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(54) **TRAVEL TIME PROVIDING DEVICE**

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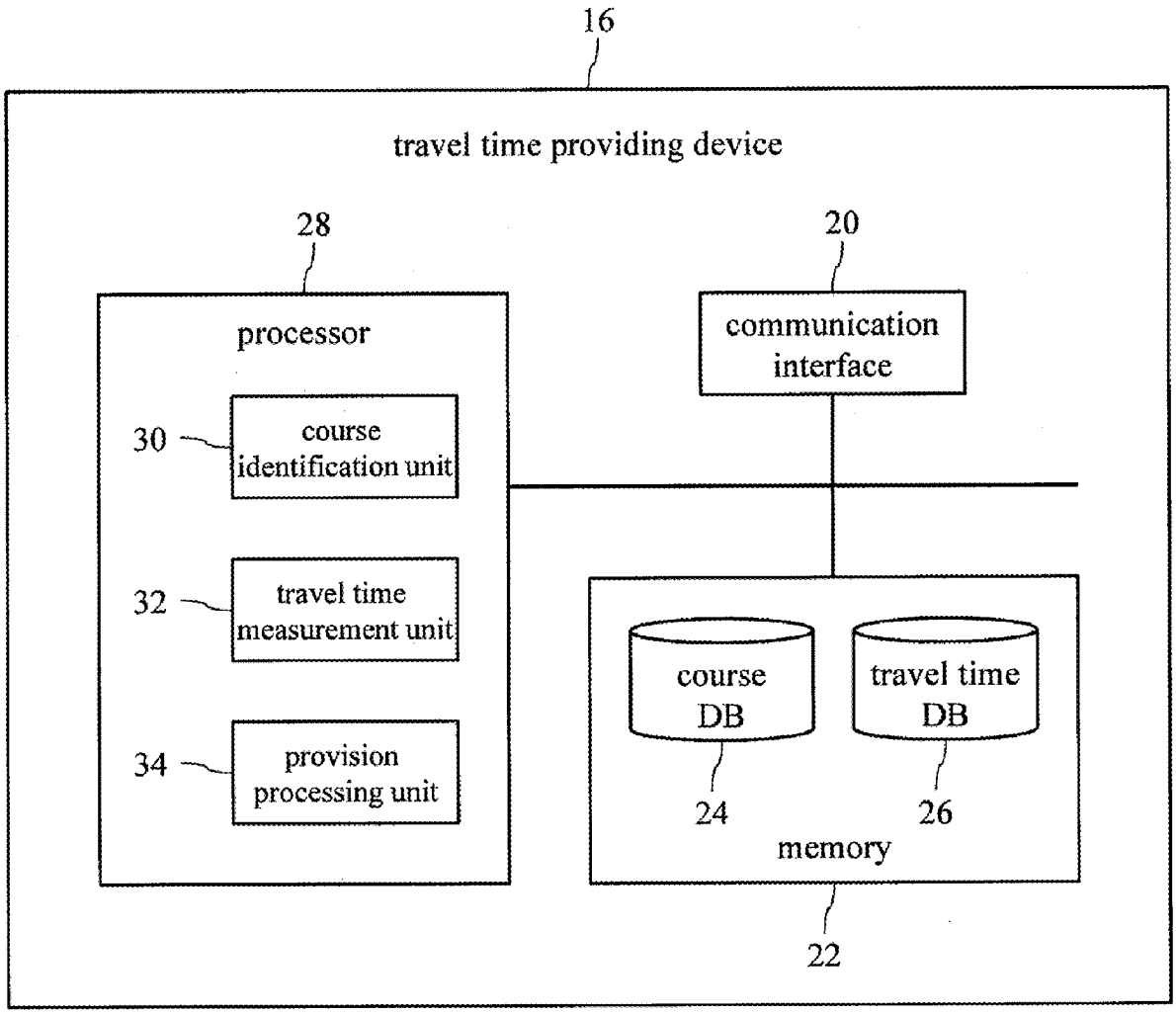
(57) **ABSTRACT**

The course DB stores a plurality of combinations of the layout of a course and the measurement reference position of that course. The course identification unit refers to the course DB and identifies the course traveled by the racing vehicle based on the route traveled by the racing vehicle. The travel time measurement unit measures the travel time of the racing vehicle based on the measurement reference position of the identified course, the vehicle position information of the racing vehicle, and the vehicle position acquisition time associated with each vehicle position information, and stores the information indicating the course and the measured travel time in the travel time DB. The information indicating the course and the measured travel time are associated and stored in the travel time DB. The provision processing unit provides multiple travel times associated with the same course to the user.



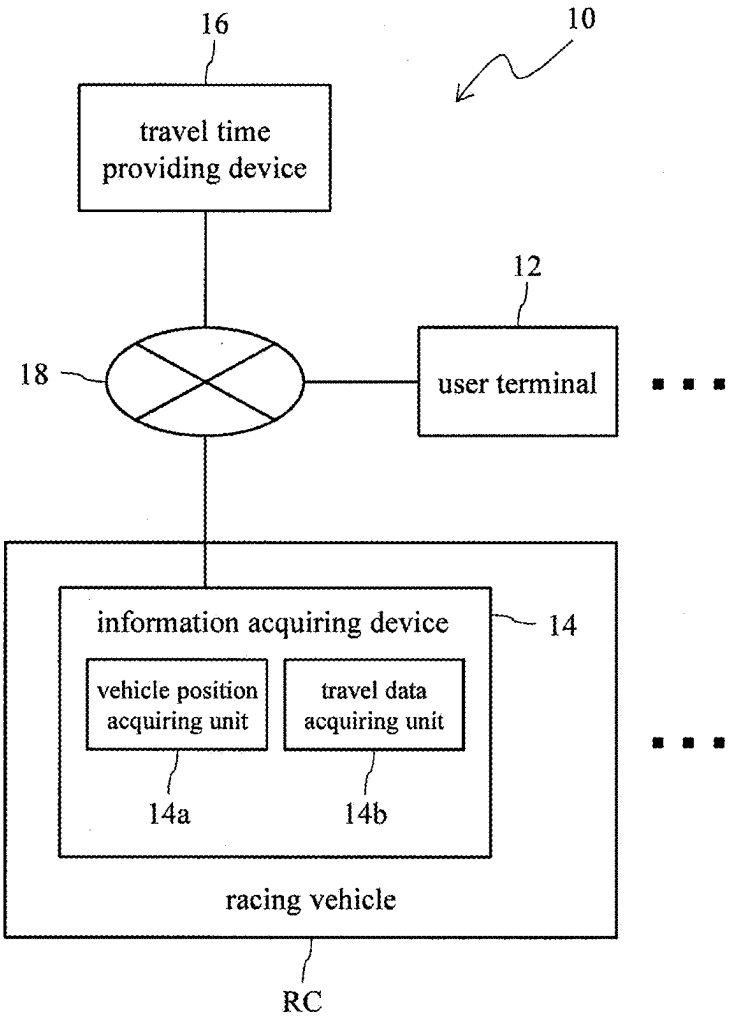

16
10
travel time providing device
12
18
user terminal
information acquiring device
14
vehicle position acquiring unit
travel data acquiring unit
14a
14b
racing vehicle
RC

FIG. 1

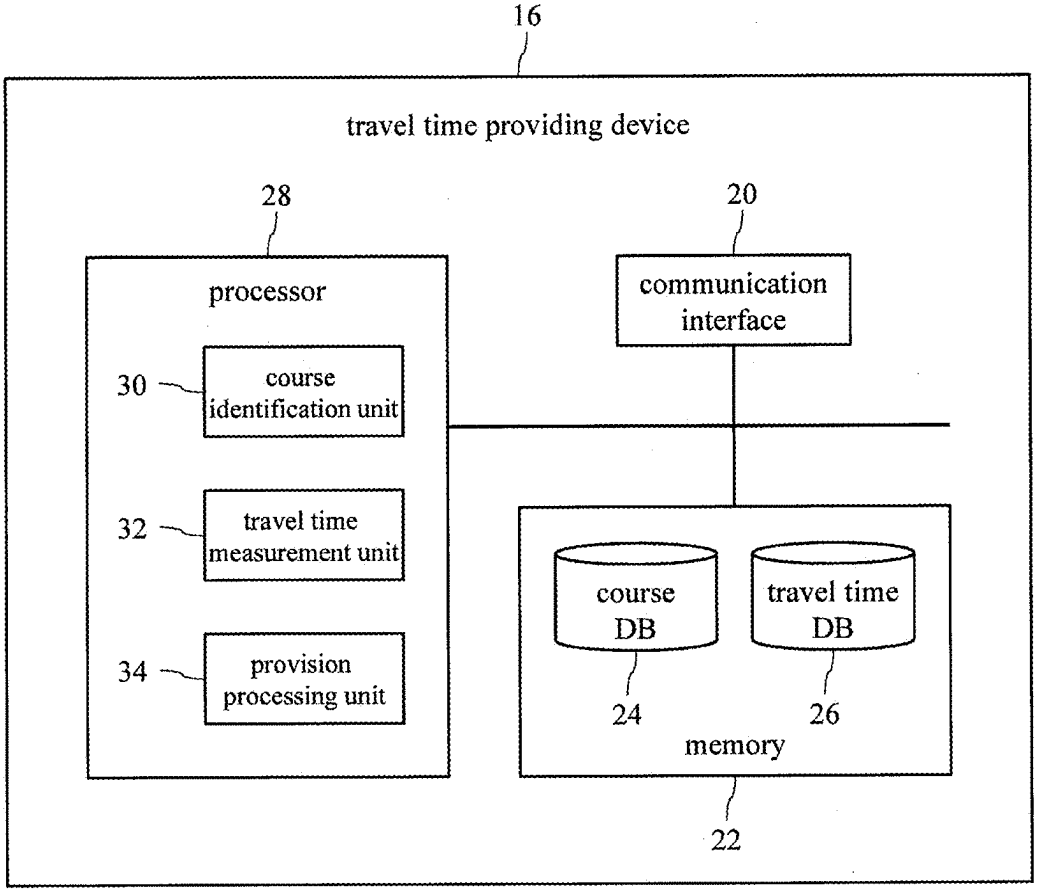

16
travel time providing device
28
processor
30
course identification unit
32
travel time measurement unit
34
provision processing unit
20
communication interface
course DB
travel time DB
24
26
memory
22

FIG. 2

24

course ID	1		2		3		...
layout							...
course length	1,620m		1,932m		1,250m		...
start line (left)	north latitude 45° 37'50.78"	east longitude 146° 17'33.09"	north latitude 38° 54'51.44"	east longitude 138° 13'07.60"	north latitude 39° 51'05.76"	east longitude 141° 31'09.11"	...
start line (right)	north latitude 45° 37'49.44"	east longitude 146° 17'32.85"	north latitude 38° 54'51.54"	east longitude 138° 13'09.17"	north latitude 39° 50'33.81"	east longitude 141° 32'25.50"	...
goal line (left)	north latitude 45° 37'50.78"	east longitude 146° 17'33.09"	north latitude 38° 54'51.44"	east longitude 138° 13'07.60"	north latitude 39° 51'05.76"	east longitude 141° 31'09.11"	...
goal line (right)	north latitude 45° 37'49.44"	east longitude 146° 17'32.85"	north latitude 38° 54'51.54"	east longitude 138° 13'09.17"	north latitude 39° 50'33.81"	east longitude 141° 32'25.50"	...
user evaluation	★230		★364		★523		...

FIG. 3

26

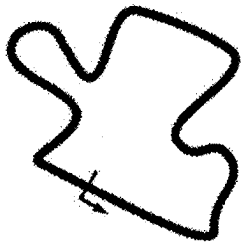
course ID	1				2				...
layout									...
	travel time	driving performance information		...	travel time	driving performance information		...	...
		car model	engine type	...		car model	engine type	...	
	1'02"105	car model B	Mxxx	...	...	...	...	...	...
	1'02"902	car model B	Gxxx	...	...	...	...	...	...
	1'01"345	car model A	Fxxx	...	...	...	...	...	...
	...	...	...	...	...	...	...	...	...

FIG. 4

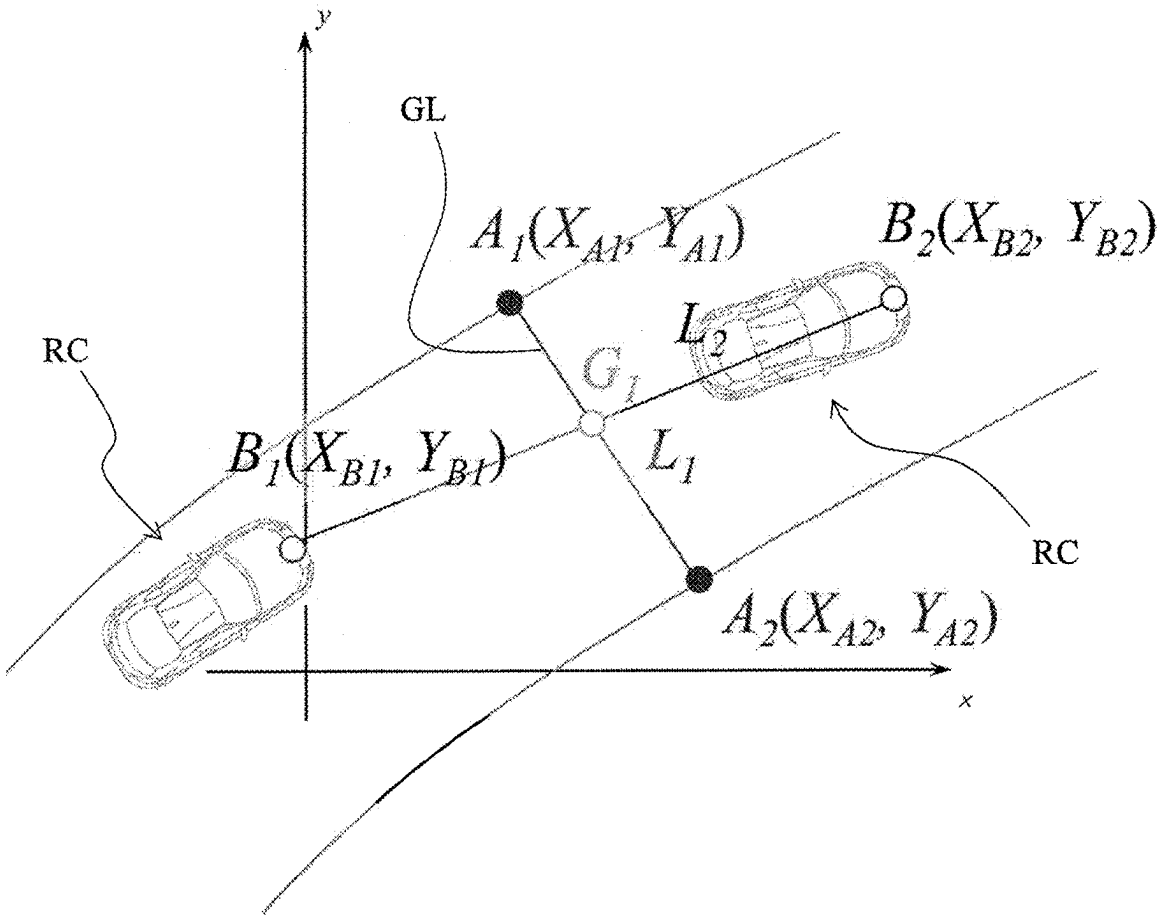


FIG. 5

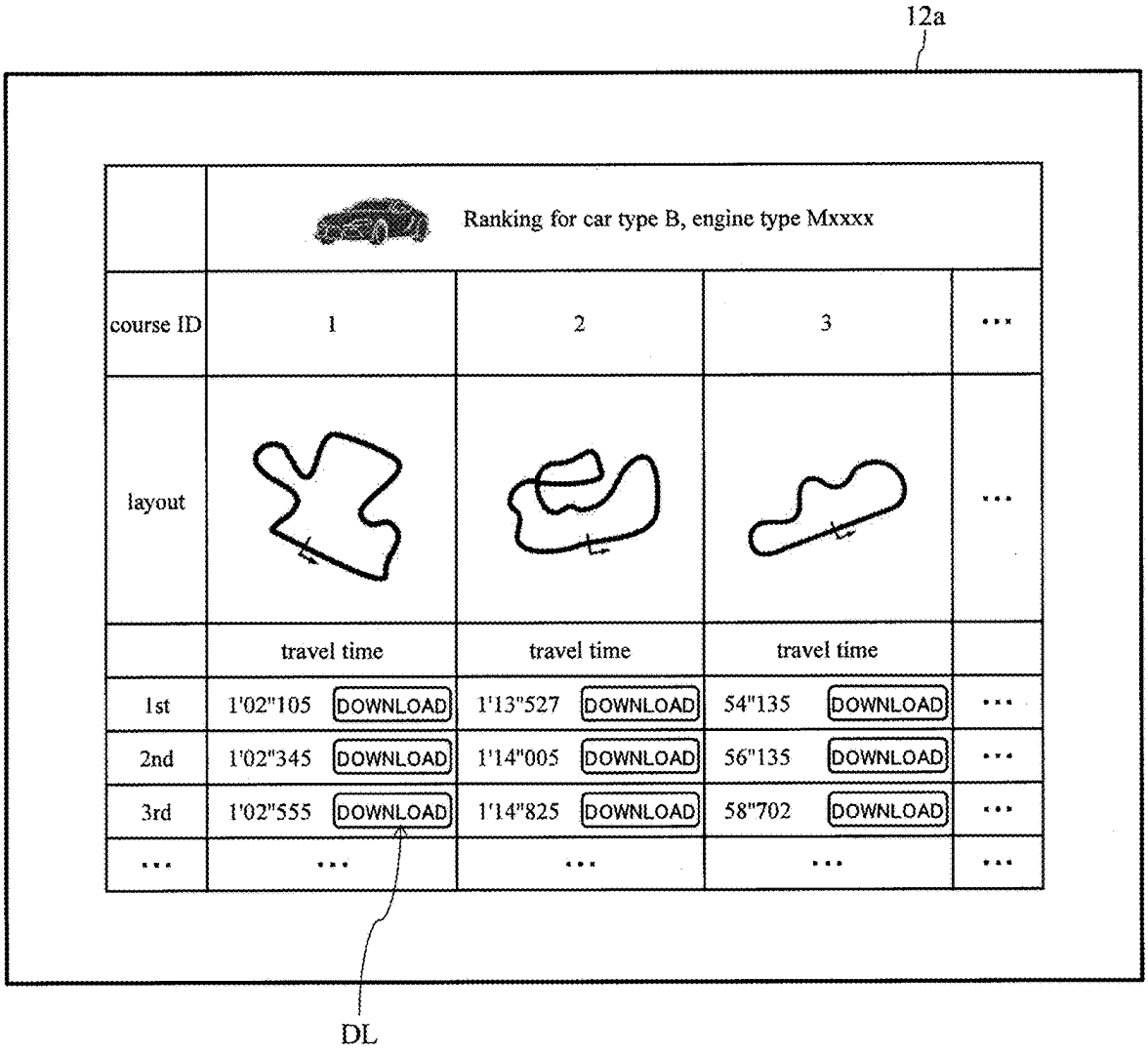

12a
Ranking for car type B, engine type Mxxxx
course ID
1
2
3
layout
travel time
travel time
travel time
1st
1'02"105 DOWNLOAD
1'13"527 DOWNLOAD
54"135 DOWNLOAD
2nd
1'02"345 DOWNLOAD
1'14"005 DOWNLOAD
56"135 DOWNLOAD
3rd
1'02"555 DOWNLOAD
1'14"825 DOWNLOAD
58"702 DOWNLOAD
DL

FIG. 6

TRAVEL TIME PROVIDING DEVICE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-018907 filed on Feb. 9, 2024, which is incorporated herein by reference in its entirety including the specification, claims, drawings, and abstract.

TECHNICAL FIELD

[0002] The present disclosure relates to improvements to travel time providing device.

BACKGROUND

[0003] Conventionally, a system for acquiring information on the running of a racing vehicle, which is a vehicle participating in a race, during a motor sports competition race is provided. For example, Patent literature 1 discloses a system that calculates an offset representing the deviation between the lap time of a racing vehicle and a predetermined reference lap time, and calculates the position of the racing vehicle on the racing course based on the elapsed time since the racing vehicle passed a reference point on the racing course and the calculated offset.

CITATION LIST

[0004] PATENT LITERATURE 1: JP2007-233462A

[0005] By the way, in motorsports competitions, we consider measuring the travel time of a racing vehicle in a race. In this specification, travel time refers to the overall time, which is the time required from the start of the race until the racing vehicle crosses the finish line, the time required for the racing vehicle to complete one lap when the racing course (hereinafter simply referred to as "course" in this specification) is a circuit course, the lap time, which is the time required for the racing vehicle to complete one lap of the course, and the time required for the racing vehicle to cross the finish line. The concept includes lap time, which is the time required for a racing vehicle to travel each section of the course (in a circuit course, a section formed by dividing a lap of the course into multiple sections), and sector time, which is the time required for a racing vehicle to travel each section of the course (in a circuit course, a section formed by dividing the course into multiple sections).

[0006] Usually, circuits where races are held have a measurement system for measuring the travel time of racing vehicles, and the measurement system measures the travel time of racing vehicles. However, such a measurement system is owned by the administrator of the circuit. Therefore, when a race operator who uses the circuit to conduct a race needs to use the measurement system, he/she needs to obtain permission from the circuit administrator or pay a fee to the circuit administrator for the use of the measurement system.

[0007] Therefore, in recent years, in addition to the method using such a measurement system, a method has been proposed to measure the running time of racing vehicles based on the vehicle position information indicating the vehicle position obtained by using the Global Navigation Satellite System (GNSS) and the vehicle position acquisition time, which is the time when each vehicle position information was acquired. The method of measuring the travel time of a racing vehicle is proposed. In this method, the server measures the travel time of each racing vehicle by acquiring the vehicle position information and the vehicle position acquisition time from each racing vehicle. This allows the server to aggregate and manage the travel times of each racing vehicle. The server can then provide the aggregated travel times to users such as racing vehicle drivers and racing team staff, for example, in the form of a ranking of the fastest travel times.

[0008] Here, travel times of multiple racing vehicles running on multiple circuits may be aggregated on the server. For example, a circuit may have multiple courses, such as a long course and a short course, etc. When multiple racing vehicles, each of which races on multiple courses included in one circuit, transmit their vehicle position information and vehicle position acquisition times to the server, the running times of the multiple racing vehicles running on the multiple courses may be aggregated to the server. The travel times of the multiple racing vehicles will be aggregated on the server.

[0009] In such a case, since it is meaningless to compare travel times of racing vehicles that ran on different courses, it is desirable to extract travel times of racing vehicles that ran on the same course and provide them to users.

[0010] The purpose of the travel time providing device disclosed herein is to measure the travel time of racing vehicles in a race without using a measurement system provided at a circuit, and then to extract and provide to the user the travel time of racing vehicles that have traveled on the same racing course.

SUMMARY

[0011] A travel time providing device disclosed in the present specification comprising:

[0012] a course identification unit that refers to a course database in which a plurality of combinations of a layout of a racing course and a measurement reference position serving as a measurement reference for a travel time of a racing vehicle on the racing course are stored, and identifies a racing course on which the racing vehicle has traveled, based on a travel path of the racing vehicle acquired from a plurality of pieces of vehicle position information indicating a position of the racing vehicle acquired over time;

[0013] a travel time measurement unit that measures the travel time of the racing vehicle that has traveled on the identified racing course based on the measurement reference position of the identified racing course, the vehicle position information, and the time at which each piece of the vehicle position information is acquired, and stores information indicating the identified racing course and the travel time in association with each other in a memory; and

[0014] a provision process unit that provides, to a user, a plurality of travel times associated with the same racing course.

[0015] The travel time measurement unit may acquire travel performance information indicating a travel performance of the racing vehicle, and may store the travel performance information in association with information indicating the identified racing course and the travel time in a memory, and

[0016] the provision process unit may provide, to the user, a plurality of travel times associated with the same

racing course and to which the travel performance information indicating equivalent travel performance is associated.

BRIEF DESCRIPTION OF DRAWINGS

[0017] Embodiment of the present disclosure will be described based on the following figures, wherein:

[0018] FIG. **1** is schematic diagram of the travel time providing system.

[0019] FIG. **2** is schematic diagram of the travel time providing device.

[0020] FIG. **3** is conceptual diagram showing an example of the contents of the course DB.

[0021] FIG. **4**: is a conceptual diagram showing an example of the contents of the travel time DB.

[0022] FIG. **5** shows the parameters used in the calculation to determine when a racing vehicle has reached the goal.

[0023] FIG. **6** shows an example of the screen for providing travel time.

EMBODIMENTS

[0024] FIG. **1** is a schematic diagram of a travel time providing system **10**. The travel time providing system **10** comprises a user terminal **12**, an information acquiring device **14** provided in a racing vehicle RC participating in a race, and a travel time providing device **16**. The user terminal **12**, the information acquiring device **14**, and the travel time providing device **16** are connected to each other via a communication line **18** such as the Internet or wireless communication.

[0025] A racing vehicle RC is not limited to a vehicle dedicated to racing, such as an F1 car, for example. Where races are conventionally held in which commercially available general vehicles can participate, general vehicles participating in such races are also included in racing vehicles RCs. The racing vehicle RC is not limited to a four-wheeled vehicle, but may also be a two-wheeled vehicle. Furthermore, the racing vehicle RC may have any type of prime mover, and the racing vehicle RC may be a vehicle without a prime mover.

[0026] The user terminal **12** is a terminal used by a user such as a driver of the racing vehicle RC or a staff member of a racing team. The user terminal **12** may be, for example, a smartphone or a PC.

[0027] The information acquiring device **14** is a device mounted on the racing vehicle RC in this embodiment. The information acquiring device **14** may also be a device that is not mounted on the racing vehicle RC as long as it is capable of performing the functions described below. For example, the information acquiring device **14** may be a portable terminal (e.g., a smart phone) that is brought into the racing vehicle RC.

[0028] As shown in FIG. **1**, the information acquiring device **14** has a vehicle position acquiring unit **14***a* and a travel data acquiring unit **14***b*.

[0029] The vehicle position acquiring unit **14***a* comprises, for example, an antenna that receives radio waves from GNSS satellites and a receiver that processes the received signals. The vehicle position acquiring unit **14***a* acquires vehicle position information indicating the position of the racing vehicle RC based on the reception timing of radio waves from the plurality of GNSS satellites. The vehicle position acquiring unit **14***a* acquires the vehicle position information intermittently. For example, the vehicle position acquiring unit **14***a* acquires vehicle position information at a frequency of about 20 Hz (about 20 times per second). In this embodiment, the vehicle location information is expressed in polar coordinates such as latitude and longitude (or even height).

[0030] Furthermore, the vehicle position acquiring unit **14***a* has a timekeeping function and acquires the vehicle position acquisition time, which is the time at which the vehicle position information is acquired.

[0031] The travel data acquiring unit **14***b* acquires various driving data related to the driving of the racing vehicle RC based on the detected values of various vehicle sensors provided in the racing vehicle RC. The driving data includes, but is not limited to, vehicle speed of the racing vehicle RC, the amount of operation of the gas pedal and brake, the amount of steering wheel operation, and images taken by the on-board camera provided with the racing vehicle RC.

[0032] The travel data acquiring unit **14***b* acquires driving data of the racing vehicle RC over time. In particular, the travel data acquiring unit **14***b* acquires driving data of the racing vehicle RC over time during a race.

[0033] The information acquiring device **14** associates the vehicle ID identifying the racing vehicle RC, the vehicle position information acquired by the vehicle position acquiring unit **14***a*, and the vehicle position acquisition time at which the vehicle position information was acquired, and transmits the information to the travel time providing device **16**. The information acquiring device **14** also associates the vehicle ID identifying the racing vehicle RC with the travel data acquired by the travel data acquiring unit **14***b* and transmits it to the travel time providing device **16**.

[0034] Further, the information acquiring device **14** may associate the vehicle ID identifying the racing vehicle RC with the traveling performance information indicating the traveling performance of the racing vehicle RC and transmit it to the travel time providing device **16**. The driving performance information includes, but is not limited to, for example, the model of the racing vehicle RC, engine model, and tire model number. These driving performance information may be obtained by the information acquiring device **14** from each part of the racing vehicle RC (ECU, engine, etc.) or may be input to the information acquiring device **14** by the driver. The racing vehicle RC's travel performance information may also be input by the user into the user terminal **12** or otherwise transmitted from the user terminal **12** to the travel time providing device **16**.

[0035] FIG. **2** is a schematic diagram of the travel time providing device **16** in this embodiment. In this embodiment, the travel time providing device **16** consists of a server computer. However, any device may be used as the travel time providing device **16** as long as it is capable of performing the functions described below. The functions described below may also be performed by multiple devices working together. In such a case, the multiple devices correspond to the travel time providing device **16**.

[0036] The communication interface **20** comprises, for example, a network adapter. The communication interface **20** functions to communicate with the user terminal **12** and the information acquiring device **14**.

[0037] Memory **22** comprises a HDD (Hard Disk Drive), SSD (Solid State Drive), eMMC (embedded Multi Media Card), ROM (Read Only Memory), or RAM (Random Access Memory). The memory **22** includes a running time

provision device. The memory **22** stores a travel time providing program for operating the various parts of the travel time providing device **16**. The travel time program can be stored in a computer-readable non-transitory storage medium, such as a USB (Universal Serial Bus) memory or an SD card, for example. The travel time providing device **16** can read and execute the travel time providing program from such a storage medium. As shown in FIG. **2**, the memory **22** stores a course DB (DataBase) **24** and a travel time DB **26**.

[0038] FIG. **3** is a conceptual diagram showing an example of the contents of the course DB **24**. The course DB **24** stores information about each course on which a race is held. In particular, the course DB **24** stores a plurality of combinations of the layout of the course and the measurement reference position that serves as the measurement reference for the travel time of the racing vehicle RC on that course. In this embodiment, the course DB **24** stores a plurality of course information in which information that uniquely identifies the course ID, the layout of the course, the length of the course, the positions of the start line and the goal line as the reference positions for measurement, and the user evaluation are associated with each other. In addition, the course information may also be associated with information indicating the positions of the start and end lines of each section (sector) provided in the course as the reference positions for measurement, and information indicating the positions of the grid lines in a course with a grid. In the example in FIG. **3**, each course is a lap course, but the course is not limited to a lap course. For example, the course may be a non-loop course, such as a rally course.

[0039] The information indicating the layout of the course may have not only a FIG. showing the shape of the course in plan view, but also location information indicating the shape of the course. For example, the information indicating the layout of the course may include location information indicating the position of each corner of the course and information indicating the order in which the corners are passed.

[0040] In the example in FIG. **3**, the length of one lap is shown as the length of the course, because each course is a circuit course.

[0041] In this system, position information indicating the location of the start and finish lines is expressed in polar coordinates such as latitude and longitude (or even height). The start line (left) in FIG. **3** means one end of the start line, and the start line (right) means the other end of the start line. In other words, in this form, the start line is represented by the polar coordinates of one end and the polar coordinates of the other end. The same is true for the finish line, the start and end lines of each sector, and the grid lines. In a circuit course, the start line and the goal line are generally at the same location, while in a noncircuit course, the start line and the goal line are at different locations.

[0042] Each course information stored in the course DB **24** is provided to the user upon request from the user. As described below, where each user can register course information to the course DB **24**, the user can input user evaluations (reviews) for the course information registered in the course DB **24**. In the example in FIG. **3**, the user evaluation is shown as a numerical value. For example, the processor **28** of the travel time providing device **16** can delete course information with a low user evaluation (e.g., course information registered by mistake or as a prank) from the course DB **24**.

[0043] The administrator of the travel time providing device **16** or the like may store course information for some courses in the course DB **24**, or course information provided by the user may be stored in the course DB **24**. Alternatively, as described below, at least the layout of the course information may be registered based on the driving path of the racing vehicle RC based on the multiple vehicle location information of the racing vehicle RC.

[0044] FIG. **4** is a conceptual diagram showing an example of the contents of the travel time DB **26**. In the Travel time DB **26**, information indicating the course (course ID and layout in the example in FIG. **4**) and the travel time of the racing vehicle RC that has traveled the course, as measured by the travel time measurement unit **32** described below, are associated and stored. The method of measuring the travel time of racing vehicles RCs and the details of the travel time DB **26** are described below.

[0045] The processor **28** comprises, for example, a CPU (Central Processing Unit). The processor **28** is communicatively connected to the communication interface **20** and the memory **22** via a data bus. The processor **28** functions as the course identification unit **30**, the travel time measurement unit **32**, and the provision processing unit **34** according to the travel time provision program stored in the memory **22**.

[0046] The course identification unit **30** identifies the course traveled by the racing vehicle RC. First, the course identification unit **30** acquires from the information acquiring device **14** a plurality of vehicle position information acquired by the vehicle position acquiring unit **14***a* over time while the racing vehicle RC is traveling on the course. The course identification unit **30** can obtain a driving route for the racing vehicle RC based on the plurality of positions indicated by the plurality of vehicle position information. In order to obtain a more accurate traveling route of the racing vehicle RC, the course identification unit **30** may obtain a traveling route of the racing vehicle RC by connecting the positions indicated by the vehicle position information in the order of the vehicle position acquisition time associated with each vehicle position information.

[0047] Next, the course identification unit **30** refers to the course DB **24** and identifies the course traveled by the racing vehicle RC based on the travel route of the racing vehicle RC. For example, the course identification unit **30** calculates the degree of similarity between the shape of the layout of each course stored in the course DB **24** and the traveling route of the racing vehicle RC, respectively, and identifies the course having the layout with the greatest degree of similarity as the course on which the racing vehicle RC has traveled.

[0048] By identifying the course on which the racing vehicle RC has traveled by the course identification unit **30**, it becomes possible to identify the measurement reference positions (e.g., start line, goal line, and start and end lines of each sector) of the course by referring to the course DB **24**.

[0049] The course identification unit **30** may identify the course traveled by the racing vehicle RC after the end of the race in which the racing vehicle RC participates, but if the lap time and sector time of the racing vehicle RC are to be measured in real time during the race, the course may be identified before the start of the race in which the racing vehicle RC participates. In this case, the course identifica-

tion unit **30** specifies the course. In this case, the course identification unit **30** may, for example, identify the course based on the driving path of the racing vehicle RC during practice runs and formation laps (the racing vehicle RC travels around the course to move to the starting position before the race).

[0050] If there is no course in the course DB **24** that is similar to the traveling path of the racing vehicle RC (e.g., if there is no course for which the similarity between the shape of the layout of the course and the traveling path of the racing vehicle RC exceeds a predetermined similarity threshold value), the course identification unit **30** identifies a new course information including the traveling path of the racing vehicle RC as the layout The course identification unit **30** may register new course information in the course DB **24** that includes the driving path of the racing vehicle RC as a layout. In this case, the course identification unit **30** requests the user to input the measurement reference position (e.g., start line and goal line) of the course, and based on the user input, the measurement reference position of the course is included in the course information. For example, the course identification unit **30** superimposes on the display of the user terminal **12** an ortho image (an aerial photo image whose tilt and misalignment have been corrected so that the image is as if seen from directly above at all locations in the image) the driving path of the racing vehicle RC, and requests the user to input the measurement reference positions on that screen. Furthermore, the course identification unit **30** measures the length of the traveling route from the input start line and goal line, which is also included in the course information concerned.

[0051] The travel time measurement unit **32** measures the travel time of the racing vehicle RC that has traveled the specified course based on the measurement reference position of the specified course, the vehicle position information of the racing vehicle RC, and the vehicle position acquisition time associated with each vehicle position information. For example, the travel time measurement unit **32** measures the time from the race start time to the time when the racing vehicle RC crosses the finish line as the overall time. In addition, the travel time measurement unit **32** measures the time from the time when the vehicle crosses the start line to the time when the vehicle crosses the finish line on the lap course as the lap time. The travel time measurement unit **32** also measures the time from the time when the driver crosses the start line of a sector to the time when the driver crosses the end line as sector time. The race start time can be, for example, the time when the racing vehicle RC departed from the start line or the grid vicinity based on the vehicle position information and the vehicle position acquisition time.

[0052] Referring to FIG. **5**, the method of determining whether or not the racing vehicle RC has passed the measurement reference position (line) based on the vehicle position information and the vehicle position acquisition time, and the method of identifying the time when the racing vehicle RC passed the measurement reference position (line) will be explained below. In the following, the case where the reference position is the finish line is explained, but even if the reference position is the start line or the start and end line of a sector, the same method can be used to determine whether the vehicle has passed and to specify the time of passing. In the following explanation, the antenna of the vehicle position acquiring unit **14***a* is provided at the front end of the racing vehicle RC, and the vehicle position information of the racing vehicle RC shall indicate the position of the front end of the racing vehicle RC.

[0053] First, the method of determining whether or not the racing vehicle RC has passed the measurement reference position (line) is described. The travel time measurement unit **32** converts the two polar coordinates indicating the positions of one end and the other end of the measurement reference position (goal line **L1** in the example in FIG. **5**) into Cartesian coordinates (xyz coordinates). The conversion to Cartesian coordinates can be performed using known methods (e.g., "GPS Theory and Applications," B. Hoffman-Wellenhoff, H. Lichtenegger, J. Collins, Springer-Verlag Tokyo, p. 319), so a detailed explanation is omitted here. Similarly, the travel time measurement unit **32** also converts the polar coordinates indicating the position of the racing vehicle RC to Cartesian coordinates.

[0054] In FIG. **5**, one end of the goal line L_1 is represented by the Cartesian coordinates A_1 (X_{A1}, Y_{A1}), the other end of the goal line L_1 is represented by the Cartesian coordinates A_2 (X_{A2}, Y_{A2}), and the position of the racing vehicle RC is represented by the Cartesian coordinates B_1 (X_{B1}, Y_{B1}) and B_2 (X_{B2}, Y_{B2}). B_2 represents the vehicle position of the racing vehicle RC at the present time (just after crossing the goal line L_1), and B_1 represents the vehicle position of the racing vehicle RC in the past (just before crossing the goal line L_1). In the example shown in FIG. **5**, the z-axis coordinates of each position are omitted for convenience.

[0055] First, the line segment connecting A_1 and A_2 (i.e., the goal line L_1) can be expressed by the following equation (2-1).

$$y = m_A x + b_A \tag{2-1}$$

[0056] In equation (2-1), ma and ba are as follows.

$$m_A = \frac{Y_{A2} - Y_{A1}}{X_{A2} - X_{A1}} \tag{2-2}$$

$$b_A = Y_{A1} - m_A \times X_{A1} \tag{2-3}$$

[0057] Assuming that the direction of travel of the racing vehicle RC is in the positive incremental direction of the x-axis, the following equations (2-4) and (2-5) are satisfied after crossing the goal line L_1. That is, the travel time measurement unit **32** judges that the racing vehicle RC has crossed the goal line L_1 when the following equation (2-4) or equation (2-5) is satisfied. The ma in equation (2-5) is expressed by equation (2-2) and b_A is expressed by equation (2-3).

[0058] When the goal line L_1 is parallel to the y-axis (X_{A1}=X_{A2})

$$X_{B2} \geqq X_{A2} = X_{A1} \tag{2-4}$$

[0059] When the goal line L_1 is not parallel to the y-axis ($X_{A1} \neq X_{A2}$)

$Y_{B2} \geq y$

[0060] Substituting $x=X_{B2}$ into equation (2-1)

$$Y_{B2} \geqq m_A \times X_{B2} + b_A \tag{2-5}$$

[0061] Next, the method of identifying the time when the racing vehicle RC passed the measurement reference position (line) is explained. First, a straight line parallel to the goal line L_1 is expressed by the following equation (3-1), and a straight line parallel to the direction of travel of the racing vehicle RC is expressed by the following equation (3-2).

$$y = m_A x + b_A \tag{3-1}$$

$$y = m_B x + b_B \tag{3-2}$$

[0062] The passing point G_1, which is the point on the goal line L_1 that the racing vehicle RC passes, is the intersection of the straight line expressed in Equation (3-1) and the straight line expressed in Equation (3-2). In other words, the time when the racing vehicle RC reaches the passing point G_1 is the time when the racing vehicle RC crosses the goal line L_1, so the travel time measurement unit **32** calculates the time when the racing vehicle RC reaches the passing point G_1.

[0063] From equations (3-1), (3-2), the coordinates of A_1, A_2, B_1, and B_2, equations (3-3) through (3-5) hold.

$$m_A = \frac{Y_{A2} - Y_{A1}}{X_{A2} - X_{A1}} \tag{3-3}$$

$$m_B = \frac{Y_{B2} - Y_{B1}}{X_{B2} - X_{B1}} \tag{3-4}$$

$$b_A = Y_{A1} - m_A \times X_{A1} \tag{3-5}$$

$$b_B = Y_{B1} - m_B \times X_{B1} \tag{3-6}$$

[0064] Also, when equation (3-1) and equation (3-2) are coupled, equation (3-7) is obtained.

$$m_A x + b_A = m_B x + b_B \tag{3-7}$$

[0065] Equation (3-7) is transformed to Equation (3-8).

$$x = \frac{b_B - b_A}{m_A - m_B} \tag{3-8}$$

[0066] Here, if the acquisition interval of the vehicle position information and the vehicle position acquisition time is sufficiently short and the speed change of the racing vehicle RC is extremely small, the time when the racing vehicle RC reaches the passing point G_1 can be calculated by linear interpolation using the following formula (3-9).

$$T = \frac{T_B - x}{X_B} \tag{3-9}$$

[0067] In Equation (3-9), T_{B1} is the time when racing vehicle RC is at B_1 (i.e., the vehicle location acquisition time associated with the vehicle location information indicating B_1), T_{B2} is the time when racing vehicle RC is at B_2, and T_B is the difference between T_{B2} and T_{B1}, i.e. Equation (3-10).

$$T_B = T_{B2} - T_{B1} \tag{3-10}$$

[0068] X_B is the difference between the x-coordinates of B_1 and B_2, i.e., as in Equation (3-11).

$$X_B = X_{B2} - X_{B1} \tag{3-11}$$

[0069] The travel time measurement unit **32** associates the information indicating the course identified by the course identification unit **30** with the travel time of the racing vehicle RC that was measured and stores it in the travel time DB **26**. In this embodiment, the travel time measurement unit **32** stores the travel time in the travel time DB **26** in association with the course ID and layout of the course identified by the course identification unit **30**.

[0070] As shown in FIG. **4**, the travel time measurement unit **32** may store the information indicating the course identified by the course identification unit **30** and the travel time of the racing vehicle RC in the travel time DB **26** by associating the driving performance information of the said racing vehicle RC obtained from the information acquiring device **14** (or user terminal **12**). Furthermore, the travel time measurement unit **32** may store the driving data of the racing vehicle RC obtained by the travel data acquiring unit **14***b* during the relevant race in the travel time DB **26** by further associating such data with the travel time of the racing vehicle RC.

[0071] The provision processing unit **34** provides a user with a plurality of travel times of a plurality of racing vehicles RCs that have been measured by the travel time measurement unit **32** and stored in the travel time DB **26**. In particular, where a plurality of travel times associated with a plurality of courses are stored in the travel time DB **26**, the provision processing unit **34** provides the user with a plurality of travel times associated with the same course among the plurality of travel times stored in the travel time DB **26**. At this time, the provision processing unit **34** may provide the plurality of travel times to the user in the form of a ranking in order of earliest to latest.

[0072] For example, the user specifies a desired course (e.g., the course he/she has driven if the user is a driver). When the provision processing unit **34** receives the designation of the course from the user, it provides the user with a plurality of travel times associated with the designated course. This allows the user to check only those travel times that are relevant to him/her (i.e., the travel times associated with the specified course) out of the plurality of travel times stored in the travel time DB **26**.

[0073] In particular, the provision processing unit **34** may provide the user with a plurality of travel times associated

with the same course and with travel performance information indicating equivalent travel performance. In this case, the user specifies the desired driving performance (e.g., engine model, horsepower range, etc.) along with the desired course. When the provision processing unit **34** receives the specification of the course and driving performance from the user, it provides the user with a plurality of travel times associated with the specified course and associated with driving performance information that satisfy the specified driving performance. It may not be very meaningful to compare travel times related to racing vehicles RCs with completely different driving performance (e.g., completely different engine performance), even if they ran on the same course. In such cases, the user can specify the course and driving performance to check only those travel times that are relevant to him/her (i.e., multiple travel times associated with the specified course and associated with driving performance information that satisfy the specified driving performance).

[0074] FIG. **6** shows an example of the travel time provision screen. In this embodiment, the provision processing unit **34** provides travel times to the user by displaying the travel time provision screen on the display unit **12***a* of the user terminal **12**. As shown in FIG. **6**, the provision processing unit **34** can also provide multiple travel times for multiple courses to the user. The travel time provision screen also includes a download button DL associated with each travel time. When a user operates the download button DL associated with a certain travel time, the provision processing unit **34** provides the user with the travel data of the racing vehicle RC during the race that is associated with the travel time and stored in the travel time DB **26**. This allows, for example, the user to check the travel data concerning a racing vehicle RC that has achieved an excellent travel time, which can be used as a reference for his/her own driving.

[0075] The travel time providing device of the present disclosure is not limited to the above embodiments, but can be modified in various ways without departing from the intent of the above embodiments.

REFERENCE SIGNS LIST

[0076] **10** travel time providing system, **12** user terminal, **14** information acquiring device, **14***a* vehicle position acquiring unit, **14***b* travel data acquiring unit, **16** travel time providing device, **20** communication interface, **22** memory, **24** course DB, **26** travel time DB, **28** processor, **30** course identification unit, **32** travel time measurement unit, **34** provision processing unit.

1. A travel time providing device comprising:

a course identification unit that refers to a course database in which a plurality of combinations of a layout of a racing course and a measurement reference position serving as a measurement reference for a travel time of a racing vehicle on the racing course are stored, and identifies a racing course on which the racing vehicle has traveled, based on a travel path of the racing vehicle acquired from a plurality of pieces of vehicle position information indicating a position of the racing vehicle acquired over time;

a travel time measurement unit that measures the travel time of the racing vehicle that has traveled on the identified racing course based on the measurement reference position of the identified racing course, the vehicle position information, and the time at which each piece of the vehicle position information is acquired, and stores information indicating the identified racing course and the travel time in association with each other in a memory; and

a provision process unit that provides, to a user, a plurality of travel times associated with the same racing course.

2. The travel time providing device according to claim **1**,

wherein the travel time measurement unit acquires travel performance information indicating a travel performance of the racing vehicle, and stores the travel performance information in association with information indicating the identified racing course and the travel time in a memory, and

the provision process unit provides, to the user, a plurality of travel times associated with the same racing course and to which the travel performance information indicating equivalent travel performance is associated.

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