the user **2** from the front side) is expressed as a parameter (index) on a transverse axis, and an angle of shaft viewed from a direction of viewing the user from the directly upper side (a direction of viewing the user **2** from the parietal region) is expressed as a parameter (index) on a longitudinal axis. A range of a flying ball direction in either of the two cases is set to "0 degrees". A set of distributions of first analysis information in the golf course which is first position information is displayed in a first region image **80**, and a set of distributions of second analysis information in the golf practice range which is second position information is displayed in a second region image **90**. The units for the transverse axis and the longitudinal axis in FIG. **12** are meter (m).

[0143] FIG. **13** illustrates distributions in the golf course and the golf practice range in a case where a grip position (a position in a height direction) at the top (with a grip position at the address as a reference) for a grip position at the address, viewed from a direction of viewing the golf club **3** from the front side (a direction of viewing the user **2** from the front side) is expressed as a parameter (index) on a transverse axis, and a grip position (a position in a rear direction) at the top (with a grip position at the address as a reference) for the grip position at the address, viewed from a direction of viewing the user from the directly upper side is expressed as a parameter (index) on a longitudinal axis. A set of distributions of first analysis information in the golf course which is first position information is displayed in a first region image **80**, and a set of distributions of second analysis information in the golf practice range which is second position information is displayed in a second region image **90**. A position in the height direction may be a grip position at the top with the ground as a reference. The units for the transverse axis and the longitudinal axis in FIG. **13** are meter (m).

[0144] FIG. **14** illustrates distributions in the golf course and the golf practice range in a case where a swing time for a backswing is expressed as a parameter (index) on a transverse axis, and a swing time for a downswing is expressed as a parameter (index) on a longitudinal axis. A set of distributions of first analysis information in the golf course which is first position information is displayed in a first region image **80**, and a set of distributions of second analysis information in the golf practice range which is second position information is displayed in a second region image **90**. The units for the transverse axis and the longitudinal axis in FIG. **14** are millisecond (ms).

[0145] The first region image and the second region image can be easily identified by changing display colors or patterns. Two or more pieces of analysis information may be used.

[0146] In the present embodiment, the image data generation portion **212** generates an image on the basis of the image display parameters **246** stored in the memory section **24**. The image display parameters **246** specify, for example, parameters (indexes) or ranges on a longitudinal axis and a transverse axis of a correlation diagram, and an attribute of a region image based on analysis information.

[0147] The image display parameters (indexes) **246** are determined as predetermined set values in advance, but there may be an aspect in which the user **2** can change the set values. For example, in FIG. **12**, a parameter on the longitudinal axis may be changed to the parameter (index) used for the longitudinal axis in FIG. **13**, that is, an address grip position at top.

[0148] In a case where a correlation diagram as illustrated in FIG. **12** is displayed, if the user **2** indicates desired data on the screen, the image data generation portion **212** may display detailed information regarding the indicated data in a text form in an overlapping manner around the data of the correlation diagram. The displayed information is assumed to be, for example, a hole position in the golf course, the presence or absence of a slice, and a curving direction.

[0149] According to the above-described embodiment, the following effects can be achieved.

[0150] (1) Since a swing is analyzed on the basis of motion information corresponding to each of a swing in a golf practice range and a swing in a golf course, it is possible to perform swing analysis corresponding to a swing position.

[0151] (2) It is possible to visually recognize an analysis image related to the first analysis information based on a swing in a golf course and an analysis image related to the second analysis information based on a swing in a golf practice range.

[0152] (3) The first region image and the second region image can be displayed in a coordinate system having two indexes respectively related to the first analysis information and the second analysis information as axes.

[0153] (4) Since motion information is transmitted to the server apparatus **30**, and a swing analysis result is acquired from the server apparatus **30**, it is possible to reduce a burden on the swing analysis apparatus **20** required for swing analysis.

[0154] As mentioned above, a preferred embodiment has been described with reference to the accompanying drawings, but a preferred embodiment is not limited to the above-described embodiment. An embodiment may be variously modified within the scope without departing from the spirit of the invention, and may be carried out as follows.

[0155] The golf club **3** as an exercise equipment may be any of a driver, an iron, and a putter.

[0156] In the embodiment, the motion analysis system **1** analyzing a golf swing has been described as an example, but the invention is applicable to other exercise equipments used to hit a ball.

[0157] An apparatus carrying out the technique may be realized by a single apparatus, may be realized by combining a plurality of apparatuses, and includes various aspects.

[0158] The functional portions of the processing section **21** illustrated in FIG. **6** indicate functional configurations realized through cooperation between hardware and software, and specific installation aspects are not particularly limited. Therefore, hardware individually corresponding to each functional portion is not necessary installed, and a single processor may realize functions of a plurality of

functional portions by executing a program. In the embodiment, some of the functions realized by software maybe realized by hardware, or some of the functions realized by hardware may be realized by software. In addition, a specific detailed configuration of each of other portions of the processor **21** can be changed at random within the scope without departing from the spirit of the invention.

What is claimed is:

1. A motion analysis device analyzing a swing using a golf club, the apparatus comprising:

an acquisition portion as apart of a processor acquiring position information, and motion information output from an inertial sensor;

an analysis portion as apart of the processor generating first analysis information obtained by analyzing a plurality of the swings at first position information and second analysis information obtained by analyzing a plurality of the swings at second position information; and

a display outputting a first region image based on the first analysis information and a second region image based on the second analysis information.

2. The motion analysis device according to claim **1**,

wherein the first region image and the second region image are displayed in a coordinate system having two indexes respectively related to the first analysis information and the second analysis information as axes.

3. The motion analysis device according to claim **1**,

wherein the first analysis information includes information related to at least one of a movement distance or a movement time of a head of the golf club from address to halfway back and from the halfway back to top, angles of a shaft of the golf club viewed from a front side and an upper side of the golf club at top, a movement distance of a grip of the golf club at the time of address in a height direction or a rear direction at top, and times required for a backswing and a downswing.

4. The motion analysis device according to claim **1**,

wherein the first position information indicates a golf course, and the second position information indicates a golf practice range.

5. The motion analysis device according to claim **1**, further comprising:

a communication section that performs communication with a server apparatus via a network,

wherein the communication section transmits the motion information to the server apparatus, and receives a swing analysis result transmitted from the server apparatus, and

wherein the analysis portion generates the first analysis information and the second analysis information on the basis of the swing analysis result.

6. The motion analysis device according to claim **1**,

wherein the inertial sensor detects at least one of acceleration and angular velocity.

7. The motion analysis device according to claim **1**,

wherein the position information is calculated on the basis of a satellite signal transmitted from a positioning satellite.

8. A motion analysis method of analyzing a swing using a golf club, the method comprising:

acquiring position information, and motion information output from an inertial sensor;

generating first analysis information obtained by analyzing a plurality of the swings at first position information;

generating second analysis information obtained by analyzing a plurality of the swings at second position information; and

outputting a first region image based on the first analysis information and a second region image based on the second analysis information.

9. A motion analysis system analyzing a swing using an exercise equipment, the system comprising:

an acquisition portion as apart of a processor acquiring position information, and motion information output from an inertial sensor;

an analysis portion as apart of the processor generating first analysis information obtained by analyzing a plurality of the swings at first position information and second analysis information obtained by analyzing a plurality of the swings at second position information; and

a display outputting a first region image based on the first analysis information and a second region image based on the second analysis information.

10. A display method comprising:

generating first analysis information obtained by analyzing a plurality of the swings at first position information and second analysis information obtained by analyzing a plurality of the swings at second position information on the basis of position information, and motion information output from an inertial sensor;

generating a first region image based on the first analysis information and a second region image based on the second analysis information; and

displaying the first region image and the second region image in a coordinate system having at least two indexes as axes.

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