NAVIGATION DEVICE, NAVIGATION METHOD, AND NON-TRANSITORY COMPUTER-READABLE STORAGE MEDIUM STORING NAVIGATION PROGRAM

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a navigation device, a navigation method, and a non-transitory computer-readable storage medium storing a navigation program.

2. Description of Related Art

[0002] As systems using dedicated short range communications, automatic toll collection systems called ETC (registered trademark) systems have been put to practical use. An ETC system having become widespread in Japan is provided with a toll fare collection lane for guiding a vehicle to a tollbooth through a tollgate, an antenna device that performs road-vehicle wireless communication between the antenna device and an ETC on-vehicle device mounted on the vehicle, a vehicle detector which is installed at a side portion of the toll fare collection lane, and an opening/closing bar which is installed on an exit side of the toll fare collection lane. When the approach of the vehicle to the tollgate is detected by the vehicle detector, the antenna device starts road-vehicle wireless communication between the antenna device and the ETC on-vehicle device to perform billing processing. When the billing processing is normally terminated, the opening/closing bar is opened, and thus the vehicle can pass through the tollbooth. The toll fare collection lane can be roughly classified into a lane which guides a vehicle mounted with an ETC on-vehicle device to a tollbooth performing billing processing through road-vehicle wireless communication (hereinafter, referred to as an "ETC lane"), and a lane which guides a vehicle not mounted with an ETC on-vehicle device to a tollbooth performing billing processing through a toll collector (hereinafter, referred to as a "general lane"). Japanese Unexamined Patent Application Publication No. 2009-042225 (JP 2009-042225 A) discloses a navigation device that displays guidance to a tollgate by

distinguishing between an ETC lane of a tollbooth and a general lane.

SUMMARY OF THE INVENTION

[0003] In Japan, a method of performing billing processing through a tollbooth having a tollgate has become mainstream, and thus it is helpful to display guidance to the tollgate. However, other countries having an automatic toll collection system also include a country that adopts a method of performing billing processing through, for example, road-vehicle wireless communication or a process of imaging a vehicle number without providing a tollgate. In the above-described country, the display of guidance to the tollgate is not necessary. Normal navigation devices also include a navigation device that displays guidance to a tollgate without distinguishing an automatic toll collection system not having a tollgate, and thus there have been demands for an improvement.

[0004] The invention provides a navigation device, a navigation method, and a non-transitory computer-readable storage medium storing a navigation program which are capable of changing the display of guidance to a tollgate in accordance with the presence or absence of a tollgate of an automatic toll collection system.

[0005] A first aspect of the invention relates to a navigation device including a storage device, a position detection device, a determination unit, and a display device. The storage device is configured to store positional information on an automatic toll collection system and information indicating whether the automatic toll collection system uses tollgates in association with each other. The position detection device is configured to detect positional information on a vehicle. The determination unit is configured to determine whether the automatic toll collection system through which the vehicle is expected to pass uses tollgates based on the positional information on the vehicle detected by the position detection device, the positional information on the automatic toll collection system which is stored in the storage device, and the information indicating use of non-use of tollgates which is stored in the storage device. The display device is configured to display guidance to a tollgate in a case where the determination unit determines that the automatic toll collection system through which the vehicle is expected to

pass uses tollgates, and to display a toll fare but not to display guidance to a tollgate in a case where the determination unit determines that the automatic toll collection system through which the vehicle is expected to pass does not use tollgates.

[0006] According to the navigation device of the first aspect of the invention, it is possible to change the display of guidance to a tollgate in accordance with the presence or absence of a tollgate of the automatic toll collection system through which the vehicle is expected to pass.

[0007] In the first aspect of the invention, the determination unit may determine whether or not the vehicle is in a state where wireless billing is able to be performed between the vehicle and the automatic toll collection system.

[0008] A second aspect of the invention relates to a navigation method including storing positional information on an automatic toll collection system and information indicating whether the automatic toll collection system uses tollgates in association with each other by a computer system, detecting positional information on a vehicle by the computer system, determining whether the automatic toll collection system through which the vehicle is expected to pass uses tollgates by the computer system based on the detected positional information on the vehicle, the stored positional information on the automatic toll collection system, and the stored information indicating use or non-use of tollgates, and displaying guidance to a tollgate by the computer system in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass uses tollgates, and displaying a toll fare but not displaying guidance to a tollgate by the computer system in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass does not use tollgates.

[0009] A third aspect of the invention relates to a non-transitory computer-readable storage medium storing a navigation program. The navigation program executes a step of storing positional information on an automatic toll collection system and information indicating whether the automatic toll collection system uses tollgates in association with each other, a step of detecting positional information on a vehicle, a step of determining

whether the automatic toll collection system through which the vehicle is expected to pass uses tollgates based on the detected positional information on the vehicle, the stored positional information on the automatic toll collection system, and the stored information indicating use or non-use of tollgates, and a step of displaying guidance to a tollgate in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass uses tollgates, and displaying a toll fare but not displaying guidance to a tollgate in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass does not use tollgates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a diagram illustrating a hardware configuration of a navigation device according to an embodiment of the invention;

FIG. 2 is a table of attribute information on an automatic toll collection system according to the embodiment of the invention;

FIG. 3 is a flowchart illustrating a flow of processing of a navigation method according to the embodiment of the invention;

FIG. 4 is a diagram illustrating an example of a display screen according to the embodiment of the invention;

FIG. 5 is a diagram illustrating an example of a display screen according to the embodiment of the invention;

FIG. 6 is a diagram illustrating an example of a display screen according to the embodiment of the invention; and

FIG. 7 is a diagram illustrating an example of a display screen according to the embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, an embodiment of the invention will be described with

reference to the accompanying drawings. Here, the same components are denoted by the same reference numerals and signs, and a repeated description thereof will be omitted. FIG. 1 is a diagram illustrating a hardware configuration of a navigation device 10 according to the embodiment of the invention. The navigation device 10 is an on-vehicle device that guides a recommended route ranging from a departure point to a destination point to a vehicle 100. The navigation device 10 is a computer system including a position detection device 20, a storage device 30, a communication module 40, an operation unit 50, a navigation Electronic Control Unit (ECU) 60, and a guiding device 70.

[0012] The position detection device 20 includes a Global Positioning System (GPS) detecting the absolute position of the vehicle 100, and a vehicle speed sensor and an orientation sensor which detect the relative position of the vehicle 100.

[0013] The storage device 30 is an optical disk medium such as a Compact Disc Read Only Memory (CD-ROM) or a Digital Versatile Disc Read Only Memory (DVD-ROM), or a memory device such as a memory card which stores map information 31. The map information 31 includes, for example, a road layer carrying information on connection relationships between roads in a plurality of different countries, a background layer carrying information for displaying a background object, a letter layer carrying information for displaying letters such as municipalities, and an Integrated Information Service (IIS) layer carrying IIS information. The road layer treats a road section from a certain intersection to another intersection as a link of a graph based on a graph theory and treats the intersection as a node of the graph. The road layer includes information on a connection relationship between the node and the link, information indicating the type of link (for example, distinguishment between a general road and a toll road), and the like. The map information 31 further includes attribute information 90 on an automatic toll collection system in each country as illustrated in FIG. 2. Details of the attribute information 90 will be described later.

[0014] The communication module 40 receives traffic information (for example, congestion information, accident information, construction work information, and traffic control information) from a road traffic information communication system.

[0015] The operation unit 50 is a user interface, such as a touch panel or a remote controller, which receives an operation input (for example, an input of setting such as a destination point and route search conditions) from an occupant (a driver or a passenger).

[0016] The navigation ECU 60 searches for a recommended route based on positional information on the vehicle 100 detected by the position detection device 20, the map information 31 read out from the storage device 30, traffic information received by the communication module 40, setting information (setting information such as a destination point and route search conditions) which is input through the operation unit 50, and the like.

[0017] The guiding device 70 is a user interface that guides the recommended route searched for by the navigation ECU 60 and an auxiliary route to be described later to an occupant (a driver or a passenger). The guiding device 70 includes a display device 71 that visually guides a recommended route and an auxiliary route by displaying an image, and a sound output device 72 that aurally guides the recommended route and the auxiliary route by outputting a sound. The display device 71 is, for example, a liquid crystal display, and the sound output device 72 is, for example, a speaker.

[0018] The navigation ECU 60 includes a processor 61 and a storage resource 62. The storage resource 62 is a storage region (logical device) provided by a computer-readable recording medium (physical device). The computer-readable recording medium is a storage device such as a semiconductor memory (a volatile memory or a non-volatile memory) or a disk medium. The storage resource 62 stores a navigation program 63 for realizing various navigation functions (for example, a function of setting a search starting point, a function of searching for a recommended route, a function of searching for an auxiliary route, and a function of generating and guiding route information). The processor 61 reads out the navigation program 63 stored in the storage resource 62 to analyze and execute the navigation program.

[0019] Here, the function of setting a search starting point is a function of obtaining positional coordinates (a longitude and a latitude) which serve as a starting point for searching for a recommended route such as a departure point, a target point, and a

via-point. The function of searching for a recommended route is a function of setting a searching range of a recommended route from a starting point for searching a route such as a departure point, a target point, and a via-point, and searching for a recommended route satisfying search conditions. The function of searching for an auxiliary route is a function of searching for a detour route for detouring a recommended route based on traffic information (information such as unexpected congestion or an accident) or searching for a return route for attempting return to the recommended route in a case where the vehicle 100 deviates from the recommended route. The auxiliary route is a route collectively referring to a detour route and a return route. The function of generating and guiding route information is a function of generating and outputting an image signal and a voice signal for guiding various routes (a recommended route and an auxiliary route). For example, Dijkstra's method is used in the searching of a recommended route, and, for example, a genetic algorithm is used in the searching of an auxiliary route.

[0020] The ETC on-vehicle device 80 is an on-vehicle device that performs road-vehicle wireless communication with a tollbooth of an ETC system and exchanges information needed for billing processing (information such as a number of an ETC card, an entrance tollbooth, an exit tollbooth, and a toll fare) to perform the adjustment of a toll fare. The execution of billing processing through the above-described road-vehicle wireless communication is called wireless billing. The ETC on-vehicle device 80 is connected to the navigation device 10, and transmits the billing information to the navigation device 10. The billing information transmitted to the navigation device 10 is sent to an occupant (a driver or a passenger) of the vehicle 100 through the guiding device 70 as needed.

[0021] FIG. 2 illustrates the attribute information 90 on the automatic toll collection system. The attribute information 90 is information in which identification information (ID) 91 on the automatic toll collection system, positional information 92 on the automatic toll collection system, and information 93 indicating the presence or absence of a tollgate of the automatic toll collection system are associated with each other.

[0022] FIG. 3 is a flowchart illustrating a flow of processing of a navigation

method according to the embodiment of the invention. A command for instructing the processor 61 to execute the processing illustrated in FIG. 3 is written in the navigation program 63. The processor 61 analyzes and executes the navigation program 63 to control the units (the position detection device 20, the guiding device 70, and the like) of the navigation device 10, and executes the processing illustrated in FIG. 3.

[0023] The processor 61 detects positional information on the vehicle 100 by using the position detection device 20 (step S301).

[0024] The processor 61 determines the presence or absence of a tollgate of an automatic toll collection system through which the vehicle 100 is expected to pass, based on the positional information on the vehicle 100 detected by the position detection device 20, the positional information 92 on the automatic toll collection system which is stored in the storage device 30, and the information 93 indicating the presence or absence of a tollgate which is stored in the storage device 30 (step S302). It is possible to specify an automatic toll collection system through which the vehicle 100 is expected to pass, by comparing the positional information on the vehicle 100 and the positional information 92 on the automatic toll collection system with each other. With regard to the automatic toll collection system through which the vehicle 100 is expected to pass, it is possible to determine the presence or absence of a tollgate of the automatic toll collection system through which the vehicle 100 is expected to pass, with reference to the information 93 indicating the presence or absence of a tollgate.

[0025] The processor 61 determines whether or not the vehicle 100 is in a state where wireless billing can be performed between the vehicle and the automatic toll collection system (step S303). In a case where an ETC card of which the term of validity has not yet expired is inserted into the ETC on-vehicle device 80, the processor determines that the vehicle 100 is in a state where wireless billing can be performed between the vehicle and the automatic toll collection system. On the other hand, in a case where an ETC card is not inserted into the ETC on-vehicle device 80 or in a case where the term of validity of an ETC card inserted into the ETC on-vehicle device 80 has expired, the processor determines that the vehicle 100 is in a state where wireless billing cannot be

performed between the vehicle 100 and the automatic toll collection system.

[0026] The wireless billing is not limited to a system using an ETC card. Examples of the system include a system in which billing processing is performed by reading information recorded in an on-vehicle Radio Frequency Identification (RFID) by an RFID reader disposed on a road side of a toll fare collection lane. In a case where the vehicle 100 uses a system for performing wireless billing by using RFID instead of the system for performing wireless billing by using the ETC card, the processor 61 determines whether or not the RFID is mounted on the vehicle 100 in step S303. In a case where the RFID is mounted on the vehicle 100, the processor determines that the vehicle 100 is in a state where wireless billing can be performed between the vehicle and the automatic toll collection system. On the other hand, in a case where the RFID is not mounted on the vehicle 100, the processor determines that the vehicle 100 is in a state where wireless billing cannot be performed between the vehicle and the automatic toll collection system.

[0027] In a case where the automatic toll collection system through which the vehicle 100 is expected to pass has a tollgate and the vehicle 100 is in a state where wireless billing can be performed (step S304; YES), the display device 71 displays guidance to the tollgate (step S305). In the above-described case, the display device 71 may perform the guide display of the tollgate by distinguishing between the ETC lane and a general lane so as to guide the vehicle 100 to a tollbooth allowing wireless billing, for example, as illustrated in FIG. 4, or may perform the guide display together with a toll fare.

[0028] In a case where the automatic toll collection system through which the vehicle 100 is expected to pass has a tollgate and the vehicle 100 is in a state where wireless billing cannot be performed (step S306; YES), the display device 71 displays guidance to the tollgate (step S307). In the above-described case, the display device 71 may display guidance to the tollgate by distinguishing between an ETC lane and a general lane so as to guide the vehicle 100 to a tollbooth performing billing processing through a toll collector, for example, as illustrated in FIG. 5.

[0029] In a case where the automatic toll collection system through which the vehicle 100 is expected to pass does not have a tollgate and the vehicle 100 is in a state

where wireless billing can be performed (step S308; YES), the display device 71 does not display guidance to a tollgate (step S309). In the above-described case, the display device 71 may display a toll fare without displaying guidance to a tollgate, for example, as illustrated in FIG. 6.

[0030] In a case where the automatic toll collection system through which the vehicle 100 is expected to pass does not have a tollgate and the vehicle 100 is in a state where wireless billing cannot be performed (step S310; YES), the display device 71 does not display guidance to a tollgate (step S311). In the above-described case, the display device 71 may display a warning (a warning notifying a driver that the vehicle 100 passes through a tollbooth without performing wireless billing) and a toll fare without displaying guidance to a tollgate, for example, as illustrated in FIG. 7.

[0031] Functions as units executing the processes of steps S301 to 311 are realized by cooperation of a hardware resource of the navigation device 10 and the navigation program 63. The same function as the above-described functions may be realized using a dedicated hardware resource (for example, an Application Specific Integrated Circuit (ASIC)) or firmware.

[0032] As described above, according to the navigation device 10 of the embodiment, it is possible to eliminate usual inconvenience that guidance to a tollgate is displayed, even though an automatic toll collection system through which the vehicle 100 is expected to pass does not have a tollgate.

[0033] The above-described embodiment is intended to facilitate the understanding of the invention and not to limitedly analyze the invention. The invention can be changed or improved without departing from the scope, and the invention also includes its equivalent.

CLAIMS

1. A navigation device characterized by comprising:

a storage device configured to store positional information on an automatic toll collection system and information indicating whether the automatic toll collection system uses tollgates in association with each other;

a position detection device configured to detect positional information on a vehicle;

a determination unit configured to determine whether the automatic toll collection system through which the vehicle is expected to pass uses tollgates based on the positional information on the vehicle detected by the position detection device, the positional information on the automatic toll collection system which is stored in the storage device, and the information indicating use or non-use of tollgates which is stored in the storage device; and

a display device configured to display guidance to a tollgate in a case where the determination unit determines that the automatic toll collection system through which the vehicle is expected to pass uses tollgates, and the display device being configured to display a toll fare but not to display guidance to a tollgate in a case where the determination unit determines that the automatic toll collection system through which the vehicle is expected to pass does not use tollgates.

2. The navigation device according to claim 1, wherein the determination unit determines whether or not the vehicle is in a state where wireless billing is able to be performed between the vehicle and the automatic toll collection system.

3. A navigation method characterized by comprising:

storing positional information on an automatic toll collection system and information indicating whether the automatic toll collection system uses tollgates in association with each other by a computer system;

detecting positional information on a vehicle by the computer system;

determining whether the automatic toll collection system through which the vehicle is expected to pass uses tollgates by the computer system based on the positional information on the vehicle, the positional information on the automatic toll collection system, and the information indicating use or non-use of tollgates; and

displaying guidance to a tollgate by the computer system in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass uses tollgates, and displaying a toll fare but not displaying guidance to a tollgate by the computer system in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass does not use tollgates.

4. A non-transitory computer-readable storage medium storing a navigation program executing:

a step of storing positional information on an automatic toll collection system and information indicating whether the automatic toll collection system uses tollgates in association with each other;

a step of detecting positional information on a vehicle;

a step of determining whether the automatic toll collection system through which the vehicle is expected to pass uses tollgates based on the positional information on the vehicle, the positional information on the automatic toll collection system, and the information indicating use or non-use of tollgates; and

a step of displaying guidance to a tollgate in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass uses tollgates, and displaying a toll fare but not displaying guidance to a tollgate in a case where the determining step confirms that the automatic toll collection system through which the vehicle is expected to pass does not use tollgates.