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[Continued on next page]

(54) Title: A SYSTEM AND METHOD FOR DETERMINING ROAD ATTRIBUTES

(57) Abstract: A method of determining at least one attribute of a road (412), comprising selecting a region (410) of a road area, determining, for each of a plurality of road users, the value of at least one property relating to the passage of the road user through the selected region (410), determining, for the plurality of road users, a distribution of values of the at least one property, and determining at least one attribute of the road (412) in dependence upon the determined distribution.

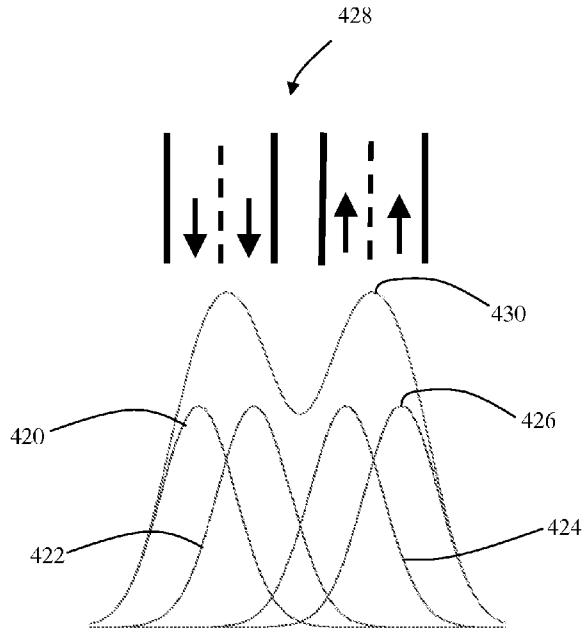


Figure 9

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A SYSTEM AND METHOD FOR DETERMINING ROAD ATTRIBUTES

Field of the Invention

The present invention relates to the determination of attributes of roads. The invention relates also to the determination of map data that may be used, for example, by portable navigation devices.

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

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 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 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.

PNDs of this type may 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 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.

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.

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 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 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.

The utility of portable navigation devices depends on the reliability of the map data used by the devices, and the detail provided by that map data. The location of roads available to a user can be obtained from the map data. However, such pre-existing map data representative of a road or network of roads usually provide a limited amount of information, typically lines representative of the position of the route followed by the centre line of each road (or the positions centre line of each carriageway in the case of major roads) and nodes representative of the position of junctions of roads. In order to obtain additional information concerning a particular road manual inspection of images of segments of the road or on-site inspection of segments of the road during a vehicle test run along the road is required. Thus, a large amount of effort and time may be required in order to obtain information concerning detailed attributes of even a single road.

Summary of the Invention

According to a first aspect of the present invention, there is provided a method of determining at least one attribute of a road, comprising:- selecting a region of a road area; determining, for each of a plurality of road users, the value of at least one property relating to the passage of the road user through the selected region; determining, for the plurality of road users, a distribution of values of the at least one property; and determining at least one attribute of the road in dependence upon the determined distribution.

For each road user, the value of the at least one property may be obtained from

data received from a portable device associated with the road user.

Thus, an attribute of a road may be determined from road users present in or passing along the road. An attribute of a road may be determined, for example, from the behaviour of traffic passing along the road rather than requiring a dedicated on-site survey of the road or a detailed examination of images of the road.

The road may comprise any location on which traffic, in particular vehicular traffic, may be present or along which users may pass, and may be paved or unpaved, public or private. A road is not limited to being a route that leads from one place to another, and may comprise for example, a dead end or parking area. The road may be of any scale and of any type, for example a freeway, autoroute or motorway, a dual carriageway, a lane or a residential, urban or suburban road.

A road user may be a vehicle of any type, for example a car, lorry, coach, bus, or farm or industrial vehicle, or bicycle. The road user may be a person.

Each portable device may be a portable location determining device and/or may be a GPS enabled device. The portable devices may be of the same or different type, and may be, for example, portable navigation devices, mobile phones, or GPS data logging devices such as logging devices installed in taxis or goods vehicles.

Each portable device may be associated with a respective vehicle. For example, each portable device may be installed in a respective vehicle when present in the selected region. The property may comprise a property of the portable device itself when present in the selected region, for instance its location or speed, and/or may comprise a property of a vehicle in which it is installed during its passage through the selected region.

The method may further comprise receiving data for or from each of the portable devices that is representative of the at least one property. The data may comprise location data and/or speed data . The data may comprise GPS data, and may comprise GPS data that is regularly logged as part of the ordinary operation of a GPS system. The data may be received over a period of time, for instance a pre-determined measurement period. The distribution may be determined for portable devices passing through or present in the selected region for at least part of a or the pre-determined measurement period. Alternatively, the distribution could represent a snapshot at a particular instant in time. The region of the road may comprise a cross-section of the road.

The distribution may comprise a distribution as a function of position within the region and/or as a function of time. The distribution may be a historical distribution over a selected time interval. The distribution may be a distribution as a function of distance

in a direction substantially orthogonal to the direction of travel on the road. The distribution may be a distribution of the number of road users as a function of distance or position in the region and/or may be a distribution of the value of a property of each road user (for example speed) as a function of distribution or position in the region.

The method may comprise determining distributions of a plurality of properties relating to the passage of the road users. For example both speed and location distributions may be determined. Each distribution may be determined independently of the other. The method may comprise determining a plurality of attributes of the road from one or more of the distributions. The road attributes may be determined independently of each other.

The at least one property may comprise location. The distribution may comprise a distribution of locations of road users in the selected region.

The location of the portable devices is usually determined with greater resolution than the size of the region of the road, and location data may be used to provide a spatial distribution of vehicles across the region of the road. In turn, that distribution may be used to determined at least one attribute of the road that determines the location of vehicles as they pass along the road.

The at least one property may comprise speed of road users when present in the selected region, and the distribution may comprise a distribution of speeds in the selected region. Speed data may be representative of the average speed at which each road user travelled when present in the region of the road. The at least one property may comprise at least one further property as well as or instead of location or speed. The at least one property may relate to a portable device itself, to a vehicle in which the portable device is installed or to the behaviour of that vehicle in relationship to other vehicles, and/or to an environmental condition experienced by the portable device or vehicle. For example the property may be the spacing of a vehicle in which a portable device was installed to other vehicles when present in the region of the road. The at least one property may comprise an operational parameter concerning operation of the portable device, or an operational parameter concerning operation of a vehicle in which it is installed. The property may also comprise a traffic or weather parameter representative of traffic or weather conditions. The various types of properties may be processed in combination with the location and/or speed properties or the various properties may be processed independently. Further data may be used to preselect speed or location data for use in determination of the distribution. So, for example, if operational data indicated that a car had broken down or that a PND was faulty, location or speed data for that car or PND may be excluded from the distribution determination.

Alternatively, the determination of the distribution may comprise determining the distribution of the further data as well as or instead of location and/or speed.

The at least one attribute of the road may comprise at least one aspect of the layout of the road. The at least one aspect of layout of the road may comprise at least one of the number of lanes, the position of a centre line, the width of one or more lanes, and the presence of a junction or bifurcation from one or more lanes. A junction or other bifurcation may comprise for example an entry or exit lane or slip road.

The method may further comprise determining a plurality of sub-distributions of road users within the region, and preferably each sub-distribution corresponds to a lane of the road.

The method may further comprise determining the position of a centre line in dependence upon the mean of the distribution or of a sub-distribution. Alternatively or additionally the method may comprise determining the width of the road from a variance of the distribution or of a sub-distribution.

Determining the distribution may comprise assigning each road user to a respective sub-region of the region of the road. Determining of the distribution may be performed in dependence upon the number of road users assigned to each sub-region and/or the average value of the or a property for each sub-region.

The method may further comprise fitting the distribution to at least one function and determining the at least one attribute of the road in dependence upon the fitted at least one function. The at least one function may comprise at least one Gaussian function. The fitting may comprise a least-squares fitting procedure, preferably a Levenberg-Marquardt fitting procedure. The method may comprise providing a separate function for each lane. The number of lanes may be determined in dependence upon a comparison of the quality of fit provided by each of a different number of functions.

The method may further comprise:- for each of a plurality of regions of the road area, determining for each of a plurality of road users the value of at least one property relating to the passage of the road user through the region, and determining for the plurality of road users a distribution of values of the at least one property; and comparing differences in the distributions for the plurality of regions of the road to determine at least one attribute of the road.

The at least one attribute of the road may comprise the location of a bifurcation. The method may further comprise determining the location of the bifurcation in dependence upon a widening of the distribution of portable location-determining devices in respect of at least one of the regions of the road.

The method may further comprise comparing the determined at least one

attribute of the road to map data representative of the road and modifying the map data in dependence upon the comparison.

The method may further comprise selecting the region of the road area in dependence upon map data representative of the road. Selecting the region of the road may comprise selecting an area that covers or overlaps the road, or the expected location of the road.

In another independent aspect of the invention there is provided a method of mapping a traffic network comprising receiving map data representative of a traffic network, selecting at least one region of the traffic network, determining at least one attribute of the at least one region of the traffic network using a method as claimed or described herein, and processing the map data to incorporate data representative of the determined at least one attribute of the at least one region of the traffic network. The at least one region may comprise a road or a region of a road.

In another independent aspect of the invention there is provided a mapping system for mapping an area, comprising:- a receiver configured to receive data representative of at least one property relating to the passage of road users; and a processor configured to select a region of the area, to process the data to determine, for each portable device, the value of the at least one property relating to the passage of the road user through the selected region, to determine, for the plurality of road users, a distribution of values of the at least one property, and to determine at least one attribute of the selected region in dependence upon the determined distribution.

The system may further comprise a storage means for storing map data, and the processor may be configured to process the map data to incorporate the determined at least one attribute.

In another independent aspect of the invention there is provided a portable navigation device, comprising:- a location determining device for determining the location of the portable navigation device; a processing resource configured to receive data representative of at least one attribute of a road determined using a method as claimed or described herein, and to provide an output representative of the at least one attribute at the determined location.

In a further independent aspect of the invention there is provided a computer program product comprising computer readable instructions executable to put into effect a method as claimed or described herein.

Any feature in one aspect of the invention may be applied to other aspects of the invention, in any appropriate combination. In particular, apparatus features may be applied to method features and vice versa.

Brief Description of the Drawings

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 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;

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

Figure 6 is a schematic diagram of a system for determining at least one attribute of a road;

Figure 7 is a schematic illustration of a stretch of road to be analysed;

Figure 8 is a further schematic illustration of the stretch of road of Figure 7;

Figure 9 is a plot of Gaussian distributions that may be used to model the distribution of data for traffic lanes;

Figure 10 is a flow chart illustrating in overview one mode of operation of the system of Figure 6;

Figure 11 is a schematic illustration of a stretch of road including slip lanes;

Figure 12 is a plot of the distribution of GPS position data for selected regions of the stretch of road of Figure 11;

Figure 13 is a plot of the distribution of GPS position data for selected regions of a further stretch of road, including a slip road; and

Figure 14 is a plot of the distribution of speeds obtained from GPS data for a further stretch of road.

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 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. 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 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 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/manufacturer specific settings may be stored on the navigation device 200 for example. The data stored for this information can be updated.

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 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 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 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 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.

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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 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 respect, part of the application software 286 comprises a view generation module 288.

As mentioned above, the navigation device 200 uses map data to display the location of the navigation device 200 on a map on the display device 206, and updates the displayed location on the map to reflect movement of the navigation device 200. The map data is also used in planning and displaying routes.

The location of roads available to a user can be obtained from pre-existing maps suitably stored in electronic form as map data. However, such pre-existing map data usually provides only limited if any information concerning attributes of particular roads.

A system is illustrated in Figure 6 which uses data representative of the values of properties relating to the passage of road users when passing through a selected region of a road in order to obtain detailed information concerning the attributes of a road. In particular, the system is able to provide information not provided by normal map data, such as the width and number of lanes, the beginning of bifurcations and the most appropriate moment for a user to follow such bifurcations, and the presence of higher and lower speed lanes. The information can also be used to correct existing map data, if necessary. Portable navigation devices can in turn use such information to provide more accurate information or instructions to users, such as advising users of the most appropriate lane to be in, advising users of the best moments to turn off and accurately displaying the position of the user's vehicle on the road.

The system comprises the server 150 in communication with a plurality of navigation devices and linked to a data store 400 which stores map data. Only five navigation devices 200a to 200e are shown for clarity, but it will be understood that in practice many thousands, or more, of navigation devices may be in communication with the server 150. The server 150 includes a mapping module 402 for reading and processing map data from the data store 400 and a location data processing module 404 for processing location data received from the navigation devices 200a to 200e.

In the normal course of operation of the navigation devices 200a to 200e, GPS data from the devices are regularly recorded (typically, each 5 seconds for current systems) on a logging device, usually in the form of a data logger module included on the portable navigation devices themselves. The GPS data for each navigation device is typically transmitted to the server 150 via an internet connection when the navigation device is docked by the user in a docking station for charging or updating. The user is usually asked his or her permission to transmit the GPS data to the server, and it has been found that most users permit such transmission of the GPS data. In a variant of the described embodiment, the data is transmitted directly from the navigation devices 200a to 200e using a wireless connection. In each case, the GPS data is treated anonymously and cannot be tracked back to a particular user.

The server 150 stores all the GPS data collected over time together with latitude/longitude positioning information in the mass data storage 160. It will be understood that a huge quantity of GPS data from many users is built up, and over time GPS data representative of travel over every possible road in a region or network is obtained. As well as providing location information, the GPS data can be analysed to provide speed or other trajectory data or operational data for each navigation device if required.

The map data store 400 may also form part of the mass data storage 160, although in Figure 6 it is shown as being a separate component. The map data stored in the data store 400 includes a digital graph of the road network describing the topology of the road network as a mathematical graph using nodes and connection structures (road segments).

As will be described in more detail below, the mapping module 402 cooperating with the location data processing module 404 provides an automatic analysis of GPS data obtained from the navigation devices in order to calculate more detailed map features than are provided by the map data stored in data store 400.

In a first stage, each road segment (or just representative road segments) or stretch of road of a given digital map is divided into portions of appropriate length by the mapping module 402. The length of each portion is typically 25m, but the length may be varied depending on the level of resolution required for a particular application.

A rectangular region 410 aligned to a selected road portion is defined, having a length equal to the length of the selected portion (for example 25m), and a width sufficient to span the road or carriageway 412, for example 10m, as illustrated in Figure 7.

The selected length and width of each region may be varied, either automatically or in dependence upon input from a user, depending on the characteristics of the stretch of road (for example whether it is known to be a major or minor road, or whether it is close to other roads) and the resolution required. The width of regions may be widened in situations where no other roads are nearby and/or in situations where the map data may not be reliable, to ensure that the regions cover the desired regions of road. The regions usually extend beyond the expected boundaries of the road. The length of the regions of road are selected in dependence upon the spatial resolution that is required.

Regions to be selected for analysis can also be filtered, either automatically or in dependence upon input from a user, to ensure that regions that may provide unreliable or non-representative results are excluded. Such regions include regions that may provide extraneous GPS data such as regions close to parallel roads, flyovers or underpasses, or regions that are close to features that may interfere with operation of GPS or other location determination systems, such as bridges or skyscrapers.

Each rectangular region 410 is further divided into smaller strips of appropriate width, for example 1m, aligned to the direction of the road, as shown in Figure 8

The mapping module 402 provides the co-ordinates of the region 410 to the location data processing module 404.

The location data processing module 404 then performs a preconditioning of

stored GPS trajectories in the region 410 or stretch of road to be analyzed. For example, based on the given line topology of the digital map the GPS trajectories are separated by the driving direction.

GPS data for a selected driving direction is then filtered by the location data processing module 404 by selecting all GPS data representing positions falling into the region 410. The selected GPS data may optionally also then be further filtered to ensure that only a single GPS position is selected for each trajectory passing through the region 410, in order to ensure that stationary or slow moving vehicles do not weight the data inappropriately.

The number of selected GPS positions falling into each strip is then determined, to provide a distribution of GPS positions for the region 410. In variants of the embodiment, each region is not sub-divided and the distribution of GPS positions obtained for the region is analysed directly, without bucketing or binning the GPS data.

The distribution of GPS positions for the region 410 represents a distribution of positions of vehicles travelling along the stretch of road. In turn, it has been found that such a distribution reflects features of the layout of the road. For example, there is a concentration of GPS positions within the road or carriageway boundaries, and concentrations of GPS positions around the centre of each lane within the road. Conversely there are relatively few GPS positions towards the edges of lanes, and few if any GPS positions outside the road or carriageway boundaries.

Detailed information concerning attributes of the road can be determined by fitting the distribution to an appropriate function and determining values for particular attributes in dependence upon the coefficients of the fitted function.

The location data processing module 404 uses standard function fitting techniques, for example Levenberg-Marquardt (least squares curve fitting) to fit the distribution of GPS positions to one or more Gaussian functions. It has been found that, assuming a Gaussian distribution for an undisturbed cross section GPS density function along a single lane road, the mean of the distribution approximates the centre line of the road segment to be analyzed. It has also been found that the density distribution of a multi-lane road or carriageway can be approximated by a superposition of functions of Gaussian type, as illustrated schematically in Figure 9 which shows four individual Gaussian distributions 420, 422, 424, 426 for the four lanes of a dual carriageway 428 and a superposition 430 of the Gaussian distributions. In that case, the mean of each of the superposed Gaussian functions approximates the centre line of one of the lanes of the road or carriageway.

In the example of Figures 7 and 8, it is not known from the map data whether the

road comprises multi-lane or single lane carriageways. Therefore, the location data processing module 404 begins by fitting a single Gaussian function to the distribution and then fits a series of superpositions of Gaussian functions (from two Gaussian functions up to a maximum number of n Gaussian functions, where n is the supposed maximum number of lanes, usually six at most). The location data processing module 404 selects one of the fits as being the best fit, based upon an evaluation of the fitting error for each fit (taking into account the number of fit parameters) and based upon a determination of whether the values of parameters obtained from each fit are reasonable (for example by comparison with predetermined constraints or thresholds).

In some cases, in the absence of constraints to the fitting procedure, a single Gaussian can be found to be the best fit to a location distribution even if the distribution is obtained for a multilane road. In order to avoid such potential errors, the number of lanes can be obtained by dividing the total width of the road by an assumed width of each lane. For highway segments an average size of 3.5m can be assumed for lane widths. For other road categories slightly different lane sizes can applied based on building or traffic regulations valid for each particular country. The determined number of lanes is then used as a constraint to the fit.

The values of the parameters resulting from the selected single- or multi-Gaussian fit are used to determine one or more attributes of the stretch of road. For example, as mentioned above, the mean of the fitted Gaussian function or the means of each of the superposed Gaussian functions approximates the centre line of the road or the centre lines of each the lanes of the road.

Furthermore, the width of the road can be approximated by the variance parameter of a single Gaussian distribution obtained by the function fit. For a multi-lane road the width of the individual lanes can also be obtained from the variance of each of the Gaussian functions of the multi-Gaussian fit. The amplitude of the or each fitted Gaussian function can also be used as a measure of the relative intensity of flow on the road or on each lane of the road.

The map data representing the stretch of road that has been analysed can be modified to include the attributes obtained by the distribution fitting procedure and, ultimately, more detailed information concerning the stretch of road can be provided to users.

Furthermore, the attributes obtained from analysis of the distribution of position data can be used to confirm or correct map data. For example, the position of a centre line for the region of road calculated from the distribution may be found not to match precisely the position of the centre line for that region stored in the map data. In that

case the centre line data forming part of the map data for that stretch may be substituted by the calculated centre line data. The centre line data obtained from the distribution can also be used as a shape point in a digital road graph describing the road stretch.

A mode of operation of the system of Figure 6 is illustrated in overview in the flow chart of Figure 10.

In the example of Figures 7 and 8, the distribution of GPS data is analysed only for a single region 410 of the stretch of road displayed in Figures 7 and 8. Usually, a number of different regions are selected for each stretch of road. The number of regions 410 and the spacing apart of each region 410 along a length of road are selected, either manually or automatically, in dependence upon characteristics of the road to be analysed, the attributes that are desired to be extracted, and the resolution that is required.

For example, for stretches of relatively minor roads and/or stretches of road that are relatively distant from junctions, a relatively small number of widely spaced regions may be selected for GPS data distribution analysis. In contrast, for major roads, and sections of road close to junctions, and relatively complex parts of a road network a relatively small number of closely spaced regions may be selected for GPS data distribution analysis. At one extreme, a series of contiguous regions are selected along the entire length of a segment of road.

Further attributes of a road are obtained by comparing distribution data for different regions. For example, it has been found that for regions that are close to a bifurcation point between a highway stretch and one or more exit lane(s) the density distribution will become wider compared to more upstream or downstream regions. The widening of the distributions as the exit lane(s) bifurcate from the main carriageway, and the subsequent narrowing of the distributions as the exit lane(s) separate completely from the main carriageway, can be used to identify the positions of the start and the separation of the exit lane.

Figure 11 is a schematic diagram photograph showing a stretch of road including slip roads 440, 442 from two main carriageways 444, 446. The stretch of road is represented in the map data by line data representative of the centre line of the road, and node data indicating the point where the slip road is considered to bifurcate. Node data usually provides only limited information concerning the layout of a slip road, and may for example be representative of a single point location somewhere at or near where the slip road either begins to bifurcate or finally separates.

In this example, three regions of road 448, 450, 452, again of 25m of length, are selected at positions determined from the map data at 180m before the supposed

location of a slip road bifurcation, at the supposed location of the slip road bifurcation and 60m after the supposed slip road bifurcation. In this case, as can be seen from Figure 11, there is a slip road bifurcation on both carriageways at the same location.

GPS distribution data is obtained for the three regions of road 448, 450, 452, and processed by the location data processing module 404.

The distribution data for each region of road 448, 450, 452 are also plotted in Figure 12. It can be seen that the distribution for each of the regions of road 448, 450, 452 shows two large peaks, one corresponding to the centre of each carriageway.

It can also be seen that the distribution for the region of road at the supposed location of the slip road bifurcation includes two additional side peaks 454, 456 in comparison with the distributions for regions that are further away from the supposed location of the slip roads. The side peaks arise from traffic travelling along the slip roads 440, 442 as they bifurcate from the main carriageways 444, 446. Thus, comparison of distribution data obtained in this example is able to confirm the location of the slip roads obtained from the map data.

The accuracy with which the location of a slip road can be determined is increased by increasing the number of different selected regions that are analysed and/or by reducing the size of the selected regions. In one example a series of contiguous regions or overlapping regions are selected to cover a stretch of road around the supposed location of a slip road and the position of the start and/or separation of the slip road can be determined accurately by determining the region for which the distribution first starts to widen or subsequently narrow.

In order to obtain a more accurate position of the start or end of a slip road a correction term is applied. The correction term takes into consideration that the average driver will not change lane immediately at the start of the slip road but a few meters after the slip road has started.

The size of the correction that is applied for any given slip road layout can be optimized by obtaining field measurements of the precise starting locations of a number of entry or exit lanes and comparing those measurements with automatically identified start points for those entry or exit lanes obtained using distributions of GPS data. The correction factor derived by the average bias between the real start of an exit or entry lane and the automatically calculated start is a function of the road category and average speed of the road segment. The correction factor to be applied for any given exit or entry lane is therefore usually selected in dependence upon the road category and/or measured average speed of the road segment. The average speed of the road category can in turn be determined from trajectory data obtained from the stored GPS data, and

the road category is either known from the map data or can be determined from road layout attributes determined automatically from the distribution of stored GPS data.

The distribution of location data for regions at or close to a bifurcation can be fitted to functions, for example Gaussian functions, in order to obtain further information concerning attributes of the bifurcation. Usually an additional function is included in the fitting expression to represent an exit or entry lane or other bifurcation. The width and position of the centre line of the entry or exit lane to a road can be obtained from the fit parameters in the same way as the width and position of the centre line of a road or lane of the road can be obtained from the fit parameters.

By way of example, Figure 13 shows distributions obtained for three regions in the vicinity of an exit lane (in this case at 200m before the bifurcation point obtained from the map data, 80m before the bifurcation point and 100m after the bifurcation point). It can be seen that a side peak 460 corresponding to the exit lane is present in the distribution for the region 100m after the supposed start of the exit lane. In this case, the distributions have been fitted to Gaussian functions, and the main carriageway has been found to be approximately 23m wide and the exit lane has been found to be approximately 6m wide from the variances of the fitted functions.

As mentioned above, speed or other trajectory data can also be obtained from the stored GPS data. In one mode of operation, speed data for each vehicle or user passing through a selected region is obtained from the GPS data from a portable navigation device or other GPS-enabled device associated with the vehicle or user. The distribution of speed data is then used to determine one or more further attributes of a road.

In one example, a distribution of speed as a function of position within a selected region of a road is obtained. The distribution of speed can be used, for example, to determine average speeds for particular roads or lanes within the roads, the presence of fast or slow lanes, and the road type. The distribution of speed data can be particularly useful to determine the presence of dedicated lanes, for instance lanes assigned to high-occupancy vehicles, that may enable vehicles to travel at higher than average speeds. Speed distributions obtained for different regions are also compared in order to identify locations on a road where speeds change, for example near junctions or other bifurcations. Speed distributions near bifurcations can also be used to determine the average change in speed upon entering or exiting a road, for example to or from an entry or exit lane.

Stored map data can be updated to include speed-related information. Users can subsequently be advised of the historic average speed of travel for a road, or of

lanes within that road, using the map data. The user may also be advised of the expected change in speed upon entering or leaving an entry or exit road, or expected changes in speed in the region of a junction, bifurcation or other road feature.

Figure 14 is a plot of the distribution of speeds as a function of position from the left edge of a road obtained from GPS data for three regions, 200m before an exit lane, 80m before an exit lane and 100m after the exit lane. The distribution for the region 100m after the exit lane is broadened, extending to positions further to the right, corresponding to the position of the exit lane. That distribution also shows a side peak in the speed distribution at the position around 28m from the left edge of the road corresponding to speeds of vehicles travelling on the exit lane. By comparing the side peak with the main peaks it can be seen that speeds on the exit lane are clearly significantly lower than on the main carriageway.

The examples described in relation to Figures 7 to 14 each concern a single segment or stretch of road. In practice, given the amount of GPS data available, the system can be used to determine attributes of an entire network of roads automatically. For example, map data and GPS data for an entire town, city, county or even country can be provided to the system. The system is able automatically to select portions of each road in the road network for the area under investigation and to analyse the distribution of GPS data for each selected portion using the techniques described herein. Any selected portions that provide anomalous distribution data can be identified and can be discarded either automatically or upon command of a user. Attributes such as width, location of centre lines of roads, carriageways or lanes within those lanes or carriageways, position of bifurcations, and speed variations and distributions can be determined for each road in the network, and the map data for the network can be updated to include data representing such attributes.

The examples described in relation to Figures 7 to 14 relate to portable navigation devices present in vehicles. It will be understood that other portable devices may be used, including any type of GPS device, mobile phones, or vehicle data logging devices, for example logging devices installed in taxis or goods vehicles. The portable devices may be of the same or different type.

It will also be understood that embodiments described herein provide for the determination of road attributes or map data from data provided by users themselves. Thus, in contrast to the manual inspection methods, information may be obtained from any user of a navigation or location logging system. Every user is able to delivers a subset of GPS positioning information to a central server in a fully automatic processing chain, and data may be obtained and processed for each road segment graph. Attributes

of roads, for example the number of lanes, the centre line and width, can be determined from the data using a mathematical algorithm.

The advantage of the proposed solution is an acceleration of the digital mapping process and a higher quality of map features, in particular, more detailed information of the topology of the road network.

It will 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 the scope of the appended claims.

For example, although the present invention may be exemplified as a portable navigation device, it would be appreciated that 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.

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 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, 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 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 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.

It will be understood that the present invention has been described above purely by way of example, and modifications of detail can be made within the scope of the invention.

Each feature disclosed in the description, and (where appropriate) the claims and drawings may be provided independently or in any appropriate combination.

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 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 method of determining at least one attribute of a road (412), comprising:-

selecting a region (410) of a road area;

determining, for each of a plurality of road users, the value of at least one property relating to the passage of the road user through the selected region (410);

determining, for the plurality of road users, a distribution of values of the at least one property; and

determining at least one attribute of the road (412) in dependence upon the determined distribution.

2. A method according to Claim 1, wherein, for each road user, the value of the at least one property is obtained from data received from a portable device associated with the road user.

3. A method according to Claim 2, wherein each portable device is a portable location-determining device and/or each device is a GPS-enabled device.

4. A method according to Claim 2 or 3, wherein the at least one property is a property of the portable devices when present in the selected region.

5. A method according to any preceding claim, wherein the at least one property comprises location in the selected region.

6. A method according to any preceding claim, wherein the at least one property comprises speed, and the distribution comprises a distribution of speeds in the selected region.

7. A method according to any preceding claim, wherein the at least one attribute of the road comprises at least one aspect of the layout of the road.

8. A method according to Claim 7, wherein the at least one aspect of layout of the road comprises at least one of the number of lanes, the position of a centre line, the width of one or more lanes, and the presence of a bifurcation from one or more lanes.

9. A method according to any preceding claim, wherein the method further

comprises determining a plurality of sub-distributions of the portable devices within the region, and preferably each sub-distribution corresponds to a lane of the road.

10. A method according to any preceding claim, further comprising determining the position of a centre line in dependence upon the mean of the distribution or of a sub-distribution.

11. A method according to any preceding claim, further comprising determining the width of the road from a variance of the distribution or of a sub-distribution.

12. A method according to any preceding claim, further comprising:-

for each of a plurality of regions of the road area, determining for each of the plurality of road users the value of at least one property relating to the passage of the road user through the region, and determining for the plurality of road users a distribution of values of the at least one property; and

comparing differences in the distributions for the plurality of regions of the road to determine at least one attribute of the road.

13. A method according to Claim 12, wherein the at least one attribute of the road comprises the location of a bifurcation.

14. A method according to Claim 13, further comprising determining the location of the bifurcation in dependence upon a widening of the distribution of portable devices in respect of at least one of the regions of the road.

15. A method according to any preceding claim, further comprising comparing the determined at least one attribute of the road to map data representative of the road and modifying the map data in dependence upon the comparison.

16. A method according to any preceding claim, further comprising selecting the region of the road in dependence upon map data representative of the road.

17. A method of mapping a traffic network comprising receiving map data representative of a traffic network, selecting at least one region (410) of the traffic network, determining at least one attribute of the at least one region (410) of the traffic network using a method according to any of Claims 1 to 16, and processing the map

data to incorporate data representative of the determined at least one attribute.

18. A mapping system for mapping an area, comprising:-

a receiver configured to receive data representative of at least one property relating to the passage of road users; and

a processor configured to select a region (410) of the area, to process the data to determine, for each portable device, the value of the at least one property relating to the passage of the road user through the selected region (410), to determine, for the plurality of road users, a distribution of values of the at least one property, and to determine at least one attribute of the selected region (410) in dependence upon the determined distribution.

19. A portable navigation device, comprising;-

a location determining device for determining the location of the portable navigation device;

a processing resource configured to receive data representative of at least one attribute of a road (412) determined using a method in accordance with any of Claims 1 to 17, and to provide an output representative of the at least one attribute at the determined location.

20. A computer program product comprising computer readable instructions executable to put into effect a method according to any of Claims 1 to 17.

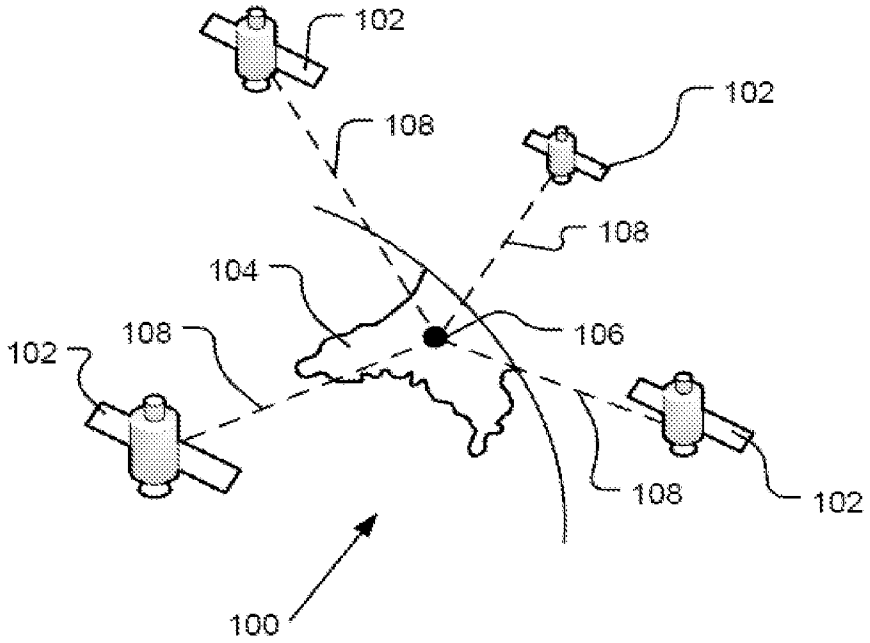


Figure 1

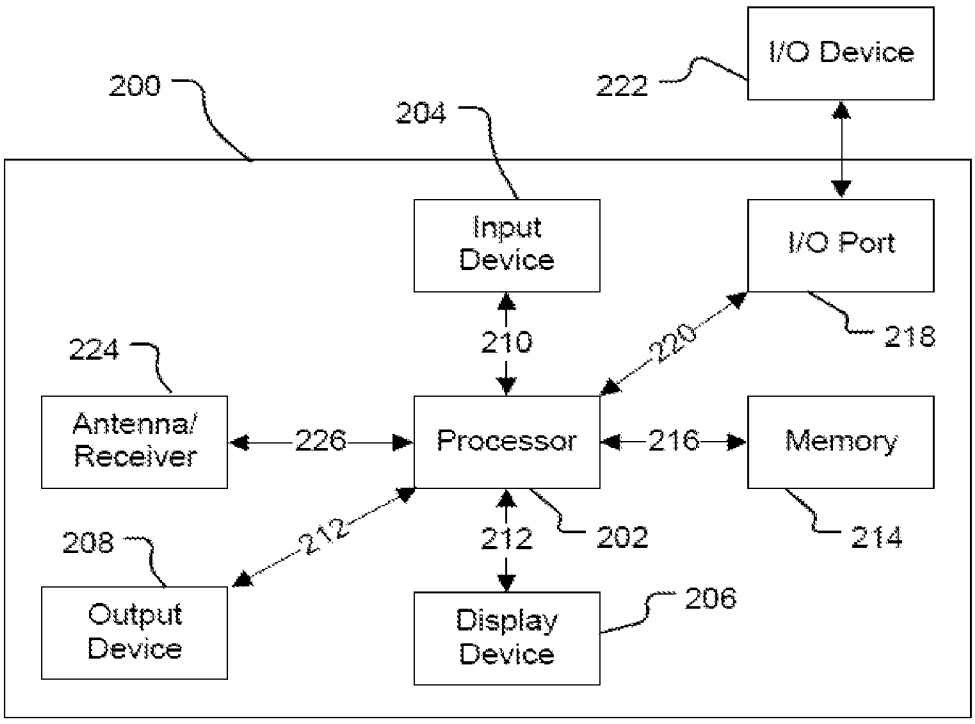
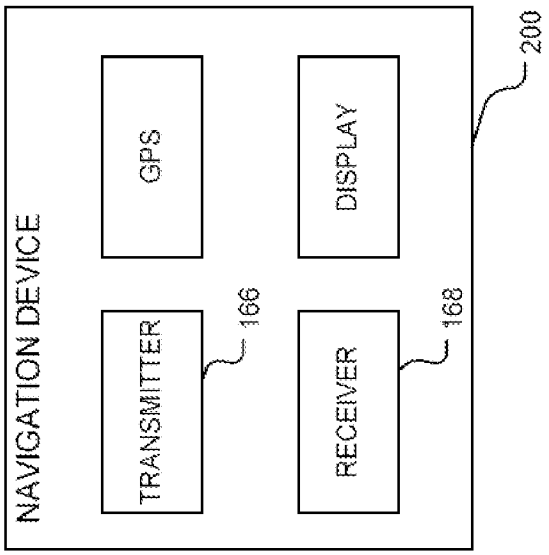
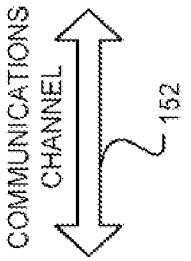


Figure 3


NAVIGATION DEVICE
GPS
DISPLAY
TRANSMITTER
166
RECEIVER
168
200


COMMUNICATIONS CHANNEL
152

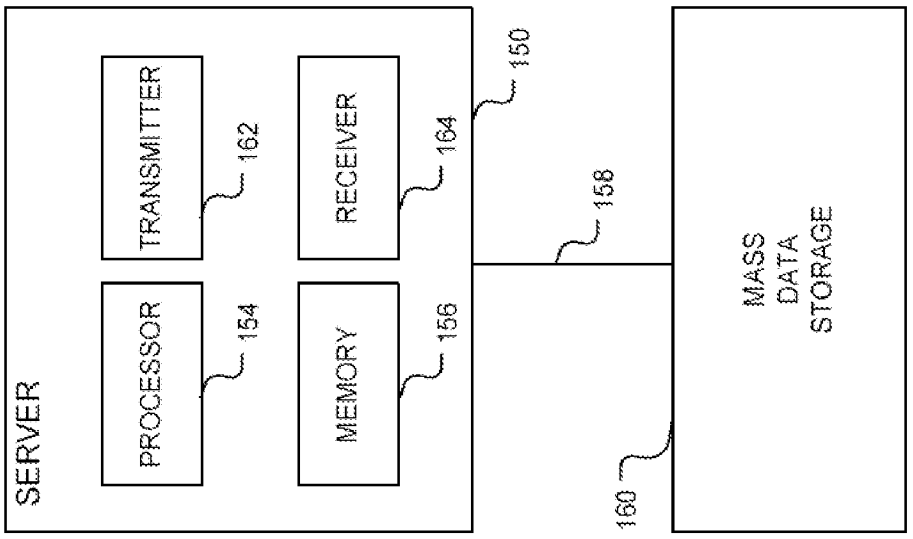

SERVER
PROCESSOR
154
TRANSMITTER
162
MEMORY
156
RECEIVER
164
150
158
160
MASS DATA STORAGE

Figure 2

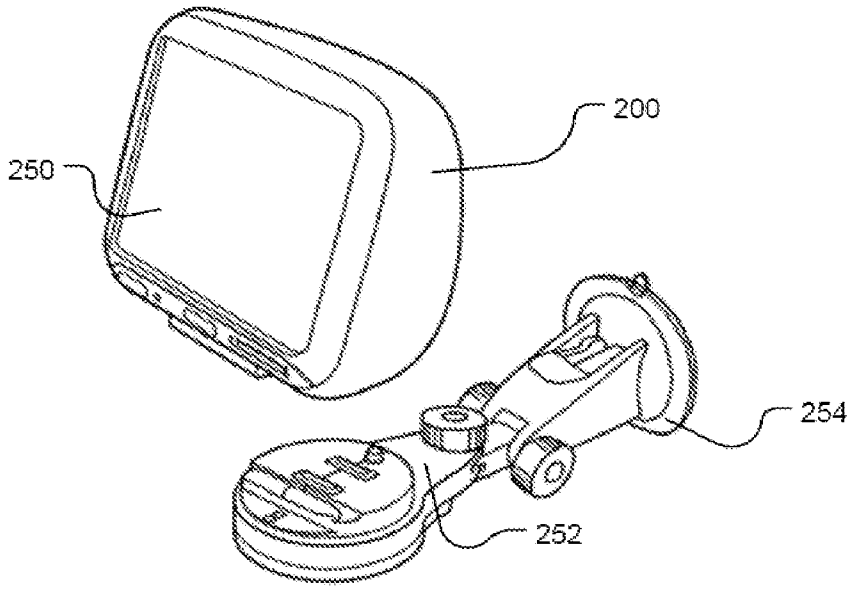


Figure 4

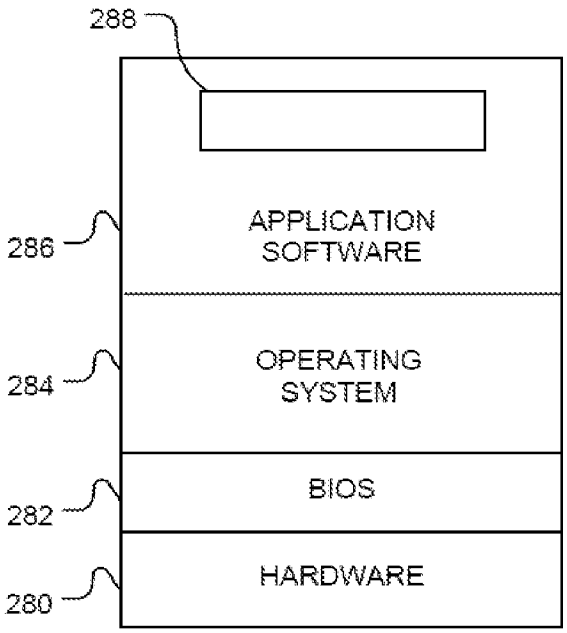


Figure 5

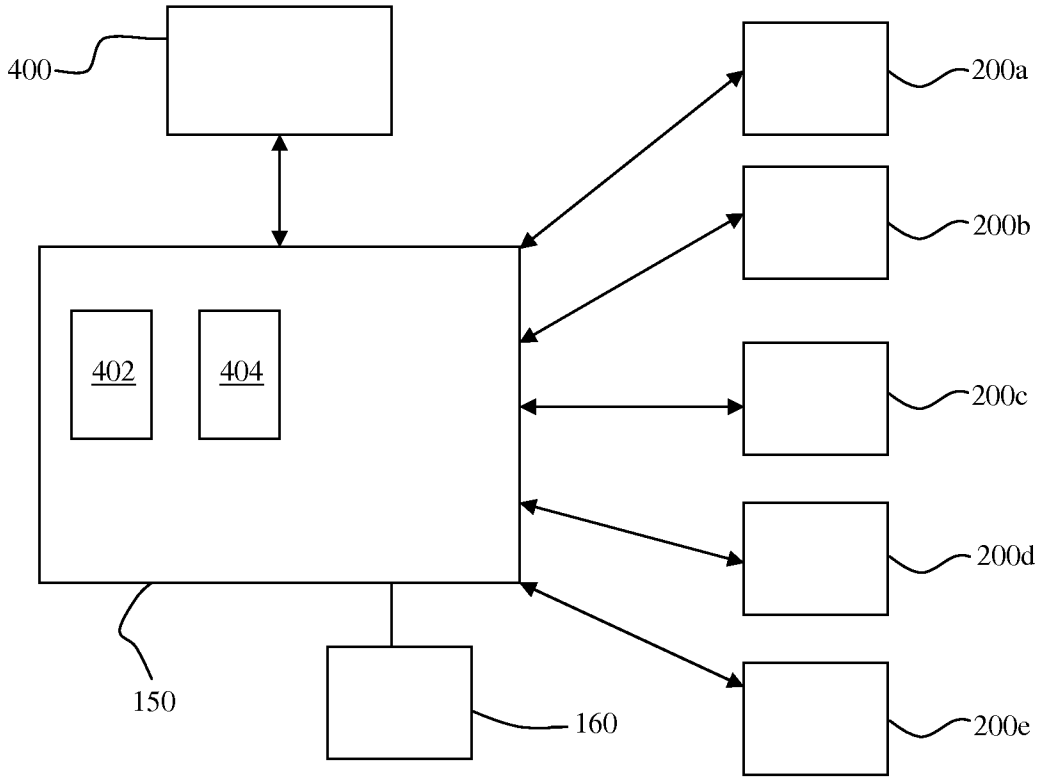


Figure 6

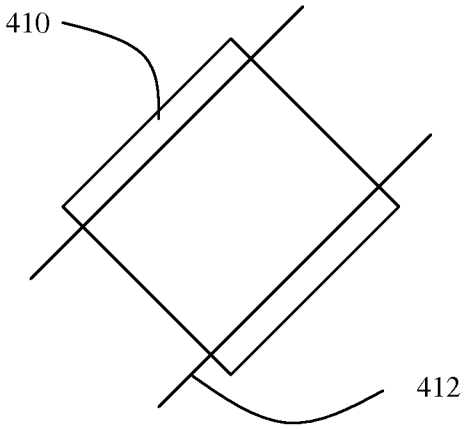


Figure 7

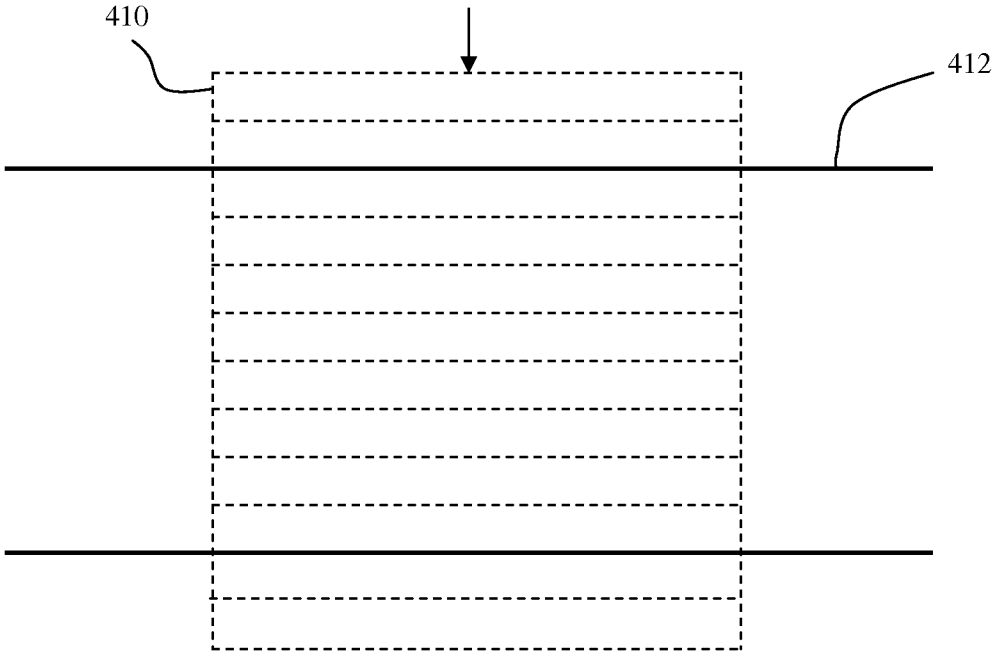


Figure 8

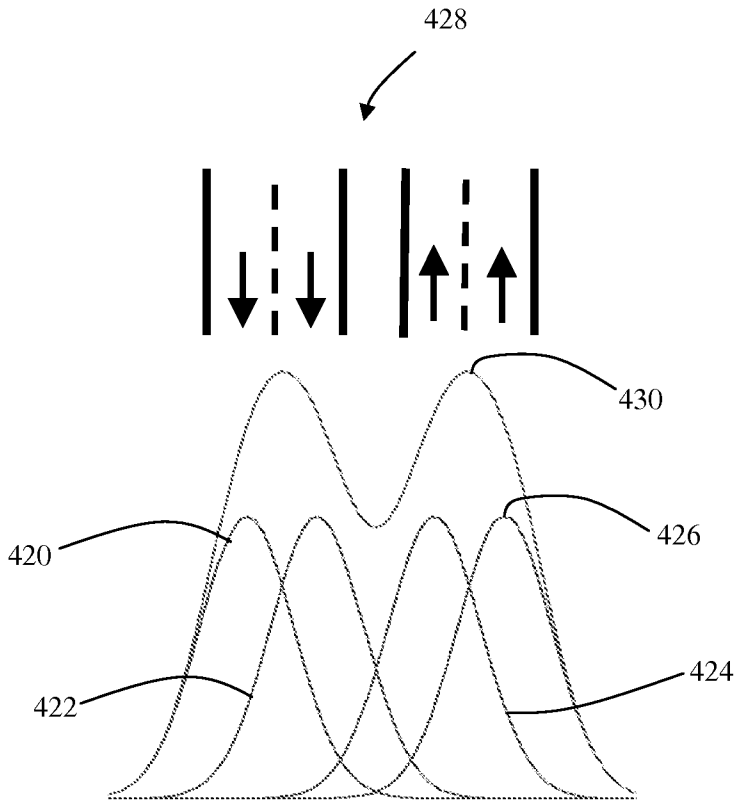


Figure 9

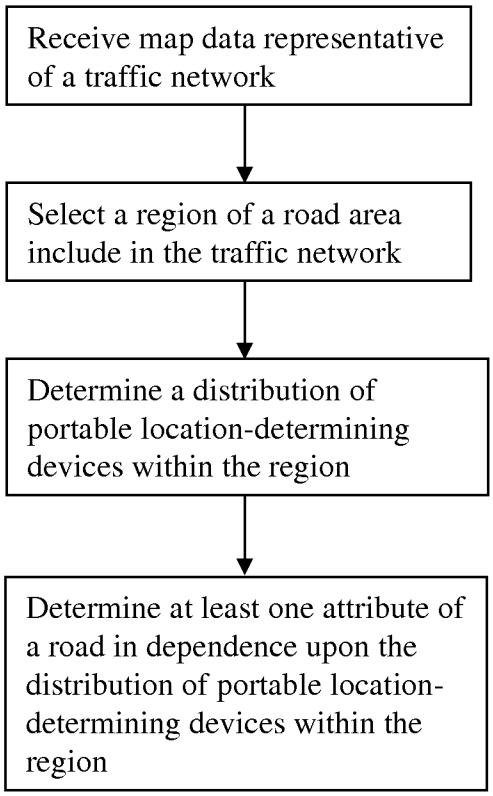

Receive map data representative of a traffic network
Select a region of a road area include in the traffic network
Determine a distribution of portable location-determining devices within the region
Determine at least one attribute of a road in dependence upon the distribution of portable location-determining devices within the region

Figure 10

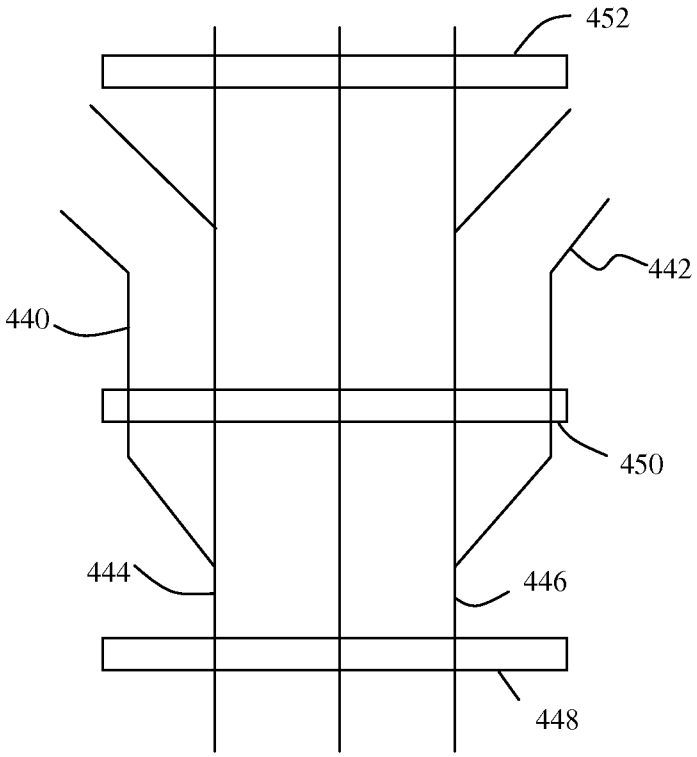


Figure 11

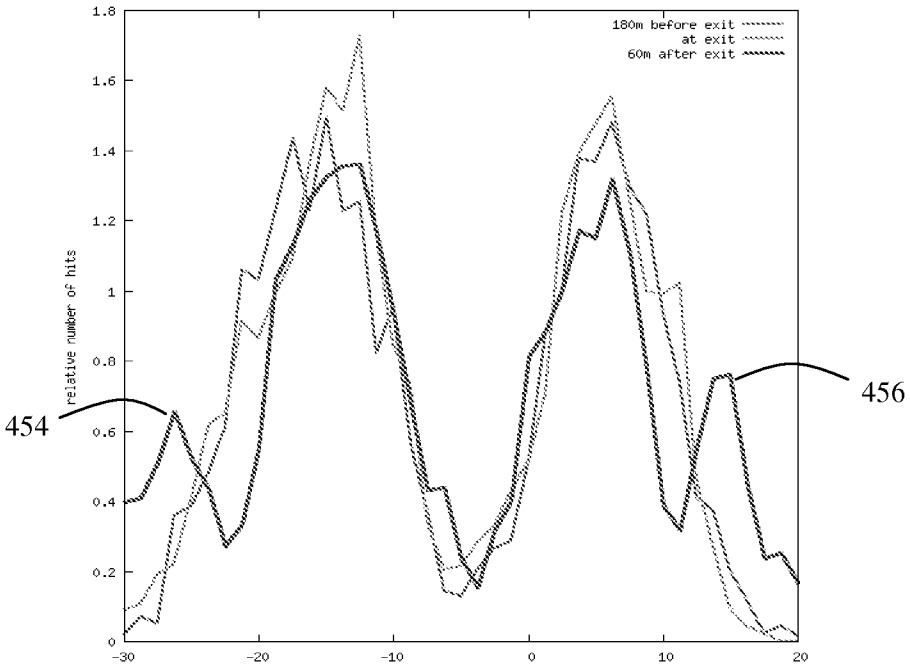

180m before exit
at exit
60m after exit
relative number of hits
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-30
-20
-10
0
10
20
454
456

Figure 12

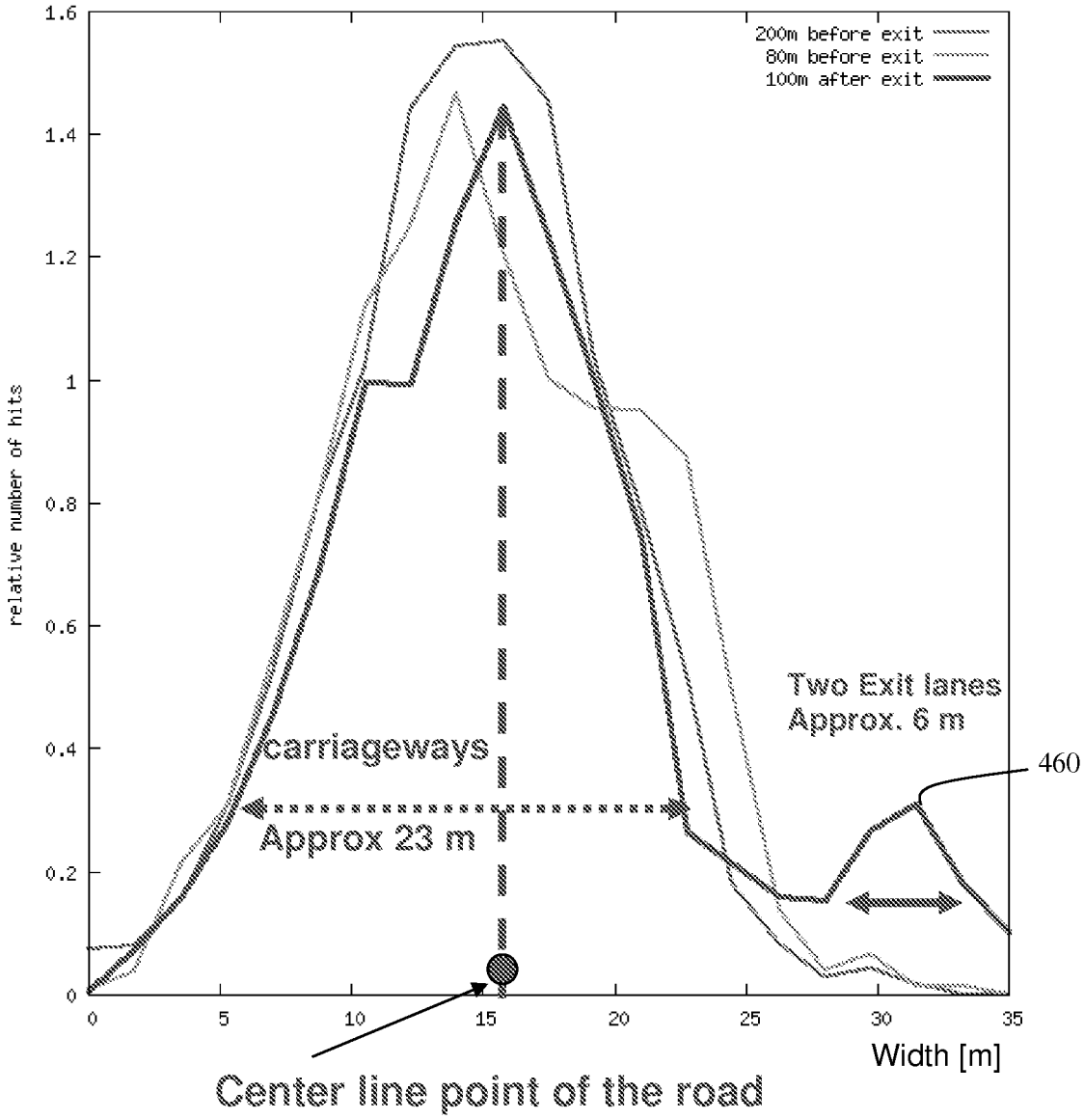

200m before exit
80m before exit
100m after exit
relative number of hits
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
35
Width [m]
carriageways
Approx 23 m
Two Exit lanes
Approx. 6 m
460
Center line point of the road

Figure 13

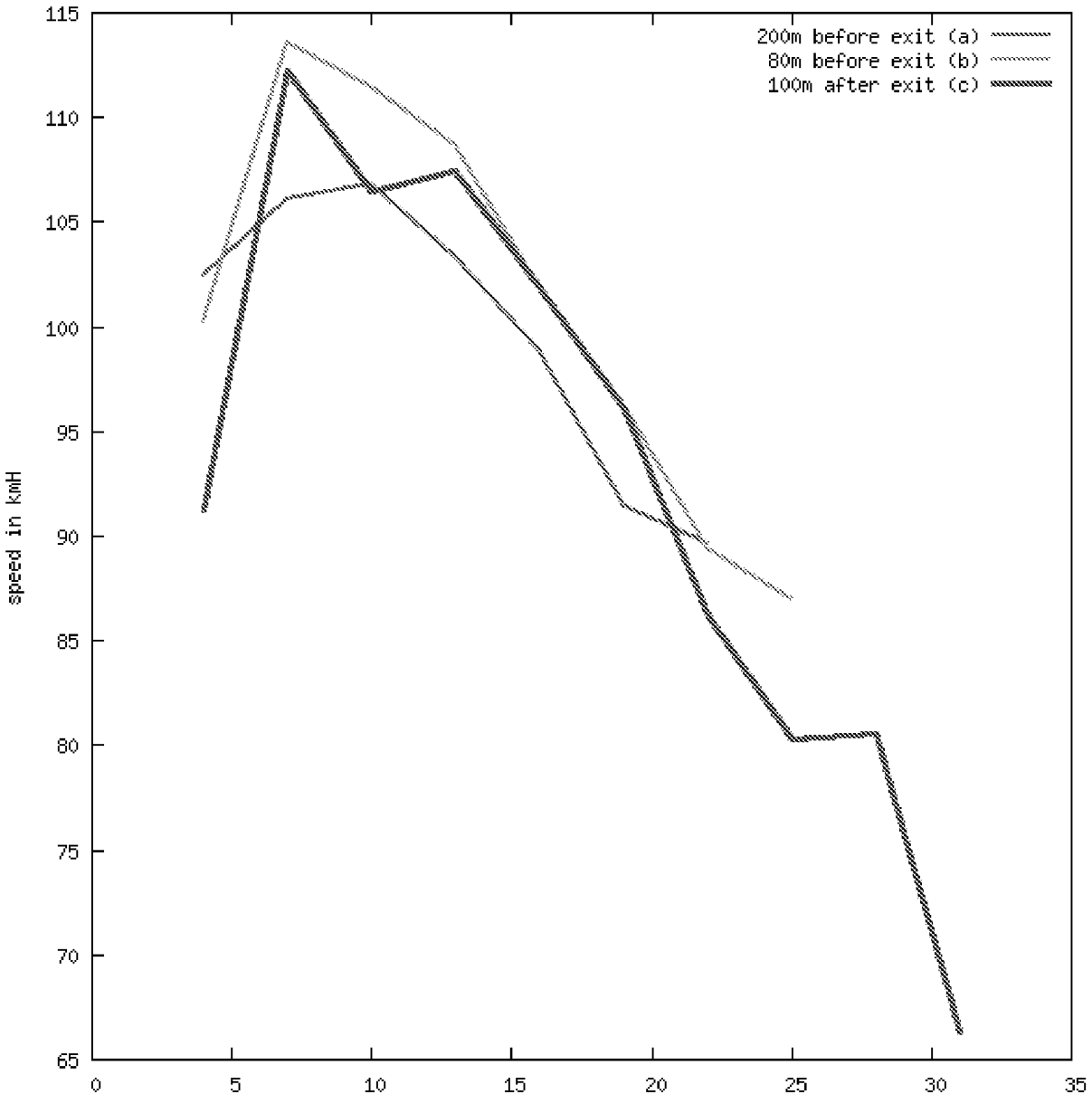

200m before exit (a)
80m before exit (b)
100m after exit (c)
speed in kmH
115
110
105
100
95
90
85
80
75
70
65
0
5
10
15
20
25
30
35

Figure 14

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2008/063481

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01C21/32

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CHRISTOPHER K. H. WILSON, SETH ROGERS, SHAWN WEISENBURGER: "The Potential of Precision Maps in Intelligent Vehicles" : 1998 IEEE INTERNATIONAL CONFERENCE ON INTELLIGENT VEHICLES, 30 October 1998 (1998-10-30), XP002533811 Stuttgart, Germany	1-5,7-20
X	columns 1-7; figure 1	6
X	SETH ROGERS PAT LANGLEY CHRISTOPHER WILSON: "Mining GPS Data to Augment Road Models" PROCEEDINGS OF THE FIFTH ACM SIGKDD INTERNATIONAL CONFERENCE ON KNOWLEDGE DISCOVERY AND DATA MINING, 1999, pages 104-113, XP002533812 San Diego, California, United States page 104, column 1 - page 113, column 2	1-20

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 June 2009	12/08/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dragomir, Adrian

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2008/063481

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SETH ROGERS , PAT LANGLEY , CHRISTOPHER WILSON: "Learning to Predict Lane Occupancy Using GPS and Digital Maps" PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE ON KNOWLEDGE DISCOVERY AND DATA MINING, ACM, 1999, pages 1-27, XP002533813 page 1 - page 27	1-20
X	US 6 850 841 B1 (CASINO ROY [US]) 1 February 2005 (2005-02-01) paragraphs [0004], [0008] - [0073]; figures 8,10,11 the whole document	1-20
X	US 2007/208496 A1 (DOWNS OLIVER B [US] ET AL) 6 September 2007 (2007-09-06) paragraphs [0041] - [0043] the whole document	1-20
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X	US 6 385 539 B1 (WILSON CHRISTOPHER KENNETH HOO [US] ET AL) 7 May 2002 (2002-05-07) paragraphs [0055] - [0057]; figure 11 the whole document	1-20
X	DE 100 30 932 A1 (BOSCH GMBH ROBERT [DE]) 3 January 2002 (2002-01-03) claims 1-8 the whole document	1-20
X	STEFAN SCHROEDL ET AL: "Mining GPS Traces for Map Refinement" DATA MINING AND KNOWLEDGE DISCOVERY, KLUWER ACADEMIC PUBLISHERS, BO, vol. 9, no. 1, 1 July 2004 (2004-07-01), pages 59-87, XP019277108 ISSN: 1573-756X paragraph [0005] the whole document	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2008/063481

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