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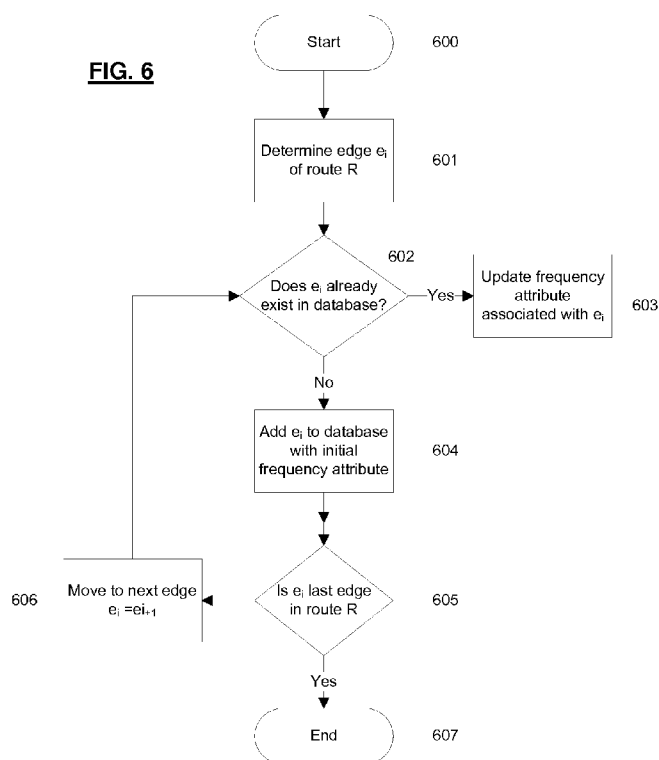
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(54) Title: NAVIGATION APPARATUS AND METHOD FOR USE THEREIN

FIG. 6

(57) **Abstract:** Embodiments of the present invention provide a navigation apparatus (200), comprising: a data storage means (214); a processor (202); and a display device (206) controlled by the processor (202), wherein the processor (202) is arranged to store in the data storage means (214) information indicative of one or more previous routes followed by the navigation apparatus; and the processor (202) is arranged to influence subsequent operation of the navigation apparatus (200) according to a current location of the navigation apparatus and the stored information.



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NAVIGATION APPARATUS AND METHOD FOR USE THEREIN

Field of the Invention

The present invention relates to a navigation apparatus of the type that, for example, determines a current location of the navigation apparatus and provides information relevant to that location. In particular, although not exclusively, the present invention relates to a navigation apparatus of the type that, for example, determines a route between locations and provides information concerning that route relevant to the current location of the navigation apparatus. The present invention also relates to methods for use in such navigation apparatus.

Background to the Invention

Portable computing devices, for example Portable Navigation Devices (PNDs) that include GPS (Global Positioning System) signal reception and processing functionality are well known and are widely employed as in-car or other vehicle navigation systems.

In general terms, a modern PND comprises a processor, memory (at least one of volatile and non-volatile, and commonly both), and map data stored within said memory. The processor and memory cooperate to provide an execution environment in which a software operating system may be established, and additionally it is commonplace for one or more additional software programs to be provided to enable the functionality of the PND to be controlled, and to provide various other functions.

Typically these devices further comprise one or more input interfaces that allow a user to interact with and control the device, and one or more output interfaces by means of which information may be relayed to the user. Illustrative examples of output interfaces include a visual display and a speaker for audible output. Illustrative examples of input interfaces include one or more physical buttons to control on/off operation or other features of the device (which buttons need not necessarily be on the device itself but could be on a steering wheel if the device is built into a vehicle), and a microphone for detecting user speech. In one particular arrangement, the output interface display may be configured as a touch sensitive display (by means of a touch sensitive overlay or otherwise) additionally to provide an input interface by means of which a user can operate the device by touch.

Devices of this type will also often include one or more physical connector interfaces by means of which power and optionally data signals can be transmitted to and received from the device, and optionally one or more wireless transmitters/receivers

to allow communication over cellular telecommunications and other signal and data networks, for example Bluetooth, Wi-Fi, Wi-Max, GSM, UMTS and the like.

PNDs of this type also include a GPS antenna by means of which satellite-broadcast signals, including location data, can be received and subsequently processed
5 to determine a current location of the device.

The PND may also include electronic gyroscopes and accelerometers which produce signals that can be processed to determine the current angular and linear acceleration, and in turn, and in conjunction with location information derived from the GPS signal, velocity and relative displacement of the device and thus the vehicle in
10 which it is mounted. Typically, such features are most commonly provided in in-vehicle navigation systems, but may also be provided in PNDs if it is expedient to do so.

The utility of such PNDs is manifested primarily in their ability to determine a route between a first location (typically a start or current location) and a second location (typically a destination). These locations can be input by a user of the device, by any of
15 a wide variety of different methods, for example by postcode, street name and house number, previously stored "well known" destinations (such as famous locations, municipal locations (such as sports grounds or swimming baths) or other points of interest), and favourite or recently visited destinations.

Typically, the PND is enabled by software for computing a "best" or "optimum"
20 route between the start and destination address locations from the map data. A "best" or "optimum" route is determined on the basis of predetermined criteria and need not necessarily be the fastest or shortest route. The selection of the route along which to guide the driver can be very sophisticated, and the selected route may take into account existing, predicted and dynamically and/or wirelessly received traffic and road
25 information, historical information about road speeds, and the driver's own preferences for the factors determining road choice (for example the driver may specify that the route should not include motorways or toll roads).

In addition, the device may continually monitor road and traffic conditions, and offer to or choose to change the route over which the remainder of the journey is to be
30 made due to changed conditions. Real time traffic monitoring systems, based on various technologies (e.g. mobile phone data exchanges, fixed cameras, GPS fleet tracking) are being used to identify traffic delays and to feed the information into notification systems.

PNDs of this type may typically be mounted on the dashboard or windscreen of a vehicle, but may also be formed as part of an on-board computer of the vehicle radio or
35 indeed as part of the control system of the vehicle itself. The navigation device may also be part of a hand-held system, such as a PDA (Portable Digital Assistant), a media

player, a mobile phone or the like, and in these cases, the normal functionality of the hand-held system is extended by means of the installation of software on the device to perform both route calculation and navigation along a calculated route.

Route planning and navigation functionality may also be provided by a desktop or mobile computing resource running appropriate software. For example, the Royal Automobile Club (RAC) provides an on-line route planning and navigation facility at <http://www.rac.co.uk>, which facility allows a user to enter a start point and a destination whereupon the server with which the user's computing resource is communicating calculates a route (aspects of which may be user specified), generates a map, and generates a set of exhaustive navigation instructions for guiding the user from the selected start point to the selected destination. The facility also provides for pseudo three-dimensional rendering of a calculated route, and route preview functionality which simulates a user travelling along the route and thereby provides the user with a preview of the calculated route.

In the context of a PND, once a route has been calculated, the user interacts with the navigation device to select the desired calculated route, optionally from a list of proposed routes. Optionally, the user may intervene in, or guide the route selection process, for example by specifying that certain routes, roads, locations or criteria are to be avoided or are mandatory for a particular journey. The route calculation aspect of the PND forms one primary function, and navigation along such a route is another primary function.

During navigation along a calculated route, it is usual for such PNDs to provide visual and/or audible instructions to guide the user along a chosen route to the end of that route, i.e. the desired destination. It is also usual for PNDs to display map information on-screen during the navigation, such information regularly being updated on-screen so that the map information displayed is representative of the current location of the device, and thus of the user or user's vehicle if the device is being used for in-vehicle navigation.

An icon displayed on-screen typically denotes the current device location, and is centred with the map information of current and surrounding roads in the vicinity of the current device location and other map features also being displayed. Additionally, navigation information may be displayed, optionally in a status bar above, below or to one side of the displayed map information, examples of navigation information include a distance to the next deviation from the current road required to be taken by the user, the nature of that deviation possibly being represented by a further icon suggestive of the particular type of deviation, for example a left or right turn. The navigation function also

determines the content, duration and timing of audible instructions by means of which the user can be guided along the route. As can be appreciated a simple instruction such as "turn left in 100 m" requires significant processing and analysis. As previously mentioned, user interaction with the device may be by a touch screen, or additionally or
5 alternately by steering column mounted remote control, by voice activation or by any other suitable method.

A further important function provided by the device is automatic route re-calculation in the event that: a user deviates from the previously calculated route during navigation (either by accident or intentionally); real-time traffic conditions dictate that an
10 alternative route would be more expedient and the device is suitably enabled to recognize such conditions automatically, or if a user actively causes the device to perform route re-calculation for any reason.

It is also known to allow a route to be calculated with user defined criteria; for example, the user may prefer a scenic route to be calculated by the device, or may wish
15 to avoid any roads on which traffic congestion is likely, expected or currently prevailing. The device software would then calculate various routes and weigh more favourably those that include along their route the highest number of points of interest (known as POIs) tagged as being for example of scenic beauty, or, using stored information indicative of prevailing traffic conditions on particular roads, order the calculated routes
20 in terms of a level of likely congestion or delay on account thereof. Other POI-based and traffic information-based route calculation and navigation criteria are also possible.

Although the route calculation and navigation functions are fundamental to the overall utility of PNDs, it is possible to use the device purely for information display, or "free-driving", in which only map information relevant to the current device location is
25 displayed, and in which no route has been calculated and no navigation is currently being performed by the device. Such a mode of operation is often applicable when the user already knows the route along which it is desired to travel and does not require navigation assistance.

Devices of the type described above, for example the 920T model manufactured
30 and supplied by TomTom International B.V., provide a reliable means for enabling users to navigate from one position to another. Such devices are of great utility when the user is not familiar with the route to the destination to which they are navigating.

Navigation apparatus or devices are particularly useful in situations where a user is unfamiliar with a current location. For example, when a user is driving in an unfamiliar
35 area or has been diverted from a familiar route because of traffic conditions. However it has been noted that users find such navigation apparatus less useful, or even

inconvenient, in areas with which they are more familiar. For example, a user driving to a frequently visited destination along a route which they know well may not find a navigation apparatus useful. Furthermore, in some situations the user may find information or guidance provided by a navigation apparatus to be inconvenient. For example when the navigation device provides visual and/or audible information concerning a route or an area with which the user is familiar.

It is desired to overcome, or at least to ameliorate, one or more of the above-mentioned problems.

10 **Summary of the Invention**

According to a first aspect of the present invention, there is provided a navigation apparatus, comprising a data storage means; a processor; and a display device controlled by the processor; characterised in that: the processor is arranged to store in the data storage means information indicative of one or more routes followed by the navigation apparatus; and the processor is arranged to influence subsequent operation of the navigation apparatus according to a current location of the navigation apparatus and the stored information.

According to a second aspect of the present invention, there is provided a method of operating a navigation apparatus, comprising: storing information indicative of one or more routes followed by the navigation apparatus; influencing subsequent operation of the navigation apparatus according to a current location of the navigation apparatus and the stored information.

The storing information indicative of one or more routes may comprise storing information identifying a route segment between two locations and information indicating a total number of times that the route segment has been travelled by the user. The information indicating a total number of times that the route segment has been travelled may be stored according to a time at which the route segment was travelled. The storage according to time may comprise identifying a period of time during which the route segment was travelled. The storing may also comprise storing information indicating an average speed at which the route segment was travelled by the user or a duration of time for travelling the route segment.

In some embodiments, said influencing of subsequent operation comprises determining an estimate of user familiarity with the current location of the navigation apparatus and adjusting a level of information visually and/or audibly output by the navigation apparatus in response to the estimate of user familiarity. The adjusting may comprise increasing or decreasing one or more of: an amount of information graphically

displayed to a user; automatic zooming of a visually displayed map; display of road identification information; a frequency of audible route advice provided to a user; a timing of audible advice relative to a distance of the navigation device from a route feature; and a provision of traffic information to a user. The adjusting may comprise selecting a configuration profile of the navigation device from a plurality of predetermined configuration profiles. The estimate of user familiarity may be determined according to a total number of previous journeys made along a route segment on which the navigation device is present. Alternatively, the navigation device may determine whether the current location is within a geographical area with which the user is deemed to be familiar.

Alternatively, said influencing of subsequent operation may comprise: determining a likelihood of a user following each of a plurality of possible routes from the current location; providing information relevant to a most likely route, such as route guidance from the current location or traffic information relevant to the most likely route. The determined likelihood may comprise comparing a total number of times which routes from the current location have been travelled by the user. Route guidance may be provided for the most travelled route from the current location. For each possible deviation from a current route, a comparison of the total number of times which the current route and the deviation have been travelled may be performed. The method may comprise storing information indicating a total number of times that one or more route segments have previously been followed by the user and determining the likelihood of the user following each of the plurality of possible routes from the current location according to the information indicating the total number of times that one or more route segments have previously been followed.

Alternatively, in some embodiments, influencing of the subsequent operation comprises determining an estimate of travelling time between at least first and second locations according to the stored information. The estimate of travelling time may be determined based upon a ratio of stored information indicative of an average speed of the user along one of more route segments and information indicative of an expected average speed over those route segments.

In some embodiments, the method may comprise determining a route between at least first and second locations which follows at least one route segment indicated in the stored data as a user preferred route segment. A user preferred route segment may be a route segment indicated in the stored data as a route segment frequently travelled by the user in preference to an alternative route segment.

It is thus possible to provide an apparatus and method capable of adapting to a

user's behaviour. Consequently, user experience is enhanced, because a navigation apparatus operates according to a user's preferences.

Brief Description of the Drawings

5 At least one embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

 Figure 1 is a schematic illustration of an exemplary part of a Global Positioning System (GPS) usable by a navigation device;

 Figure 2 is a schematic diagram of a communications system for communication
10 between a navigation device and a server;

 Figure 3 is a schematic illustration of electronic components of the navigation device of Figure 2 or any other suitable navigation device;

 Figure 4 is a schematic diagram of an arrangement of mounting and/or docking a navigation device;

15 Figure 5 is a schematic representation of an architectural stack employed by the navigation device of Figure 3;

 Figure 6 is a flow chart illustrating an example method of storing historical route data;

 Figure 7 illustrates an example method of efficiently storing historical route data
20 according to an embodiment of the present invention

 Figure 8 is a flow chart illustrating an example method of determining a configuration of a navigation device according to an embodiment of the invention;

 Figures 9 and 10 are illustrations of example historical route data;

 Figure 11 is a further illustration of example historical route data showing an
25 example of an area deemed to be well known by a user;

 Figure 12 is an illustration of a still further example of historical route data comprising alternative routes; and

 Figure 13 is a flow chart illustrating an example method of storing historical route data and average speed information for routes.

30

Detailed Description of Preferred Embodiments

 Throughout the following description identical reference numerals will be used to identify like parts.

 Embodiments of the present invention will now be described with particular
35 reference to a PND. It should be remembered, however, that the teachings of the present invention are not limited to PNDs but are instead universally applicable to any

type of processing device that is configured to execute navigation software in a portable manner so as to provide route planning and navigation functionality. It follows therefore that in the context of the present application, a navigation device is intended to include (without limitation) any type of route planning and navigation device, irrespective of whether that device is embodied as a PND, a vehicle such as an automobile, or indeed a portable computing resource, for example a portable personal computer (PC), a mobile telephone or a Personal Digital Assistant (PDA) executing route planning and navigation software.

It will also be apparent from the following that the teachings of the present invention even have utility in circumstances, where a user is not seeking instructions on how to navigate from one point to another, but merely wishes to be provided with a view of a given location. In such circumstances the "destination" location selected by the user need not have a corresponding start location from which the user wishes to start navigating, and as a consequence references herein to the "destination" location or indeed to a "destination" view should not be interpreted to mean that the generation of a route is essential, that travelling to the "destination" must occur, or indeed that the presence of a destination requires the designation of a corresponding start location.

With the above provisos in mind, the Global Positioning System (GPS) of Figure 1 and the like are used for a variety of purposes. In general, the GPS is a satellite-radio based navigation system capable of determining continuous position, velocity, time, and in some instances direction information for an unlimited number of users. Formerly known as NAVSTAR, the GPS incorporates a plurality of satellites which orbit the earth in extremely precise orbits. Based on these precise orbits, GPS satellites can relay their location to any number of receiving units.

The GPS system is implemented when a device, specially equipped to receive GPS data, begins scanning radio frequencies for GPS satellite signals. Upon receiving a radio signal from a GPS satellite, the device determines the precise location of that satellite via one of a plurality of different conventional methods. The device will continue scanning, in most instances, for signals until it has acquired at least three different satellite signals (noting that position is not normally, but can be determined, with only two signals using other triangulation techniques). Implementing geometric triangulation, the receiver utilizes the three known positions to determine its own two-dimensional position relative to the satellites. This can be done in a known manner. Additionally, acquiring a fourth satellite signal allows the receiving device to calculate its three dimensional position by the same geometrical calculation in a known manner. The position and velocity data can be updated in real time on a continuous basis by an

unlimited number of users.

As shown in Figure 1, the GPS system 100 comprises a plurality of satellites 102 orbiting about the earth 104. A GPS receiver 106 receives spread spectrum GPS satellite data signals 108 from a number of the plurality of satellites 102. The spread spectrum data signals 108 are continuously transmitted from each satellite 102, the spread spectrum data signals 108 transmitted each comprise a data stream including information identifying a particular satellite 102 from which the data stream originates. The GPS receiver 106 generally requires spread spectrum data signals 108 from at least three satellites 102 in order to be able to calculate a two-dimensional position. Receipt of a fourth spread spectrum data signal enables the GPS receiver 106 to calculate, using a known technique, a three-dimensional position.

Turning to Figure 2, a navigation device 200 comprising or coupled to the GPS receiver device 106, is capable of establishing a data session, if required, with network hardware of a "mobile" or telecommunications network via a mobile device (not shown), for example a mobile telephone, PDA, and/or any device with mobile telephone technology, in order to establish a digital connection, for example a digital connection via known Bluetooth technology. Thereafter, through its network service provider, the mobile device can establish a network connection (through the Internet for example) with a server 150. As such, a "mobile" network connection can be established between the navigation device 200 (which can be, and often times is, mobile as it travels alone and/or in a vehicle) and the server 150 to provide a "real-time" or at least very "up to date" gateway for information.

The establishing of the network connection between the mobile device (via a service provider) and another device such as the server 150, using the Internet for example, can be done in a known manner. In this respect, any number of appropriate data communications protocols can be employed, for example the TCP/IP layered protocol. Furthermore, the mobile device can utilize any number of communication standards such as CDMA2000, GSM, IEEE 802.11 a/b/c/g/n, etc.

Hence, it can be seen that the internet connection may be utilised, which can be achieved via data connection, via a mobile phone or mobile phone technology within the navigation device 200 for example.

Although not shown, the navigation device 200 may, of course, include its own mobile telephone technology within the navigation device 200 itself (including an antenna for example, or optionally using the internal antenna of the navigation device 200). The mobile phone technology within the navigation device 200 can include internal components, and/or can include an insertable card (e.g. Subscriber Identity

Module (SIM) card), complete with necessary mobile phone technology and/or an antenna for example. As such, mobile phone technology within the navigation device 200 can similarly establish a network connection between the navigation device 200 and the server 150, via the Internet for example, in a manner similar to that of any mobile
5 device.

For telephone settings, a Bluetooth enabled navigation device may be used to work correctly with the ever changing spectrum of mobile phone models, manufacturers, etc., model/manufacture specific settings may be stored on the navigation device 200 for example. The data stored for this information can be updated.

10 In Figure 2, the navigation device 200 is depicted as being in communication with the server 150 via a generic communications channel 152 that can be implemented by any of a number of different arrangements. The communication channel 152 generically represents the propagating medium or path that connects the navigation device 200 and the server 150. The server 150 and the navigation device 200 can communicate when a
15 connection via the communications channel 152 is established between the server 150 and the navigation device 200 (noting that such a connection can be a data connection via mobile device, a direct connection via personal computer via the internet, etc.).

The communication channel 152 is not limited to a particular communication technology. Additionally, the communication channel 152 is not limited to a single
20 communication technology; that is, the channel 152 may include several communication links that use a variety of technology. For example, the communication channel 152 can be adapted to provide a path for electrical, optical, and/or electromagnetic communications, etc. As such, the communication channel 152 includes, but is not limited to, one or a combination of the following: electric circuits, electrical conductors
25 such as wires and coaxial cables, fibre optic cables, converters, radio-frequency (RF) waves, the atmosphere, free space, etc. Furthermore, the communication channel 152 can include intermediate devices such as routers, repeaters, buffers, transmitters, and receivers, for example.

In one illustrative arrangement, the communication channel 152 includes
30 telephone and computer networks. Furthermore, the communication channel 152 may be capable of accommodating wireless communication, for example, infrared communications, radio frequency communications, such as microwave frequency communications, etc. Additionally, the communication channel 152 can accommodate satellite communication.

35 The communication signals transmitted through the communication channel 152 include, but are not limited to, signals as may be required or desired for given

communication technology. For example, the signals may be adapted to be used in cellular communication technology such as Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Code Division Multiple Access (CDMA), Global System for Mobile Communications (GSM), etc. Both digital and analogue
5 signals can be transmitted through the communication channel 152. These signals may be modulated, encrypted and/or compressed signals as may be desirable for the communication technology.

The server 150 includes, in addition to other components which may not be illustrated, a processor 154 operatively connected to a memory 156 and further
10 operatively connected, via a wired or wireless connection 158, to a mass data storage device 160. The mass storage device 160 contains a store of navigation data and map information, and can again be a separate device from the server 150 or can be incorporated into the server 150. The processor 154 is further operatively connected to
15 transmitter 162 and receiver 164, to transmit and receive information to and from navigation device 200 via communications channel 152. The signals sent and received may include data, communication, and/or other propagated signals. The transmitter 162 and receiver 164 may be selected or designed according to the communications requirement and communication technology used in the communication design for the navigation system 200. Further, it should be noted that the functions of transmitter 162
20 and receiver 164 may be combined into a single transceiver.

As mentioned above, the navigation device 200 can be arranged to communicate with the server 150 through communications channel 152, using transmitter 166 and receiver 168 to send and receive signals and/or data through the communications channel 152, noting that these devices can further be used to
25 communicate with devices other than server 150. Further, the transmitter 166 and receiver 168 are selected or designed according to communication requirements and communication technology used in the communication design for the navigation device 200 and the functions of the transmitter 166 and receiver 168 may be combined into a single transceiver as described above in relation to Figure 2. Of course, the navigation
30 device 200 comprises other hardware and/or functional parts, which will be described later herein in further detail.

Software stored in server memory 156 provides instructions for the processor 154 and allows the server 150 to provide services to the navigation device 200. One service provided by the server 150 involves processing requests from the navigation
35 device 200 and transmitting navigation data from the mass data storage 160 to the navigation device 200. Another service that can be provided by the server 150 includes

processing the navigation data using various algorithms for a desired application and sending the results of these calculations to the navigation device 200.

The server 150 constitutes a remote source of data accessible by the navigation device 200 via a wireless channel. The server 150 may include a network server located
5 on a local area network (LAN), wide area network (WAN), virtual private network (VPN), etc.

The server 150 may include a personal computer such as a desktop or laptop computer, and the communication channel 152 may be a cable connected between the personal computer and the navigation device 200. Alternatively, a personal computer
10 may be connected between the navigation device 200 and the server 150 to establish an internet connection between the server 150 and the navigation device 200.

The navigation device 200 may be provided with information from the server 150 via information downloads which may be periodically updated automatically or upon a user connecting the navigation device 200 to the server 150 and/or may be more
15 dynamic upon a more constant or frequent connection being made between the server 150 and navigation device 200 via a wireless mobile connection device and TCP/IP connection for example. For many dynamic calculations, the processor 154 in the server 150 may be used to handle the bulk of processing needs, however, a processor (not shown in Figure 2) of the navigation device 200 can also handle much processing and
20 calculation, oftentimes independent of a connection to a server 150.

Referring to Figure 3, it should be noted that the block diagram of the navigation device 200 is not inclusive of all components of the navigation device, but is only representative of many example components. The navigation device 200 is located within a housing (not shown). The navigation device 200 includes a processing resource
25 comprising, for example, the processor 202 mentioned above, the processor 202 being coupled to an input device 204 and a display device, for example a display screen 206. Although reference is made here to the input device 204 in the singular, the skilled person should appreciate that the input device 204 represents any number of input devices, including a keyboard device, voice input device, touch panel and/or any other
30 known input device utilised to input information. Likewise, the display screen 206 can include any type of display screen such as a Liquid Crystal Display (LCD), for example.

In one arrangement, one aspect of the input device 204, the touch panel, and the display screen 206 are integrated so as to provide an integrated input and display device, including a touchpad or touchscreen input 250 (Figure 4) to enable both input of
35 information (via direct input, menu selection, etc.) and display of information through the touch panel screen so that a user need only touch a portion of the display screen 206 to

select one of a plurality of display choices or to activate one of a plurality of virtual or "soft" buttons. In this respect, the processor 202 supports a Graphical User Interface (GUI) that operates in conjunction with the touchscreen.

In the navigation device 200, the processor 202 is operatively connected to and
5 capable of receiving input information from input device 204 via a connection 210, and operatively connected to at least one of the display screen 206 and the output device 208, via respective output connections 212, to output information thereto. The navigation device 200 may include an output device 208, for example an audible output device (e.g. a loudspeaker). As the output device 208 can produce audible information
10 for a user of the navigation device 200, it is should equally be understood that input device 204 can include a microphone and software for receiving input voice commands as well. Further, the navigation device 200 can also include any additional input device 204 and/or any additional output device, such as audio input/output devices for example.

The processor 202 is operatively connected to memory 214 via connection 216
15 and is further adapted to receive/send information from/to input/output (I/O) ports 218 via connection 220, wherein the I/O port 218 is connectible to an I/O device 222 external to the navigation device 200. The external I/O device 222 may include, but is not limited to an external listening device, such as an earpiece for example. The connection to I/O device 222 can further be a wired or wireless connection to any other external device
20 such as a car stereo unit for hands-free operation and/or for voice activated operation for example, for connection to an earpiece or headphones, and/or for connection to a mobile telephone for example, wherein the mobile telephone connection can be used to establish a data connection between the navigation device 200 and the Internet or any other network for example, and/or to establish a connection to a server via the Internet
25 or some other network for example.

Figure 3 further illustrates an operative connection between the processor 202 and an antenna/receiver 224 via connection 226, wherein the antenna/receiver 224 can be a GPS antenna/receiver for example. It should be understood that the antenna and receiver designated by reference numeral 224 are combined schematically for
30 illustration, but that the antenna and receiver may be separately located components, and that the antenna may be a GPS patch antenna or helical antenna for example.

It will, of course, be understood by one of ordinary skill in the art that the electronic components shown in Figure 3 are powered by one or more power sources (not shown) in a conventional manner. As will be understood by one of ordinary skill in
35 the art, different configurations of the components shown in Figure 3 are contemplated. For example, the components shown in Figure 3 may be in communication with one

another via wired and/or wireless connections and the like. Thus, the navigation device 200 described herein can be a portable or handheld navigation device 200.

In addition, the portable or handheld navigation device 200 of Figure 3 can be connected or "docked" in a known manner to a vehicle such as a bicycle, a motorbike, a car or a boat for example. Such a navigation device 200 is then removable from the
5 docked location for portable or handheld navigation use.

Referring to Figure 4, the navigation device 200 may be a unit that includes the integrated input and display device 206 and the other components of Figure 2 (including, but not limited to, the internal GPS receiver 224, the microprocessor 202, a power
10 supply (not shown), memory systems 214, etc.).

The navigation device 200 may sit on an arm 252, which itself may be secured to a vehicle dashboard/window/etc. using a suction cup 254. This arm 252 is one example of a docking station to which the navigation device 200 can be docked. The navigation device 200 can be docked or otherwise connected to the arm 252 of the docking station
15 by snap connecting the navigation device 200 to the arm 252 for example. The navigation device 200 may then be rotatable on the arm 252. To release the connection between the navigation device 200 and the docking station, a button (not shown) on the navigation device 200 may be pressed, for example. Other equally suitable arrangements for coupling and decoupling the navigation device 200 to a docking station
20 are well known to persons of ordinary skill in the art.

Turning to Figure 5, the processor 202 and memory 214 cooperate to support a BIOS (Basic Input/Output System) 282 that functions as an interface between functional hardware components 280 of the navigation device 200 and the software executed by the device. The processor 202 then loads an operating system 284 from the memory
25 214, which provides an environment in which application software 286 (implementing some or all of the above described route planning and navigation functionality) can run. The application software 286 provides an operational environment including the GUI that supports core functions of the navigation device, for example map viewing, route planning, navigation functions and any other functions associated therewith. In this
30 respect, part of the application software 286 comprises a user interface adaptation module 288. The user interface adaptation module adapts the user interface responsive to whether a user is deemed to be familiar the current location of the navigation device 200, as will be explained. The user interface comprises visual and audible components of the navigations device's interaction with the user.

35 In embodiments of the present invention, the navigation device 200 is arranged to determine whether it is present in, or travelling through, an area with which a user is

familiar. In this sense, "area" may mean that the user is on a route segment which has been visited or travelled along previously, or that the navigation device is in a geographical region which the user has visited previously. Based upon the result of the determination, the navigation device 200 adapts its behaviour accordingly. In some
 5 embodiments, the navigation device 200 may adapt its interface with the user. Interface may mean the visual and/or audible interaction with the user. In some embodiments, the navigation device 200 predicts a route the user will take and provides information responsive to that route. In some embodiments, the navigation device 200 is arranged to provide route information, such as speed and/or time of arrival information, based
 10 upon information indicative of previous visits to the area. Embodiments of the present invention will now be described in more detail.

Embodiments of the present invention store historical information concerning previous journeys. In some embodiments, the navigation device 200 is arranged to store historic route data recording one or more previously travelled routes. The historic
 15 route data may be stored in the navigation device 200 itself, for example in memory 214 implemented by persistent storage such as a hard drive, solid-state memory device e.g. flash memory, an optical data storage device, or combination thereof. Alternatively, the navigation device 200 may store the historic route data in a storage device accessible via the communications channel 152, for example in a storage device of the server 150.
 20 For illustration, embodiments of the present invention will be described by way of example in which historic route data is stored in memory 214, although all of the preceding alternatives are envisaged.

Figure 6 illustrates an embodiment of a method for efficiently storing historical route data. Route data is stored in the form of a graph i.e. a collection of vertices, or
 25 nodes, and edges which connect pairs of vertices. An edge may be a road or a combination of two or more roads which interconnect two vertices. The route data is stored in a database in memory 214, thereby allowing the addition of route data to the database, updating of attributes associated with route data already present in the database and searching of the database to determine if a current route involves one or
 30 more edges already present in the database.

Map data may be defined as:

$$M = (V_M, E_M)$$

Wherein V_M and is a set of vertices or nodes and edges E_M is a set of edges defined between vertices from V_M .

35 The database storing route data is defined as a graph G comprising a set of vertices V_G and a set of edges E_G with a frequency distribution defined over the edges:

$$G = (V_G, E_G, f_G)$$

Wherein $V_G \subset V_M$, $E_G \subset E_M$ and $f_G : E_G \rightarrow N$.

Referring to Figure 6, the method begins in step 600. In step 601 a first edge e_0
 5 is selected from a route R comprising an ordered list of one or more edges:

$$R = [e_0, \dots, e_n]$$

Edges may be added to the database at a time a route is calculated, at a time each edge
 is traversed i.e. travelled by the user, or at any other appropriate time. In step 602 it is
 10 determined whether the current edge e_0 already exists in the set of edges already having
 been traversed by the navigation device E_G . That is whether:

$$e_0 \in E_G$$

If the current edge e_0 already exists in E_G then the frequency attribute for that edge is
 15 incremented in step 603, indicating that the edge has been traversed one more time.
 That is:

$$f_G(e_0) = f_G(e_0) + 1$$

Otherwise, the current edge is added to the database in step 604. The edge is added to
 20 the database by ensuring that the vertices to which it connects exist in the database, and
 by adding them if they do not, and that the edge is added to E_G with an initial frequency
 attribute of 1. This can be shown as:

$$V_G = V_G \cup \{p\} \cup \{q\}$$

$$E_G = E_G \cup \{e_0\}$$

$$25 \quad f_G(e_0) = 1$$

Wherein p and q are the vertices to which e_0 connects. In step 605 it is determined
 whether the current edge is the last in the route. This may be accomplished by
 determining the total number n of edges in the route and whether $e_i = e_n$. Alternatively,
 each edge may have been removed from the route R in step 601 and step 605 may
 30 consider whether the route R comprises further edges, that is whether R is an empty set
 $\emptyset$. If further edges remain in the route R , the current edge is incremented in step 606 to
 the next edge, for example e_1 . If, in step 605, the route is empty or all edges have been
 considered, the method ends in step 607. Following the method of Figure 6 the

database graph G comprises all edges of the route R , and where one or more edges already existed in the graph, frequency attributes for those edges indicate that they have been travelled an increased number of times.

Further embodiments of the method illustrated in Figure 6 allow storage of when each edge was traversed. In order to reduce storage requirements, storage of time information utilises a plurality of "bins". That is, a plurality of timeslots are defined. For example, a week may be divided into 2016 timeslots of 5 minutes each. Other numbers of timeslots may be used. An edge is then added to the graph G , or attributes of an existing edge updated, by including information relating to the time at which the edge is traversed. For example, in the method shown in Figure 6, in some embodiments in step 603 a total number of times of travelling the current edge is updated for a timeslot determined to include the time at which the edge is traversed. The time at which an edge is considered to be traversed may be the time at which the edge is begun to be traversed, the time at which the edge is finished being traversed or any other appropriate time, depending on the width of each timeslot with respect to the duration of edge traversal. Similarly, in step 604, a new edge is added to the graph including a frequency attribute indicating the timeslot during which the edge is traversed.

In embodiments of the present invention using timeslots, f_G is defined as $f_G : E_G \times T \rightarrow N$ where T is a set of timeslots; f_G is then updated in step 603 by incrementing the number of traversals in a timeslot t by: $f_G(e_i, t) = f_G(e_i, t) + 1$ and similarly initialising a new edge in step 604 for a traversal in a timeslot t by $f_G(e_i, t) = 1$.

Further embodiments of the present invention are envisaged in which attribute information is included in the database indicating one or more of weather conditions when each edge is traversed, for example indicating whether an edge has been traversed in rain or snow, traffic density and/or road conditions.

A method of efficiently storing a route in the database according to some embodiments of the present invention will now be described with reference to Figure 7. Figure 7(a) shows a route that had been determined between nodes, or places, A and D which travels through two intermediate places (shown as unnamed black nodes). The route could be stored in the database as comprising three edges between each of the nodes. However, this could be inefficient in terms of database storage size. In some embodiments of the present invention, a route is stored as comprising as few edges as possible. A route is only stored comprising a plurality of edges when a deviation from the route has been made at a node. That is, a choice of edge exists at a node. In the shown example a graph G stored in the database is initially empty $G = \emptyset$. A route, as

shown in Figure 7(a) is determined between nodes A and D. The route is stored as comprising a single edge AD. Thus $G=\{AD\}$. However, at a later point in time a route is determined from A which departs from the edge AD at the first black node encountered on edge AD to another node which is not shown. In order to accommodate the new route in the database, a new node B is added, as shown in Figure 7(b), and the new edge stored in the graph. Thus the original route AD is decomposed into two route segments AB and BD. The database G following the calculation of the new route from B is thus $G=\{AB, BD, BX\}$ wherein X is the new node not shown. Finally a further route to a further unshown node is determined from the remaining black node on route BD. Thus BD is decomposed into two separate edges such that $G=\{AB, BC, CD, BX, CY\}$, wherein Y is the new node. Thus, embodiments of the present invention reduce a storage requirement of historic route data by storing a minimum number of edges required to define the routes stored in the database.

Embodiments of the present invention utilise historic route data as stored in database graph G to modify behaviour of the navigation device 200. In some embodiments, behaviour of the navigation device 200 is modified with respect to whether the navigation device 200 has previously travelled along a current route or edge, or whether the navigation device is in an area including one or more previously travelled routes or edges.

As discussed above, navigation device 200 may provide information or guidance to a user when navigating a route. The information or guidance may be provided in the form of information displayed upon display 206 or output audibly to the user via output device 208. For example, the display may display information such as current speed, distance to next turning or road feature, current navigational heading etc., whilst audio device 208 may output voice instructions concerning the route ahead. However, whilst this information and guidance is useful to a user who is unfamiliar or has little familiarity with a route, to a user who is familiar with a route the information and/or guidance may be inconvenient. In recognition of this embodiments of the present invention modify the behaviour of the device to adapt a cognitive workload placed on the user at certain times. That is, the behaviour of the device is modified to reduce the level of information and/or guidance presented to the user when in a familiar area, such that the navigation device is less likely to be deemed a nuisance to the user. Similarly, the level of guidance presented to the user may be increased when in an unfamiliar area.

Methods of operating the navigation device 200 according to embodiments of the present invention will now be described with reference to Figure 8. The method begins in step 800. In step 801 a current edge is determined. That is, an edge along which the

navigation device 200 is, or is about to, travel. The edge may be determined from GPS location data or from a calculated route. In step 802, a frequency attribute f_G is obtained from the database for the current edge. In some embodiments, the frequency attribute f_G is obtained for a current edge with respect to one or more of weather conditions, traffic density and/or road conditions. For example, the frequency attribute may be obtained for traversing the edge in a timeslot relevant to the current time of day, or other parameters, such as the prevailing weather conditions or traffic density. In step 803, a cognitive workload level for the navigation device 200 is obtained. The cognitive workload level may be obtained from a database or other data storage structure. For example, the cognitive workload level may be a value obtained from a database according to the total number of journeys f_G previously obtained. The cognitive workload level (CWL) indicates a level of cognitive workload to be output by the navigation device 200 to be placed on a user. For example, a CWL of 1 may indicate that the navigation device is to place little cognitive workload on the user, a CWL of 3 may indicate a higher level of cognitive workload, except when traffic conditions dictate a variation in a route, whereas a CWL of 8 a higher cognitive workload is to be provided at all times. Based upon the CWL a system configuration is determined in step 804. The system configuration may be obtained from a configuration database or other storage structure. For example, according a CWL of 1 the navigation device 200 may operate by not outputting any visual or audible route guidance, according to a CWL of 3 the navigation device may operate by outputting limited audible route guidance and may operate according to a CWL of 8 by outputting detailed route guidance. In step 705 the navigation device operates for the current edge according to the determined configuration. If, in step 706, it is determined that the navigation device 200 is, or is about to, traverse a new edge, then the method reverts to step 801.

Referring to Table 1, an example configuration of a navigation device 200 for three levels of cognitive workload are shown. The three levels are identified as regular, wherein a user is deemed to be familiar with a segment, route or edge, normal wherein a user is deemed to be neither familiar nor unfamiliar with the segment and unknown area where a user has not previously travelled a route segment. Configuration the navigation device is divided into four separate areas, namely audible advice e.g. spoken instructions provided by the navigation device concerning the route ahead, visual/map configuration e.g. the appearance of a graphical user interface provided by the navigation device 200 and the appearance of map information on the display device 206, traffic and warnings e.g. configuration items related to the provision of traffic information and rerouting, and the provision of warnings of surrounding hazards proximal to the

5 navigations device's current location. Miscellaneous configuration items are also provided which relate to other functions of the navigation device. It will be realised that the shown configuration items and groups are merely examples and that other functions of the navigation device may also be adjusted responsive to a deemed familiarity of the user to the current location. Furthermore, whilst three levels of familiarity are shown by way of an example, more or less levels may be defined.

An example of navigating a route will now be described with reference to Figure 9. Following calculation of a route R comprising a plurality of edges, the route is added to database graph G as described previously. The graph G comprises edges AC, BC, 10 CE, DE and EF, each having an associated frequency attribute f_G . It will be realised that the direction of edges in this example is unimportant i.e. that edge AC can equally be referred to as CA and that the frequency attribute merely indicates a number of times an edge has been traversed in any direction. A user is present at node D and has operated the navigation device 200 to calculate to route to node A, which has then been added to 15 the database. The route R includes edges DE, CE and AC. Edges DE and AC have not been traversed by the user before and hence have a frequency attribute $f_G=1$, whilst edges EF, CE and BC have been traversed before $f_G>1$. Therefore the user is deemed to be familiar with these edges or roads. During navigation of edge DE since the user is unfamiliar with these roads, the navigation device 200 provides a normal level of 20 information and guidance to the user. For example, the navigation device may display a high-level on-screen information and provide audible route guidance. However, once the user reaches node E and begins to traverse edge CE, the navigation device 200 adapts the cognitive workload placed on the user during traversal of edge CE. In some embodiments, the navigation device may reduce the number of audible instructions 25 provided to the user. Similarly, the amount of on-screen information provided to the user may be changed. Once the user reaches node C and begins to traverse edge AC, the navigation device determines from the database that the user is traversing an unfamiliar route and consequently increases the amount, or frequency, of audible instructions provided to the user. Concerning on screen information, some users may wish to be 30 presented with an uncluttered or simple view of the road ahead when in an unfamiliar area, such that their attention is directed to navigating the route ahead safely. Thus, the amount of on-screen information presented to the user in an unfamiliar area may be reduced. However, some users may wish to be presented with more information in a familiar area, for example, a GPS-based calculation of their speed and/or their current 35 compass heading. In recognition of this, in familiar areas additional on-screen information may be presented to a user whilst the level of audible instructions may be

reduced. In some embodiments, when traversing a familiar route, the navigation device will only provide audible and/or visual route guidance when necessary to circumvent a traffic problem or to take advantage of an apparently faster route e.g. the user has turned off a road determined to be faster and so the navigation device offers guidance
5 back to the faster route.

Whilst in the example described with reference to Figure 9 an edge is determined to be unfamiliar to a user when it has not been traversed before ($f_G=1$) and an edge familiar to a user with a greater frequency attribute ($f_G>1$), other predetermined frequency attributes may be chosen to represent a familiar edge. For example, an edge
10 may be determined to be familiar to a user with a frequency tribute of more than 10 ($f_G>10$). Furthermore, whilst the above example has been described with reference to two classifications of edges, unfamiliar and familiar, an increased number of classifications may be used. For example, edges may be classified as one of several groups indicating differing levels of familiarity, such as familiarity level 1 is $10>f_G=>1$,
15 familiarity level 2 is $20>f_G=>10$, familiarity level 3 is $30>f_G=>20$ and so on. It will be realised that any number of familiarity levels may be used and that different frequency attribute numbers may be chosen.

Further embodiments of the present invention will now be described, wherein the navigation device 200 automatically determines an estimate of a user's route selection,
20 based upon the historical route data and provides guidance and/or information relevant to the estimated destination.

Referring to Figure 10 an example is described wherein a user departs from node A without having entered a destination into navigation device 200 and the navigation device operates in a so-called "free driving" mode, wherein it may provide a
25 graphical indication of the road ahead but without guidance to a destination. It will be recognised from the example in Figure 10 that a frequency attribute is stored separately for each direction of edge traversal, although frequency attributes for both directions are not shown for each edge. As the navigation device 200 proceeds along edge AB toward node B it determines that from node B a choice of two edges BD and BC are possible.
30 According to the relative frequency attributes for each edge, the navigation device determines that the user is more likely to take edge BD at node B, rather than edge BC. For this example, the user is three times more likely ($150/5=3$) to follow edge BD than BC. Similarly, when approaching node D, the navigation device 200 may determine that the user is more likely to follow edge DF than DE. In this case, based upon the historical
35 route data, the user is 2.75 times more likely to follow edge DF than DE. In response to the estimation of the user's route, the navigation device 200 may determine if there are

any traffic warnings or other information relevant to the estimated route and notify a driver accordingly. Further, the navigation device 200 may provide guidance to edge BD in the form of visual and/or audible guidance. However, since it is assumed that the user does not wish to be directed or given guidance, the guidance may be “subtly” provided e.g. on display device 206 but not audibly, or a limited amount of displayed guidance may be provided such that it is not intrusive to a user. In some embodiments, information and/or guidance is only provided when the navigation device 200 estimates the route with a certainty above a predetermined threshold, for example, when it is at least 50% probable that a user will follow an estimated edge.

In some embodiments, the determination of a likely edge which the user will follow is influenced by the current time and day, in conjunction with the graph stored in database storing time information for the historical route data. For example, if the user is traversing edge BD and the current time is 5:45pm on a Monday, the route data may indicate that a user is 4.5 times more likely to follow edge DF than DE during timeslot 4-5pm on Monday. However, if the current time and day is 10:25 on Saturday the route data may indicate that the user is 3.6 times more likely to follow DE than DF. Thus, the estimated next edge determined by the navigation device is adaptive to the time at which a journey is made.

A further embodiment of the present invention is described with reference to Figure 11, which illustrates a graph of historic route data similar to that shown in Figure 10 but with three additional nodes G, H and I. Based upon the route data, the navigation device 200 is arranged to determine an area 300 surrounding the edges present in the history route data deemed to be familiar. The area may be determined to be an area proximal to all edges existing in the route data, which is known from associated GPS and/or map data. The area 300 is deemed to be the area with which the user is familiar from having travelled along edges within the area a predetermined number of times. For example, it may be deemed that a user will be familiar with routes in the area 300 even if the user has not historically travelled along those routes e.g. the user uses favourite routes even though they have knowledge of other routes in the area 300. It will be noted that edges BG and GD have a relatively high frequency attribute indicating that the user is familiar with those routes. However, the area 300 surrounding the familiar edges encompasses edge GH by virtue of the area following edges BG and GD. That is, although area 300 encompasses GH the area 300 has not been specifically determined to surround GH, due to its relatively low frequency attribute ($f_G=2$), it merely incorporates it by GH being relatively close to familiar edges BG and GD. By way of another example, area 300 has not been determined to encompass edge GI since it also has a

relatively low frequency attribute.

When the user is navigating the edges shown in the graph of Figure 11, the navigation device may adapt its behaviour when traversing edge BG to that of a familiar edge due to the relatively high frequency count of that edge. However, when the user
5 traverses edge GH the navigation device 200 may also modify its behaviour to that of a familiar edge since edge GH is within area 300 with which the user is deemed to be familiar, even though edge GH has a relatively low frequency attribute, below a predetermined value at which the user would be expected to be familiar with an edge. However, when the user traverses edge GI, the edge at least partly lies outside of the
10 familiar area 300. Therefore, the navigation device 200 determines that the user is unfamiliar with edge GI.

In some embodiments, there may be more than one area determined by the navigation device. For example, a first area 300 may be determined to surround familiar edges within a distance of 1km. A second area may then be determined to surround
15 familiar edges within 5km. A third area may then be determined to surround familiar edges by 10km. In each area, differing levels of information and/or guidance may be presented to the user on the basis that the user is increasingly less familiar with edges lying in each area.

Still further embodiments of the present invention will now be described in which
20 the navigation device 200 modifies behaviour according to the historic route data stored in the database.

When determining a route between first and second locations, a navigation device 200 according to embodiments of the present invention utilises map data to determine a proposed route. In a route determination process, the navigation device
25 200 may also utilise speed information for road types present in the map data. For example, the navigation device 200 may determine a route based upon the map data including a motorway having an average speed of 130km/h against a relatively minor road having an average speed of 50 km/h. The route may be determined by considering the average speeds of various roads and their relative lengths involved in proposed
30 route. The navigation device 200 therefore determines a theoretically fastest route, if desired by the user. Alternatively, the may desire the navigation device 200 to determine a route by other criteria, such as a shortest route. However, the user may deviate from the determined route and the deviation may be recorded in the route database.

For example, Figure 12 illustrates a graph of nodes A-E. A user departs and
35 operates the navigation device 200 to determine a route from A to D. The navigation device determines the route ABCD. However, the user, being familiar with part of the

route around nodes B,C,E does not follow the determined route and instead departs from the route at B via E and then returns to the route at C. The navigation device, although having considered this route, had discounted the route ABECD on the ground that it did not meet criteria by which the route ABCD was determined e.g. the route
 5 ABECD was longer or not as fast as route ABCD. However, the user having local knowledge knows that a difficult road junction exists on edge BC at which they may be held up or do not wish to negotiate for other reasons. In one example, the user may traverse edge BC at most times, but during a 4-5pm timeslot may choose to traverse BEC. Therefore, the user navigates B to C via E. The navigation device stores the
 10 route ABECD in the database graph. Subsequently, when the user operates the navigation device 200 to determine a route involving edge BC, the navigation device 200 is able to determine that the user infrequently travels edge BC and instead prefers BEC. The navigation device therefore modifies its subsequent route planning behaviour to adopt a user's frequently used edges. However, the navigation device 200 may indicate
 15 upon display 206 that an alternative theoretically more optimal route exists at an appropriate point, such that the user is given the option to follow the optimally calculated route. If the database is stored on server 150, either by sharing a local database sorted in memory 214 of navigation device, or entirely stored on server 150, then the server may combine route data from a plurality of users to optimise map data. For example,
 20 preference of following BEC may be increased in map data making this route more favourable for sharing amongst navigation devices.

Embodiments of the present invention will now be described wherein speed information for previous journeys is stored in the database. A navigation device 200 according to some embodiments of the present invention may use the stored historic
 25 route data to improve an accuracy of journey time estimation and/or route determination.

An embodiment of a method for storing speed information for one or more edges will now be described with reference to Figure 13.

A graph of map data is defined comprising a set of vertices V_M and a set of edges defined between the vertices from V_M . $S_M(e,t)$ is an average speed profile for edge e ,
 30 dependent on a timeslot t , as explained previously,.

$$M = (V_M, E_M, s_M)$$

Similar to the embodiment described with reference to Figure 6, a database is used to store a graph S comprising a subset of edges E_S from E_M with an average speed function and a frequency distribution defined over the edges:

$$S = (E_S, s_S, f_S)$$

Wherein $E_S \subset E_M$; $s_S : E_S \times T \rightarrow R$; $f_S : E_S \times T \rightarrow N$ and T is a set of timeslots, as explained previously.

The method begins in step 130. In step 131 an edge e_i of a route is determined, or selected, from a route R . Each edge may be stored in the database immediately after completion i.e. once having been traversed by the navigation device 200, or edges from an entire route may be stored in the database after completion of that route.

In step 132 it is determined whether the edge e_i already exists in the database i.e. whether it has been traversed before, which is defined as:

$$e_i \in E_S$$

If the edge e_i exists in the database, then the frequency attribute and average speed attribute for that edge are updated in steps 133 and 134 to reflect that the edge has been traversed a further time and a new average speed of traversal. It will be realised that steps 133 and 134 may be performed in either order. In step 133 the total number of traversals of edge e_i in timeslot t is updated by:

$$f_S(e_i, t) := f_S(e_i, t) + 1$$

Updating of the average speed in step 134 for edge e_i is defined as:

$$s_S(e_i, t) := \frac{(s_S(e_i, t) \times f_S(e_i, t) + s)}{f_S(e_i, t) + 1}$$

The above function stores an updated average speed value for the edge e_i in timeslot t by taking the previous average speed $s_S(e_i, t)$ and multiplying it by a previous number of traversals $f_S(e_i, t)$ and adding the average speed of the traversal being added s . The total speed is then divided by the total number of traversals $f_S(e_i, t) + 1$ to calculate the new average speed for the edge e_i . Thus S stores a set of edges traversed, a total number of traversals and average speed information for each edge. It will be realised that whilst the described embodiment stores the total number of traversals and speed information using timeslots, an alternative embodiment stores the total number of traversals and average speed information for each edge, but without the use of timeslots. In step 137 it is determined if the edge e_i is the last edge in the route R . If it is not, then the above steps are repeated for the next edge e_{i+1} . If however edge e_i is the last edge, then the method ends in step 139.

An embodiment of a method of utilising the stored average speed information will be described.

Embodiments of the present invention use measured average speed data to correct estimated average speed information provided as part of map data. In some

embodiments, a correction factor is calculated to determine a correction of speed information provided as part of the map data relative to a particular user's actual historic speed. For example, if map data denotes that an average speed for a road as 80 km/h, a correction factor may indicate that a particular user is 20% slower than average, thus an estimate of that particular user's speed on that road is 64km/h based upon historic average speed data.

In some embodiments, the following equation is utilised:

$$s := s_M(e, t) \times \frac{1}{E_S} \sum_{e' \in E_S} \frac{s_S(e', t)}{s_M(e', t)}$$

10

Wherein s is a corrected average speed for an edge in a particular timeslot, $s_M(e, t)$ is an average speed for the edge from map data, whilst $\frac{1}{E_S} \sum_{e' \in E_S} \frac{s_S(e', t)}{s_M(e', t)}$ determines a correction factor for the map data average speed, based upon historical route data. The correction factor is determined according to a ratio between the user's historic average speed over traversed edges $s_S(e', t)$ and the average speed estimated in the map data for those edges $s_M(e', t)$. The summation is for all edges e' for which historic route data has been stored and the factor $\frac{1}{E_S}$ corrects this to be an average over the set.

For example:

Edge	Map data average speed (kmh ⁻¹)	Historic route data average speed (kmh ⁻¹)
A	80	60
B	50	40
B	120	100

20 The correction factor would be: $\frac{1}{3} \times \frac{60 + 40 + 100}{80 + 50 + 120} = 0.794$. Therefore, this user is approximately 20% slower than the map data average speed over all edges and journey time etc. can be adjusted accordingly for a given timeslot and edge. It will of course be realised that embodiments can be envisaged which do not use timeslots. Further, other ways of correcting map data average speed may be envisaged.

25 Embodiments of the present invention provide a navigation apparatus and method which adapts its behaviour according to stored route information.

It will also be appreciated that whilst various aspects and embodiments of the present invention have heretofore been described, the scope of the present invention is not limited to the particular arrangements set out herein and instead extends to encompass all arrangements, and modifications and alterations thereto, which fall within
5 the scope of the appended claims.

Whilst embodiments described in the foregoing detailed description refer to GPS, it should be noted that the navigation device may utilise any kind of position sensing technology as an alternative to (or indeed in addition to) GPS. For example the navigation device may utilise using other global navigation satellite systems such as the
10 European Galileo system. Equally, it is not limited to satellite based but could readily function using ground based beacons or any other kind of system that enables the device to determine its geographic location.

Alternative embodiments of the invention can be implemented as a computer program product for use with a computer system, the computer program product being,
15 for example, a series of computer instructions stored on a tangible data recording medium, such as a diskette, CD-ROM, ROM, or fixed disk, or embodied in a computer data signal, the signal being transmitted over a tangible medium or a wireless medium, for example, microwave or infrared. The series of computer instructions can constitute all or part of the functionality described above, and can also be stored in any memory
20 device, volatile or non-volatile, such as semiconductor, magnetic, optical or other memory device.

It will also be well understood by persons of ordinary skill in the art that whilst the preferred embodiment implements certain functionality by means of software, that functionality could equally be implemented solely in hardware (for example by means of
25 one or more ASICs (application specific integrated circuit)) or indeed by a mix of hardware and software. As such, the scope of the present invention should not be interpreted as being limited only to being implemented in software.

Lastly, it should also be noted that whilst the accompanying claims set out particular combinations of features described herein, the scope of the present invention
30 is not limited to the particular combinations hereafter claimed, but instead extends to encompass any combination of features or embodiments herein disclosed irrespective of whether or not that particular combination has been specifically enumerated in the accompanying claims at this time.

CLAIMS

1. A navigation apparatus (200), comprising:

a data storage means (214);

5 a processor (202); and

a display device (206) controlled by the processor (202);

characterised in that:

the processor (202) is arranged to store in the data storage means (214) information indicative of one or more routes followed by the navigation apparatus; and

10 the processor (202) is arranged to influence subsequent operation of the navigation apparatus according to a current location of the navigation apparatus and the stored information.

2. The navigation apparatus according to claim 1, wherein the processor (202) is
15 arranged to influence subsequent operation of the navigation apparatus by controlling a level of information provided to a user by the display device (206) and/or audibly output from an output device (208) according to the current location of the navigation apparatus (200) and the stored information.

20

3. The navigation apparatus according to claim 1 or 2, wherein the processor (202) is arranged to influence subsequent operation of the navigation apparatus (200) by determining an estimate of a route to be followed from the current location according to the stored information.

25

4. The navigation apparatus according to claim 3, wherein the processor (202) is arranged to determine the estimated route based upon a total number of times that each of a plurality of routes have been followed by the navigation apparatus (200).

30

5. The navigation apparatus according to any preceding claim, wherein the processor (202) is arranged to influence subsequent operation of the navigation apparatus (200) by determining an estimated travelling time between at least first and second locations according to the stored information.

35

6. The navigation apparatus according to any preceding claim, wherein the processor (202) is arranged to store in the data storage means (214) information

indicative of route segments followed by the navigation apparatus (200) and information indicating a number of times that each route segment has been travelled.

7. The navigation device according to any preceding claim, wherein the processor
5 (202) is arranged to store in the data storage means (214) information indicative of an average speed of route segments followed by the navigation apparatus (200).

8. A method of operating a navigation apparatus (200), comprising:
storing information indicative of one or more routes followed by the navigation
10 apparatus (200);
influencing subsequent operation of the navigation apparatus (200) according to a current location of the navigation apparatus (200) and the stored information.

9. The method of claim 8, wherein said influencing of subsequent operation
15 comprises:
determining an estimate of user familiarity with the current location of the navigation apparatus (200); and
adjusting a level of information visually and/or audibly output by the navigation apparatus (200) in response to the estimate of user familiarity.

20 10. The method of claim 8 or 9, wherein said influencing of subsequent operation comprises:
determining a likelihood of a user following each of a plurality of possible routes from the current location;
25 providing information to a user relating to a route most likely to be followed from the current location.

11. The method of claim 10, comprising:
storing information indicating a total number of times that one or more route
30 segments have previously been followed by the user; and
determining the likelihood of the user following each of the plurality of possible routes from the current location according to the information indicating the total number of times that one or more route segments have previously been followed.

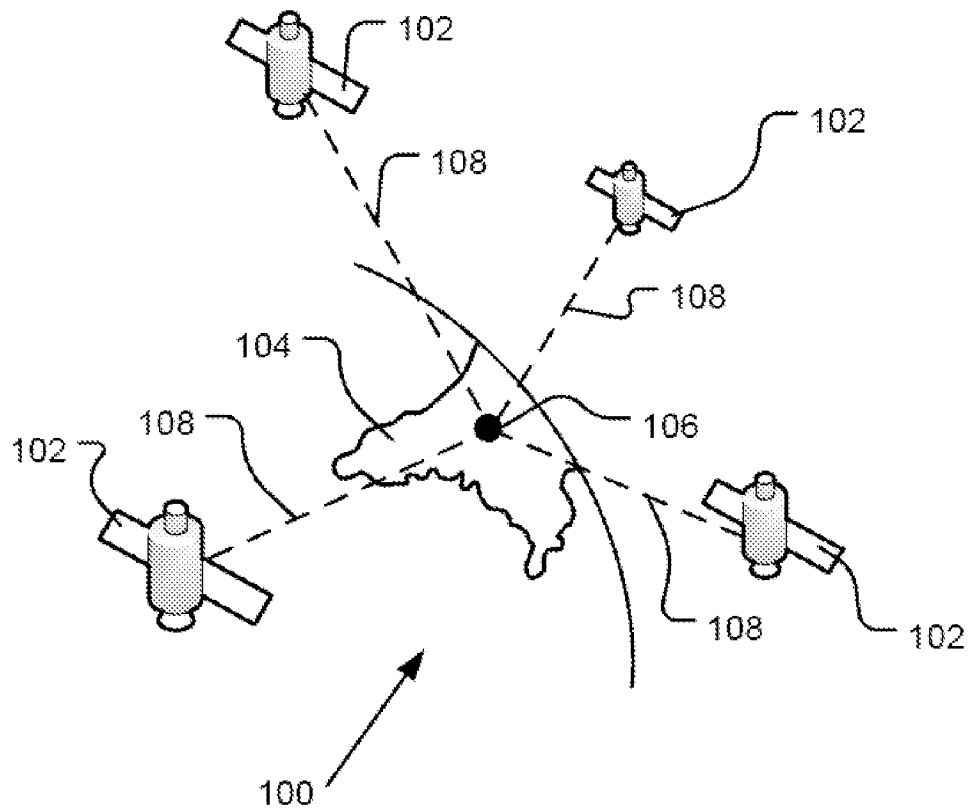
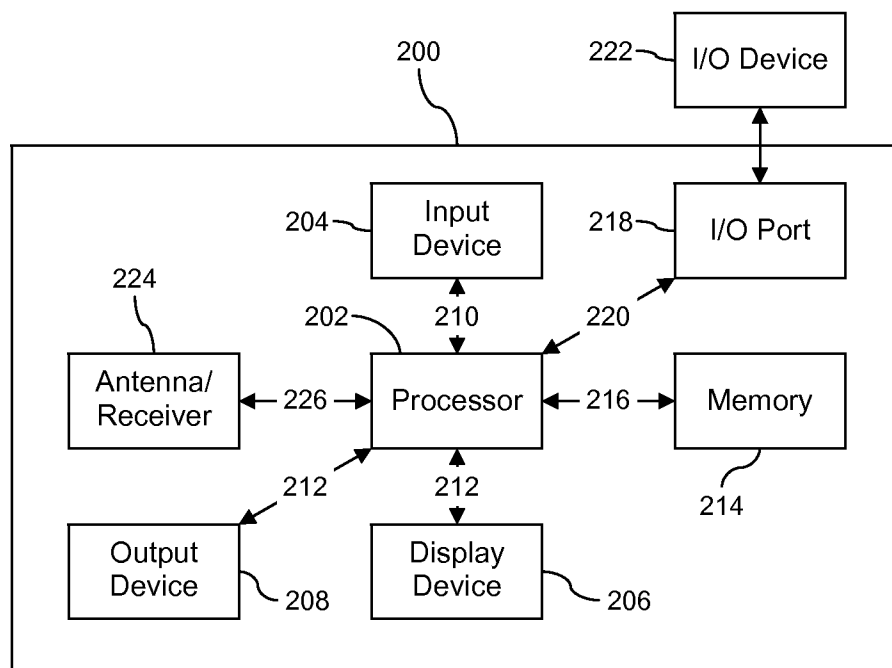
35 12. The method of any of claims 8 to 11, wherein said influencing of subsequent operation comprises:

determining an estimate of travelling time between at least first and second locations according to the stored information.

13. The method of claim 12, wherein the estimate of travelling time is determined
5 based upon a ratio of stored information indicative of an average speed of the user along one of more route segments and information indicative of an expected average speed over those route segments.

14. The method of any of claims 8 to 13, comprising:
10 determining a route between at least first and second locations which follows at least one route segment indicated in the stored data as a user preferred route segment.

15. The method of claim 14, wherein a user preferred route segment is a route
15 segment indicated in the stored data as a route segment frequently travelled by the user in preference to an alternative route segment.

**FIG. 1****FIG. 2**

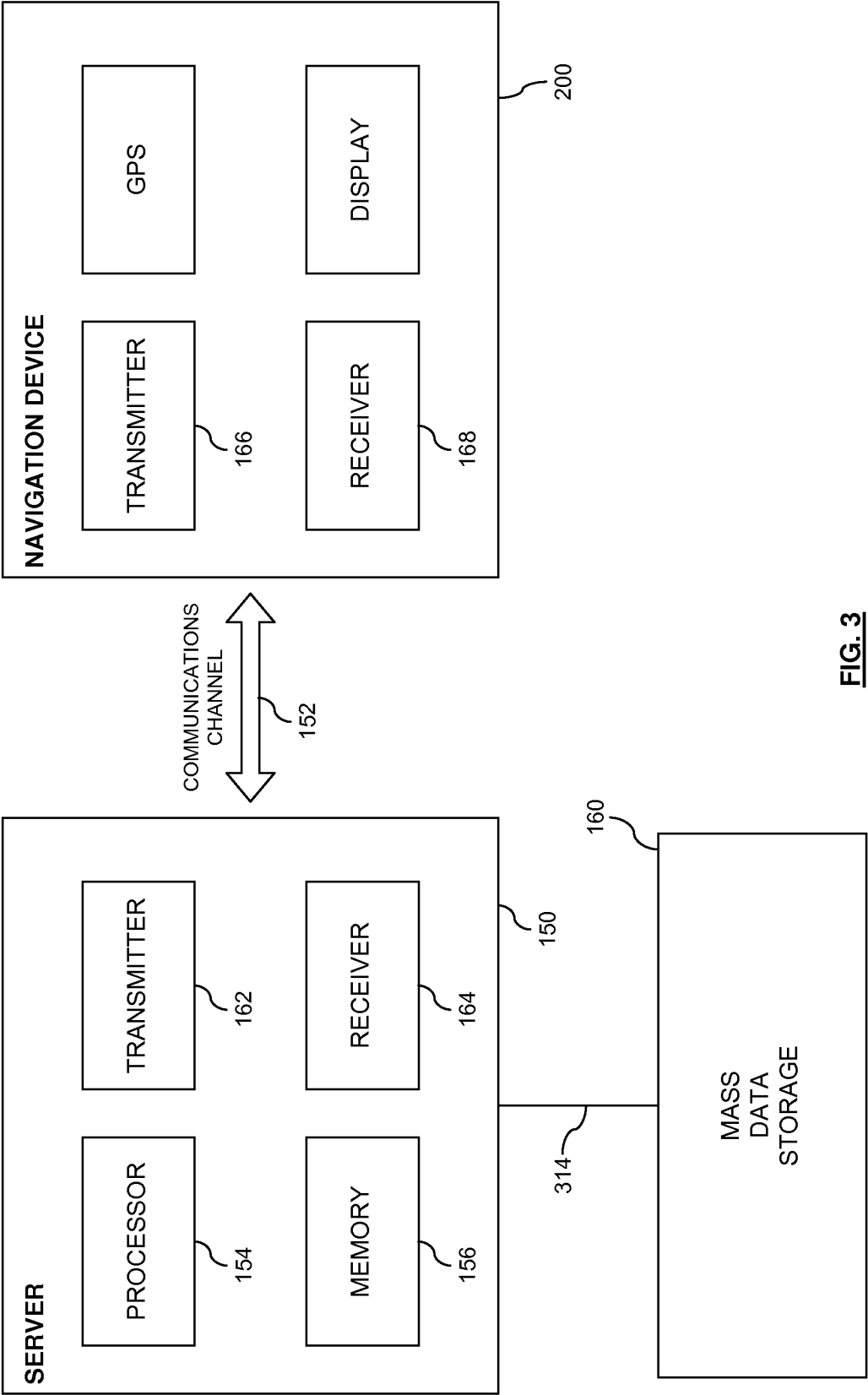
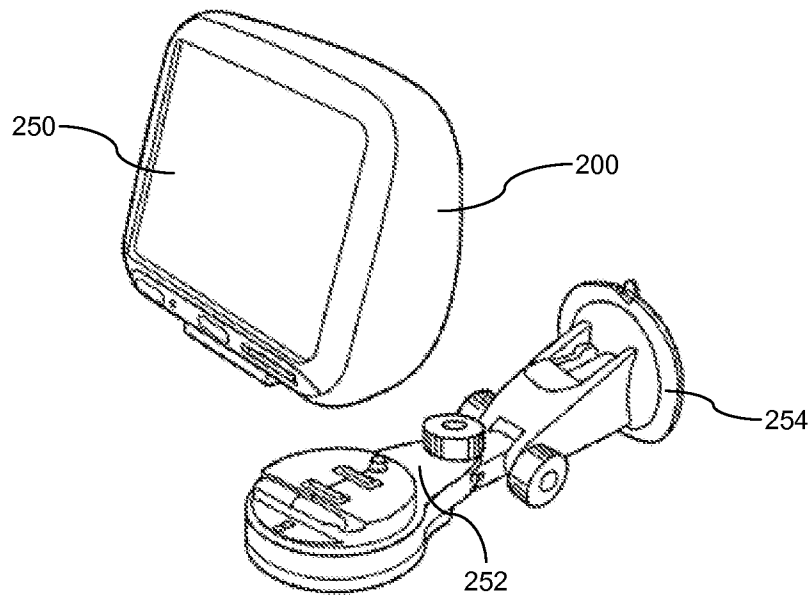
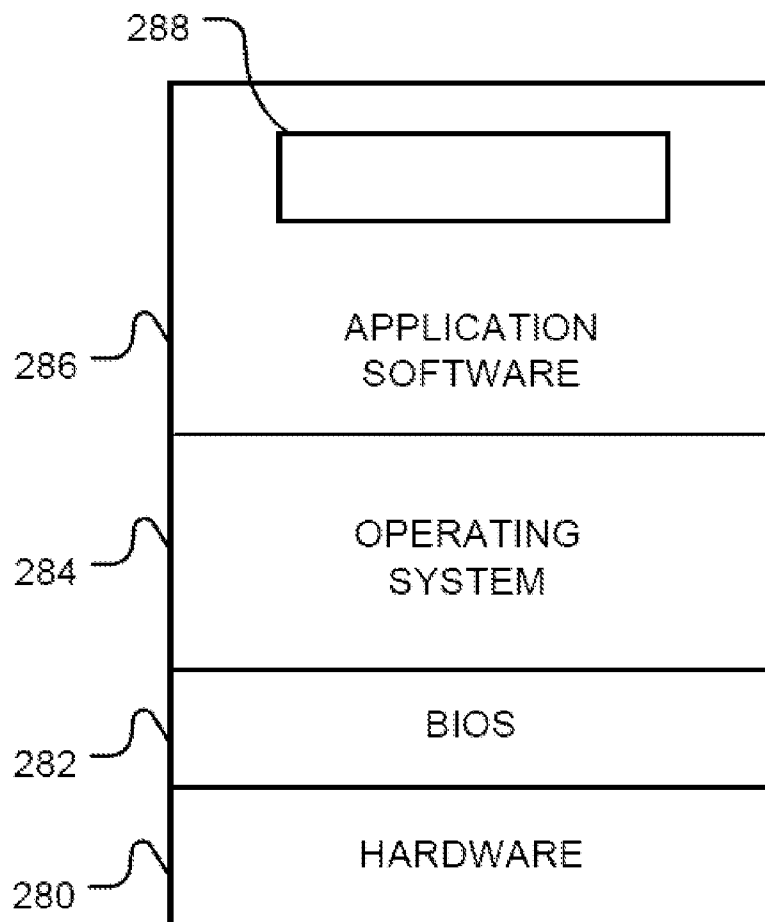
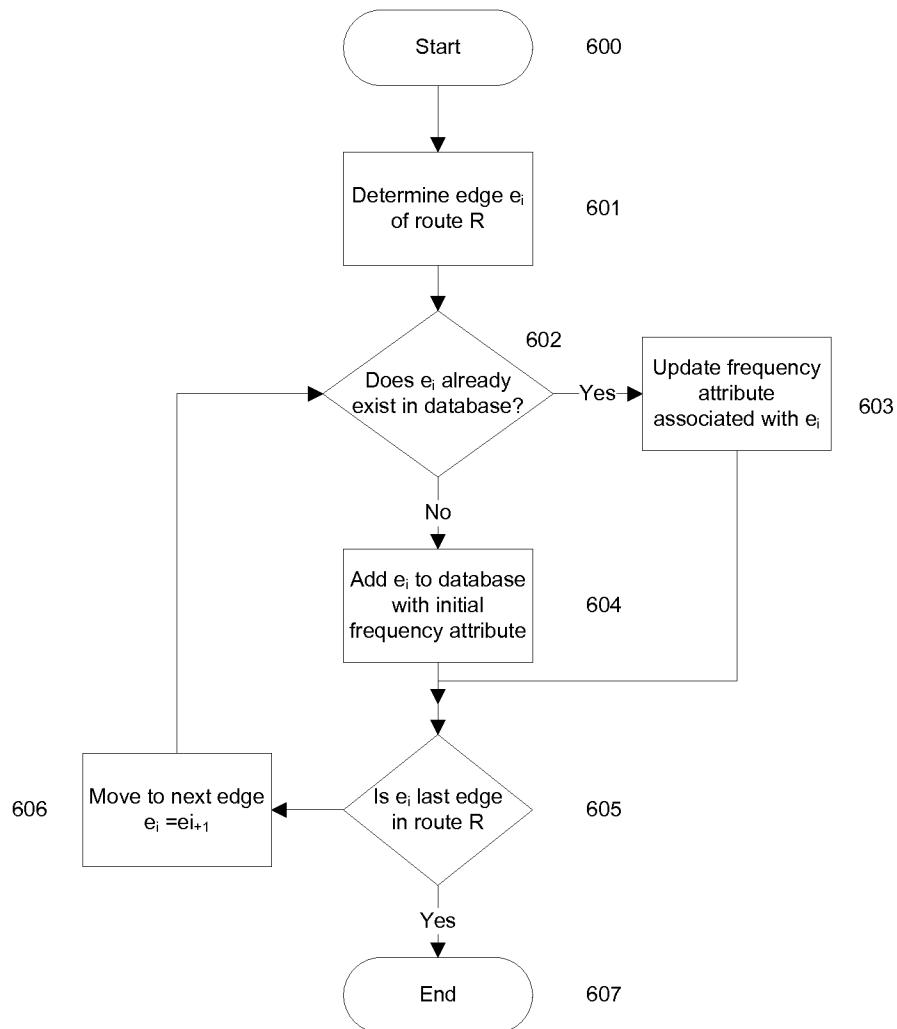


FIG. 3

**FIG. 4a****FIG. 5**

**FIG. 6**

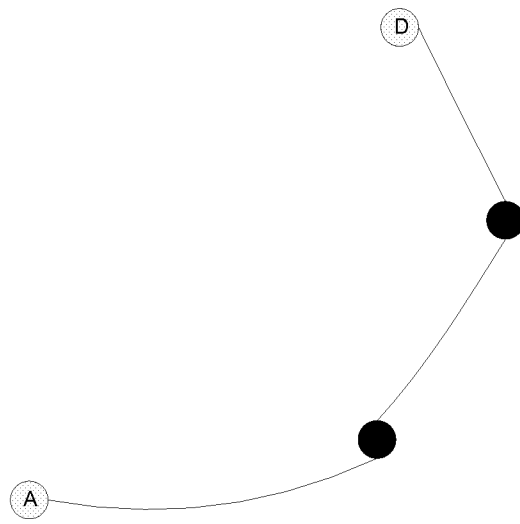


FIG. 7(a)

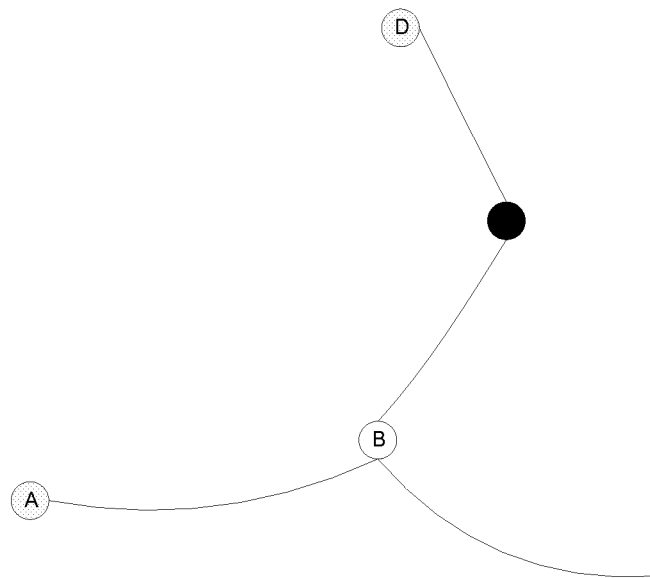
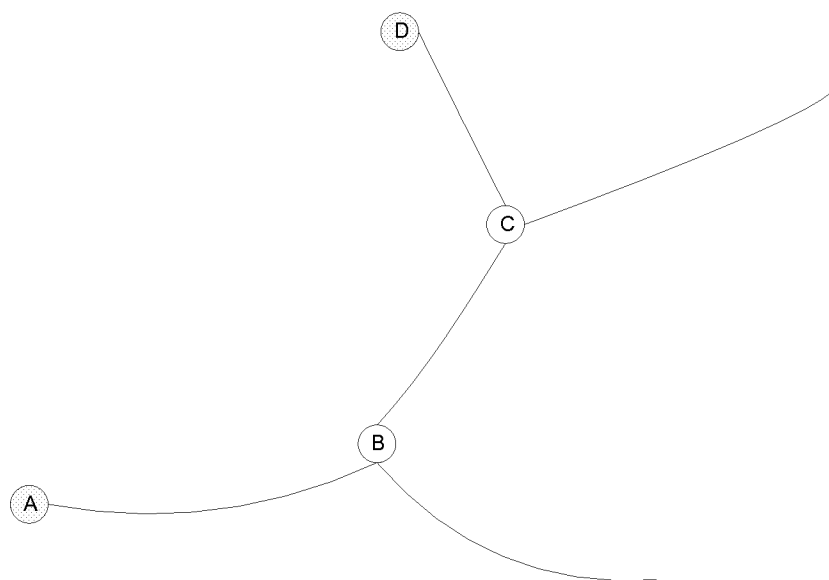
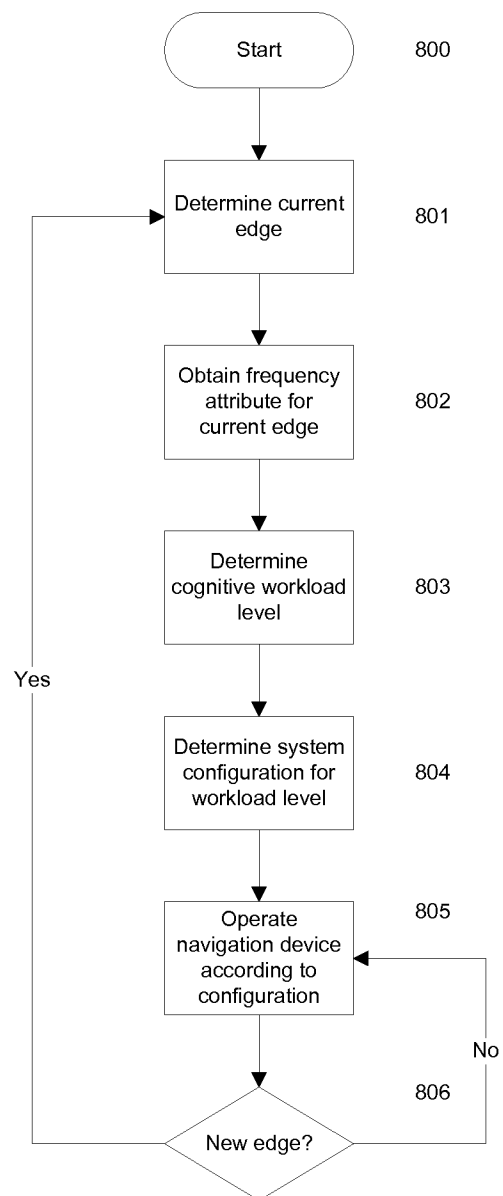
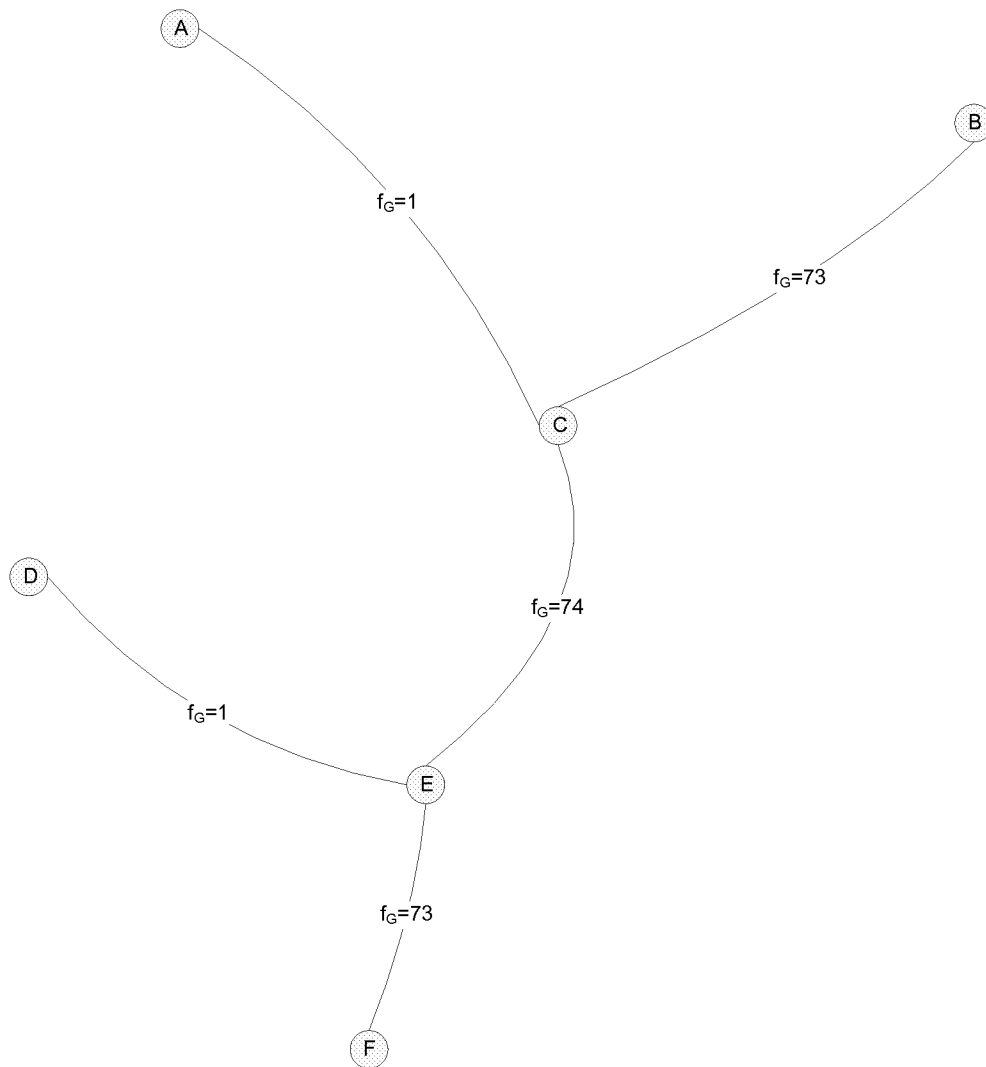
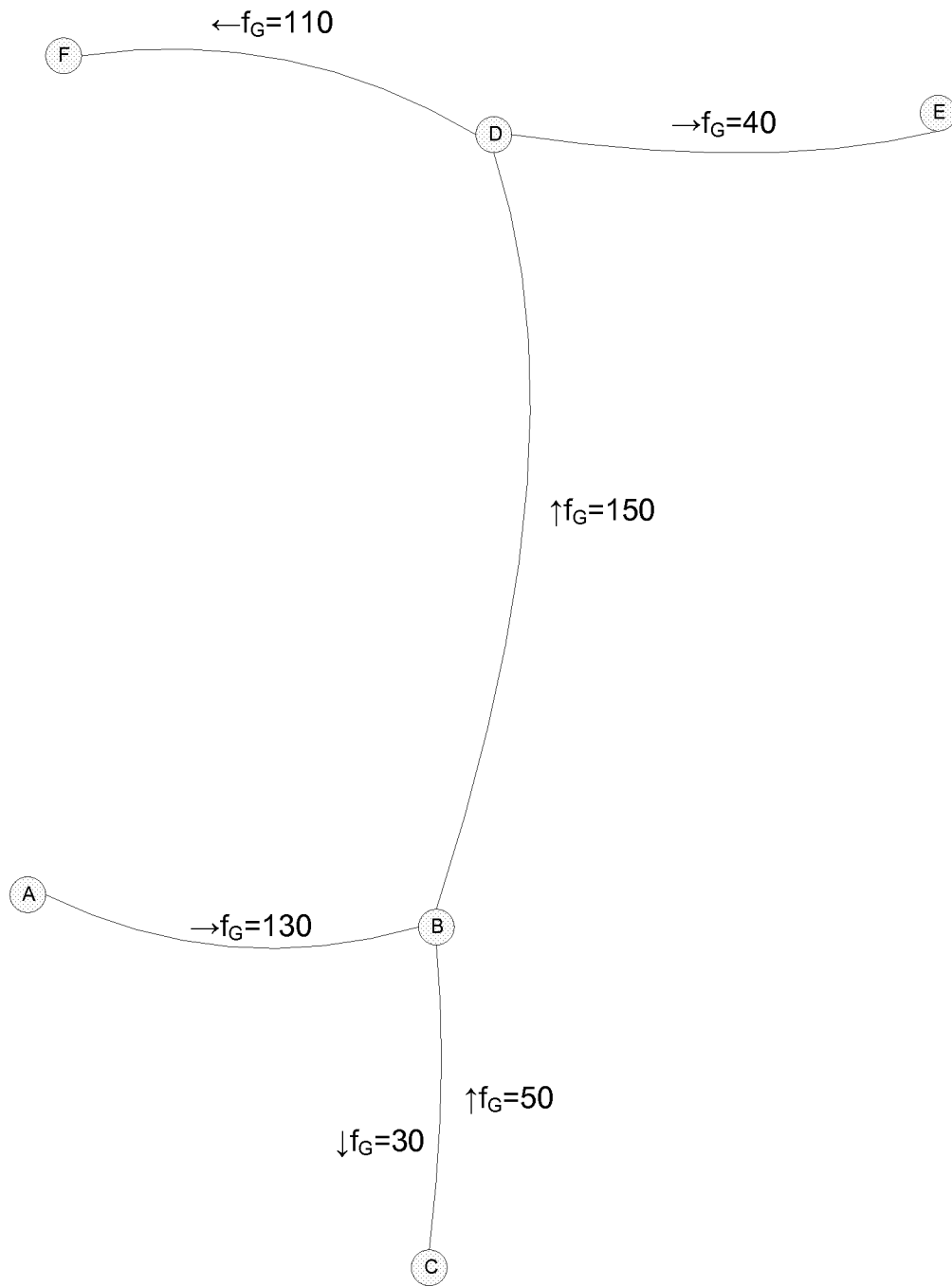


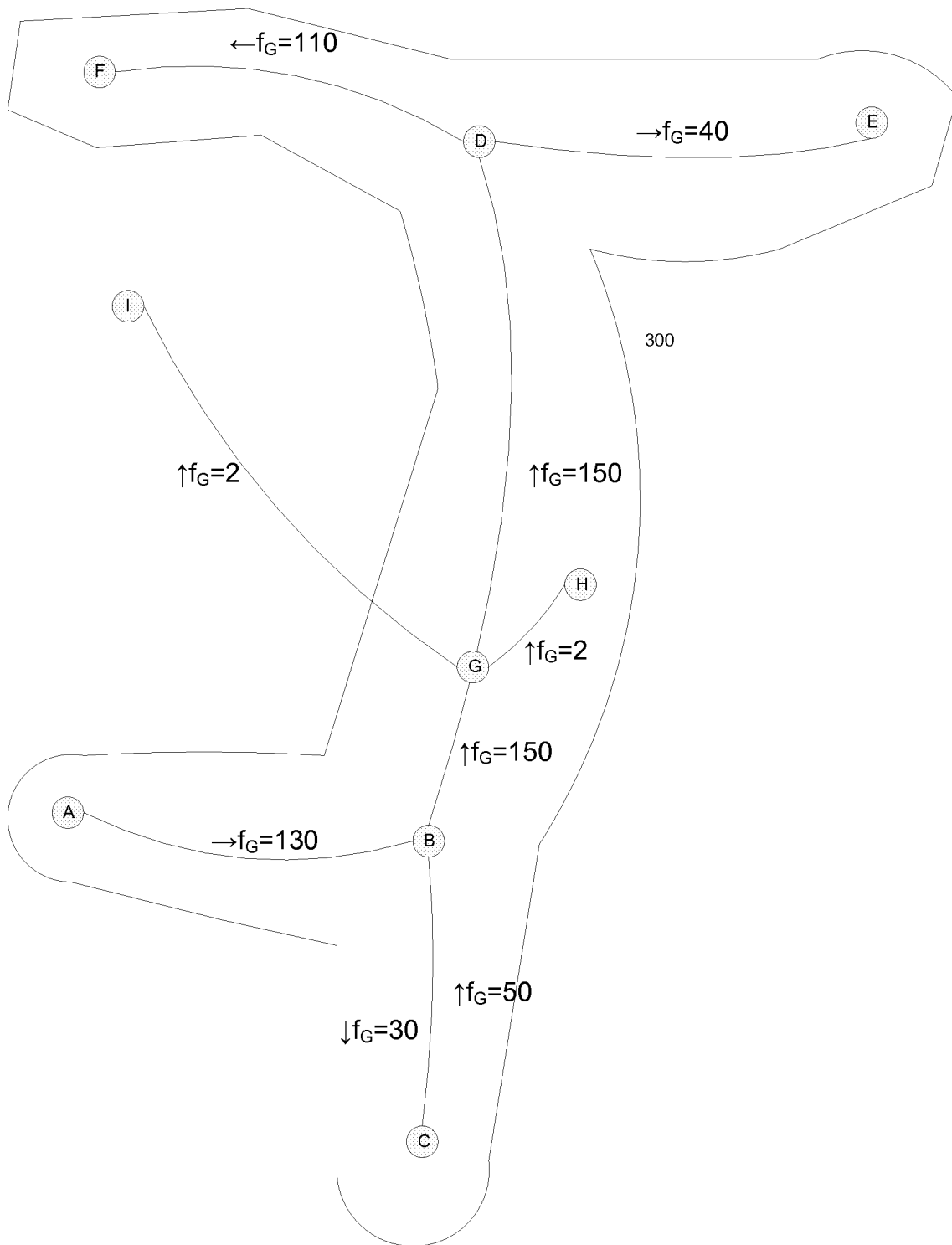
FIG. 7(b)

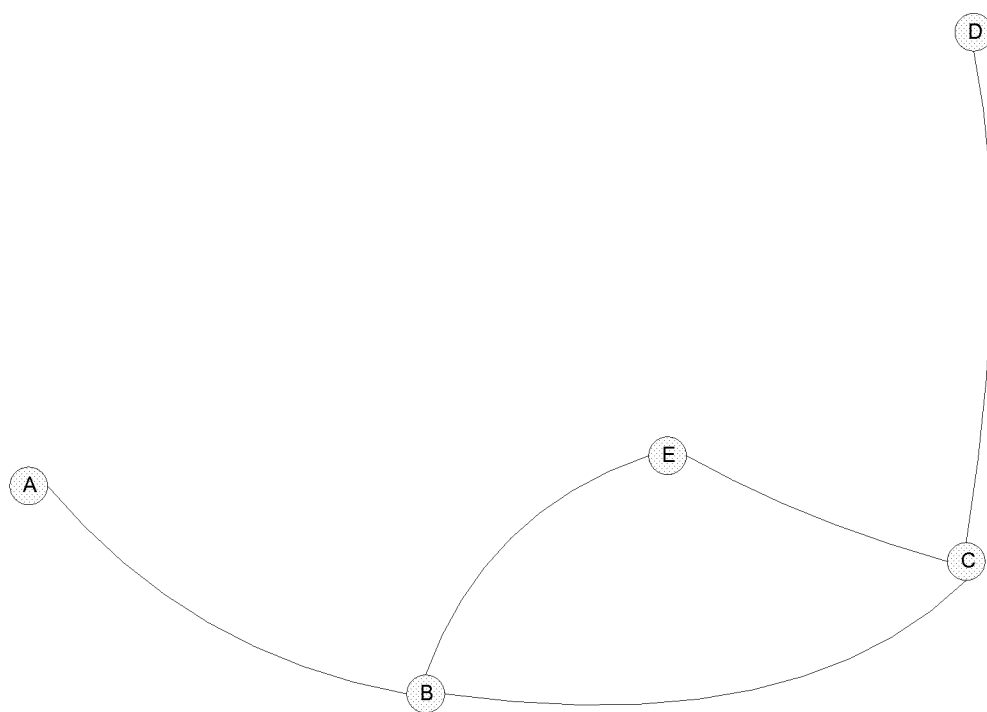
**FIG. 7(c)**

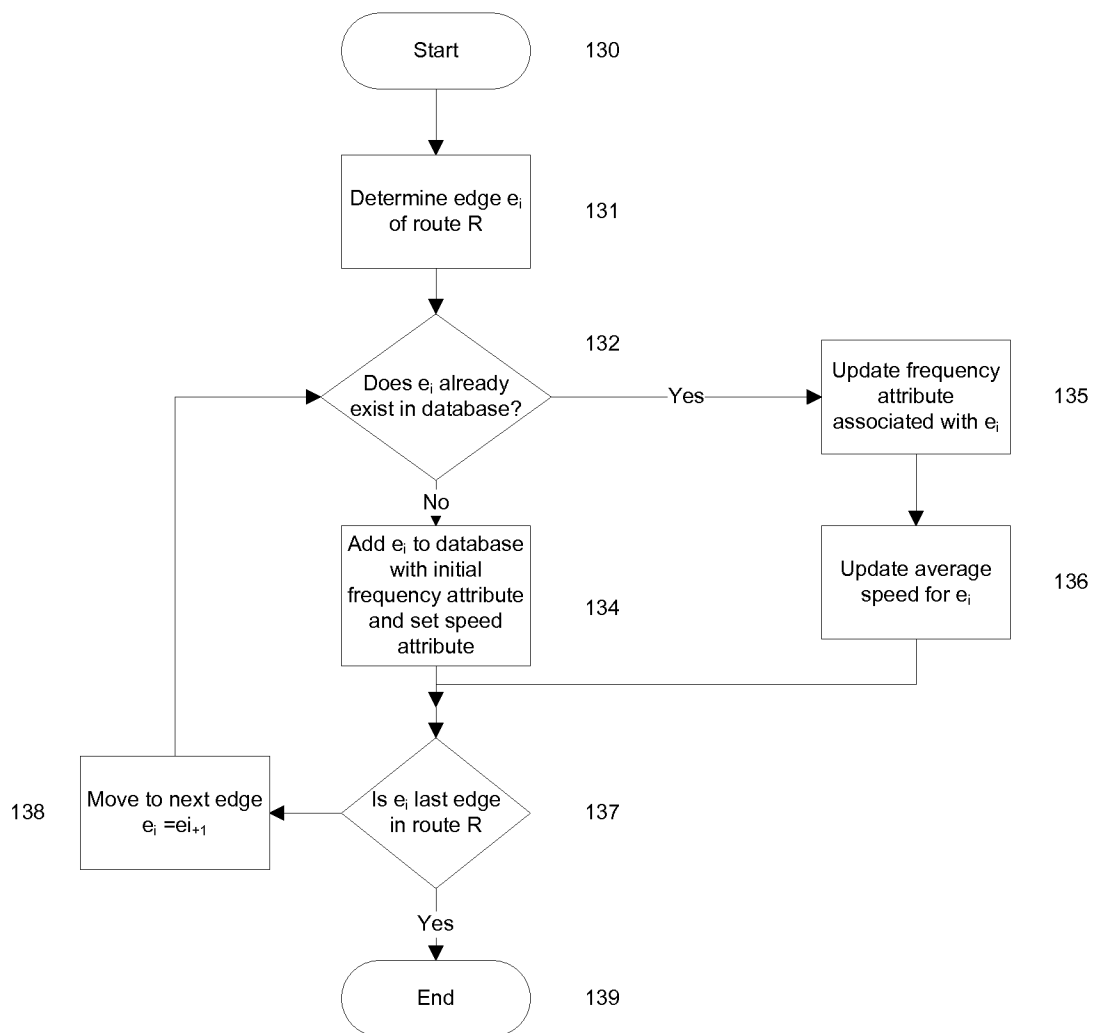
**FIG. 8**

**FIG. 9**

**FIG. 10**

**FIG. 11**

**FIG. 12**

**FIG. 13**

Configuration item	Configuration for Segment Profile		
	Regular	Normal	Unknown area
Audible advice			
Audible advice enabled	optional	yes	yes
Advice frequency	low / none	normal	high
Advice information content	low / none	normal	high
Advice timing / pre-warnings	normal / no	normal / no	early / yes
TTS settings	minimal information	normal / don't read all	optimize for information clarity
Visual guidance / map			
Size of guidance icons	normal	normal	large
Lane guidance	no	yes	yes
Automatic map zoom	user choice	user choice	yes
Show street names	user choice	default values	best clarity
Show POIs on map	user choice	user choice	minimal, e.g. only gas stations, police / authorities
Car symbol	user choice	user choice	best contrast / clarity
Show compass on map	user choice	user choice	no
Map colors	user choice	user choice	best clarity
Miscellaneous			
Music volume	normal	normal	low
GUI richness	high	normal	low / safety mode
Show weather forecast	yes	maybe	no
Route planning settings	fastest or preferred	default (fastest)	default (fastest)
Close route summary dialog after 10 seconds?	yes	yes	no, but close dialog if vehicle starts moving
Traffic and Warnings			
Traffic information	normal	normal	minimal
Automatic re-routing threshold based on traffic	low	normal	high
Warn at schools / places of worship etc.	no	user choice	yes
Mention side of road to drive on	no	user choice	yes
Disable map view while driving	no	user choice	possibly

Table 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2008/063393

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01C21/34 G01C21/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01C G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2006 057153 A1 (BOSCH GMBH ROBERT [DE]) 6 June 2007 (2007-06-06) abstract; figure 1 paragraphs [0026] - [0028] paragraphs [0031] - [0033]	1,2,6,8, 9
X	US 2006/069500 A1 (HASHIZUME MASAYUKI [JP]) 30 March 2006 (2006-03-30) abstract; figure 2 paragraph [0049]; figure 1 paragraphs [0051] - [0054]; figure 5	1,2,6,8, 9
X	US 2006/041378 A1 (CHENG HUA [US] ET AL) 23 February 2006 (2006-02-23) paragraphs [0022], [0027] - [0029] paragraph [0034]; figure 3 ----- -/--	1,2,6,8, 9

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *Z* document member of the same patent family

Date of the actual completion of the international search

1 September 2009

Date of mailing of the international search report

08/09/2009

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Jakob, Clemens

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2008/063393

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/063038 A (BOSCH GMBH ROBERT [DE]; MUELLER RUEDIGER [DE]) 7 June 2007 (2007-06-07) abstract page 3, line 7 - line 26 page 4, line 24 - page 5, line 34 -----	1,2,6,8, 9
X	JP 11 201767 A (SONY CORP) 30 July 1999 (1999-07-30) abstract; figure 1 -----	1,2,6,8, 9
X	WO 2006/027354 A (COTARES LTD [GB]; JONES ALAN HENRY [GB]) 16 March 2006 (2006-03-16) page 5, line 11 - page 6, line 3; figure 1 page 23, line 27 - line 30 page 25, line 26 - line 31 page 27, line 13 - line 22 page 28, line 20 - line 25 -----	1,3,4,6, 8,10,11, 14,15
X	US 6 680 674 B1 (PARK MICHAEL C [US]) 20 January 2004 (2004-01-20) column 2, line 60 - column 3, line 4; figure 1 column 4, line 60 - column 5, line 8; figure 3 column 6, line 54 - line 64; figure 5 -----	1,3,8, 10,14
X	US 5 919 246 A (WAIZMANN GERD [DE] ET AL) 6 July 1999 (1999-07-06) column 1, line 60 - column 2, line 30 column 4, line 61 - column 5, line 7; figure 1 -----	1,3,8, 10,14
X	US 6 708 113 B1 (VON GERLACH BJOERN [DE] ET AL) 16 March 2004 (2004-03-16) column 1, line 57 - column 2, line 3 column 2, line 22 - line 45 column 2, line 22 - line 45 column 3, line 53 - column 4, line 21; figure 1 -----	1,5,7,8, 12,13
X	EP 1 134 716 A (MANNESMANN VDO AG [DE] SIEMENS AG [DE]) 19 September 2001 (2001-09-19) abstract; figure 1 column 2, line 50 - column 3, line 2 column 4, line 6 - line 18 -----	1,5,7,8, 12,13
X	EP 0 803 708 A (AISIN AW CO [JP]) 29 October 1997 (1997-10-29) ----- page 7, line 57 - page 8, line 2; figure 6 page 8, line 50 - line 56; figure 7 page 17, line 34 - line 42 page 18, lines 19,20 -----	1,3,4, 6-8, 10-15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2008/063393

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1,2, 6, 8, 9

controlling a level of information provided to the user
based on information indicative of routes followed by the
navigation apparatus

2. claims: 1, 3, 4, 8, 10, 11, 14, 15

using information indicative of routes followed by the
navigation apparatus for route estimation

3. claims: 1, 5, 7, 8, 12, 13

estimating travelling time or speed using time or speed
information indicative of routes followed by the navigation
apparatus

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2008/063393

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102006057153 A1	06-06-2007	NONE	
US 2006069500 A1	30-03-2006	DE 102005046177 A1 JP 2006119120 A	30-03-2006 11-05-2006
US 2006041378 A1	23-02-2006	EP 1779068 A1 WO 2006023191 A1	02-05-2007 02-03-2006
WO 2007063038 A	07-06-2007	EP 1957940 A1 EP 1957941 A1 WO 2007063127 A1	20-08-2008 20-08-2008 07-06-2007
JP 11201767 A	30-07-1999	NONE	
WO 2006027354 A	16-03-2006	EP 1787087 A1	23-05-2007
US 6680674 B1	20-01-2004	NONE	
US 5919246 A	06-07-1999	AT 189056 T AU 3696895 A WO 9611380 A1 EP 0805951 A1 ES 2140713 T3 FI 971419 A	15-02-2000 02-05-1996 18-04-1996 12-11-1997 01-03-2000 04-04-1997
US 6708113 B1	16-03-2004	AU 6979900 A WO 0106479 A1 DE 19933638 A1 EP 1204957 A1	05-02-2001 25-01-2001 18-01-2001 15-05-2002
EP 1134716 A	19-09-2001	AT 276564 T AU 2486301 A CN 1313504 A DE 60013763 D1 DE 60013763 T2 US 2001025221 A1	15-10-2004 20-09-2001 19-09-2001 21-10-2004 27-01-2005 27-09-2001
EP 0803708 A	29-10-1997	DE 69731579 D1 DE 69731579 T2 US 6049753 A	23-12-2004 31-03-2005 11-04-2000