(12) UK Patent Application (19) GB (11) 2586490 (13) A

(43) Date of A Publication 24.02.2021

(21) Application No: 1912005.4

(22) Date of Filing: 21.08.2019

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(51) INT CL:
B60W 50/08 (2020.01) ***B60W 30/182*** (2020.01)
B60W 60/00 (2020.01) ***G01C 21/34*** (2006.01)

(56) Documents Cited:
WO 2018/094384 A1 **US 8634980 B1**
US 20180361972 A1 **US 20180239359 A1**
US 20150149017 A1 **US 20140025259 A1**

(58) Field of Search:
INT CL **B60W, G01C**
Other: **WPI, EPODOC**

(54) Title of the Invention: **Autonomous driving mode selection system**
Abstract Title: **Autonomous driving style selection**

(57) A method of controlling an autonomous vehicle according to a driver preference where the driver selects a route to be driven by the vehicle, and the route data is analysed to determine if the selected driving style exists for the selected route and if the selected driving style is permitted, wherein if the selected driving style is available and permitted 940 for the selected route then the method further comprises the step of configuring parameters 955 for an autonomous driving control system according to the selected driving style preference. If the selected style is not available or prohibited, the method may comprise determining alternative driving style preferences 950, or alternative routes where the selected style is available and permitted may be suggested 925. Also provided are four further inventions regarding methods for: adapting driver style preferences, modifying a vehicle driving style, deriving a driving style model and training a driving style identification model.

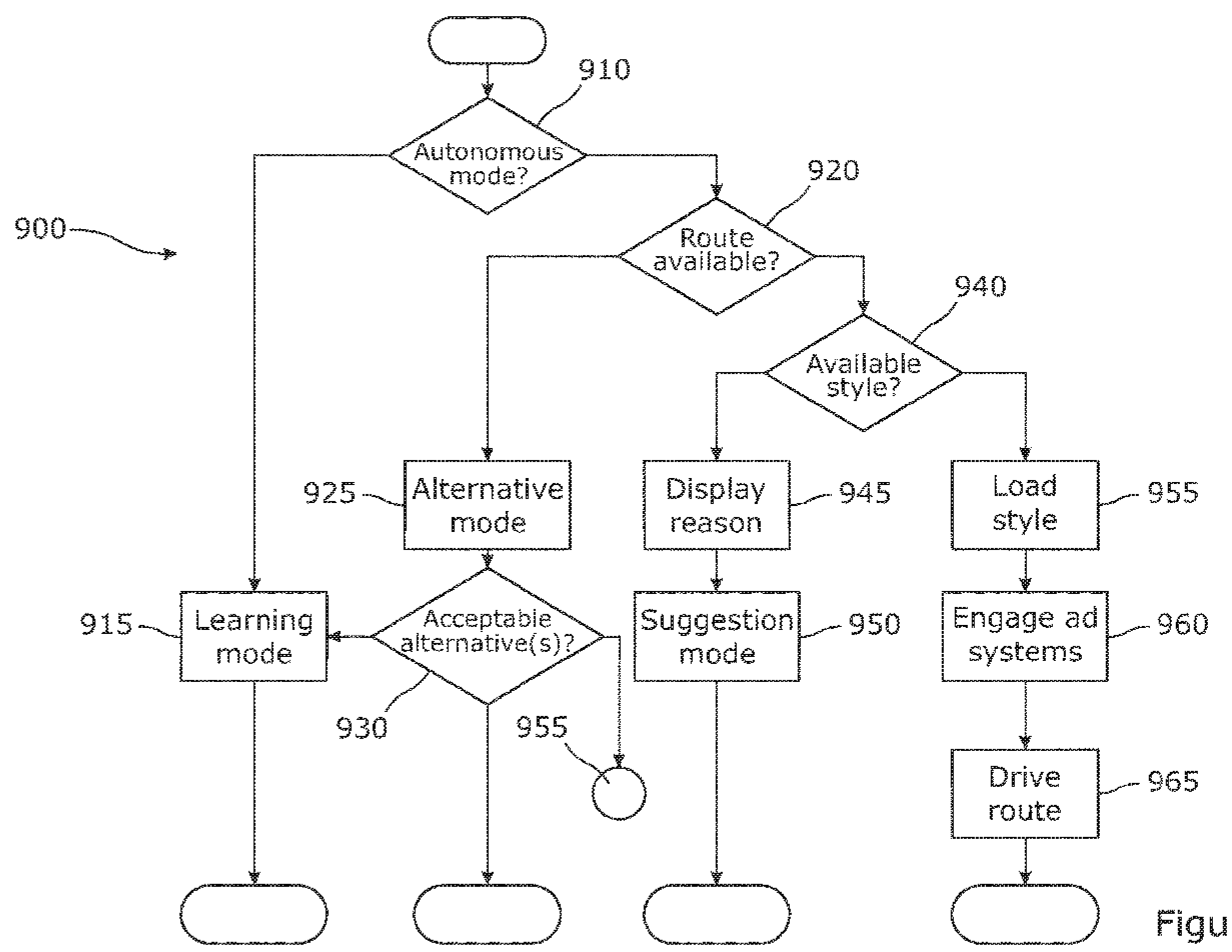

Figure 9

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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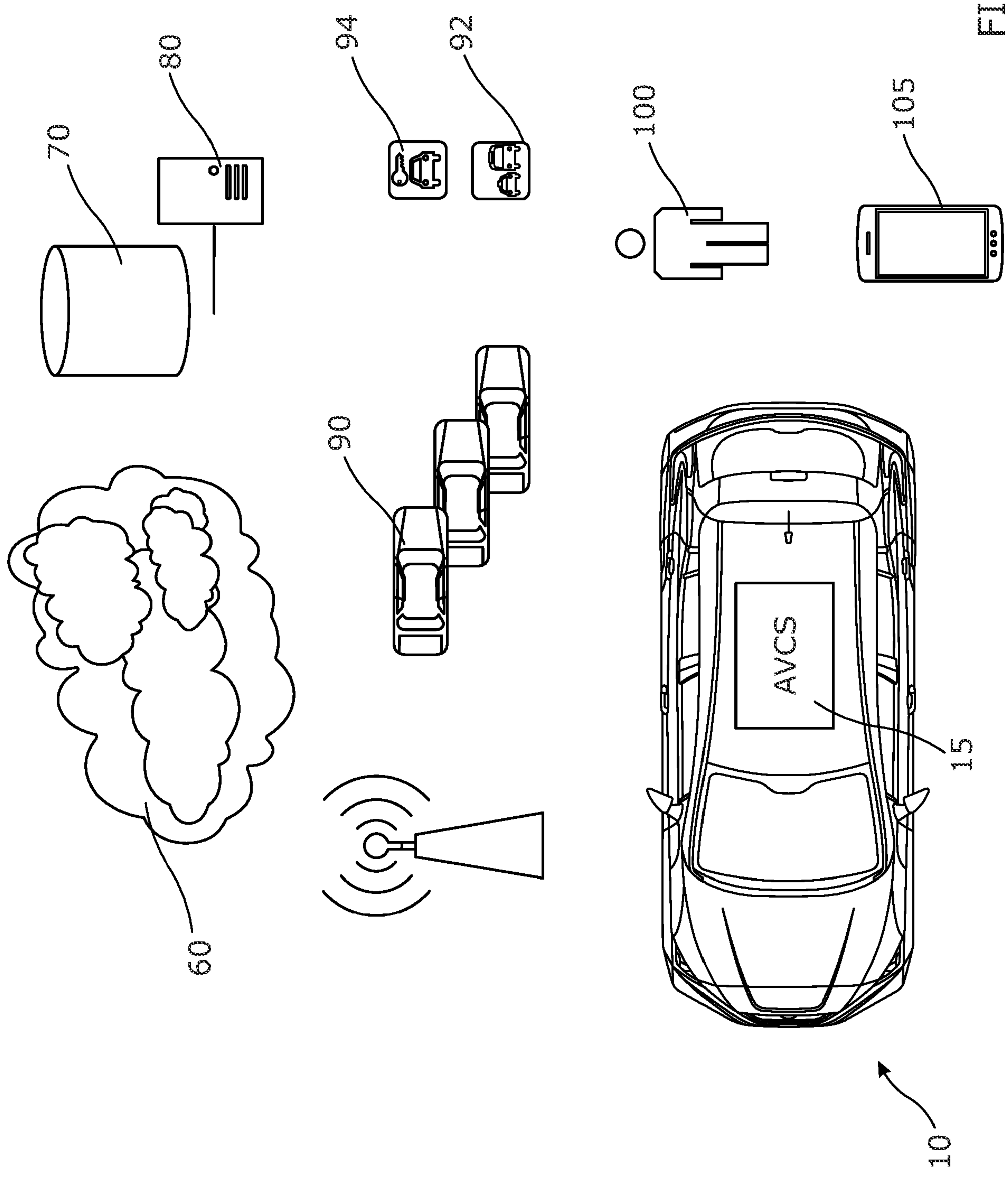

FIGURE 1

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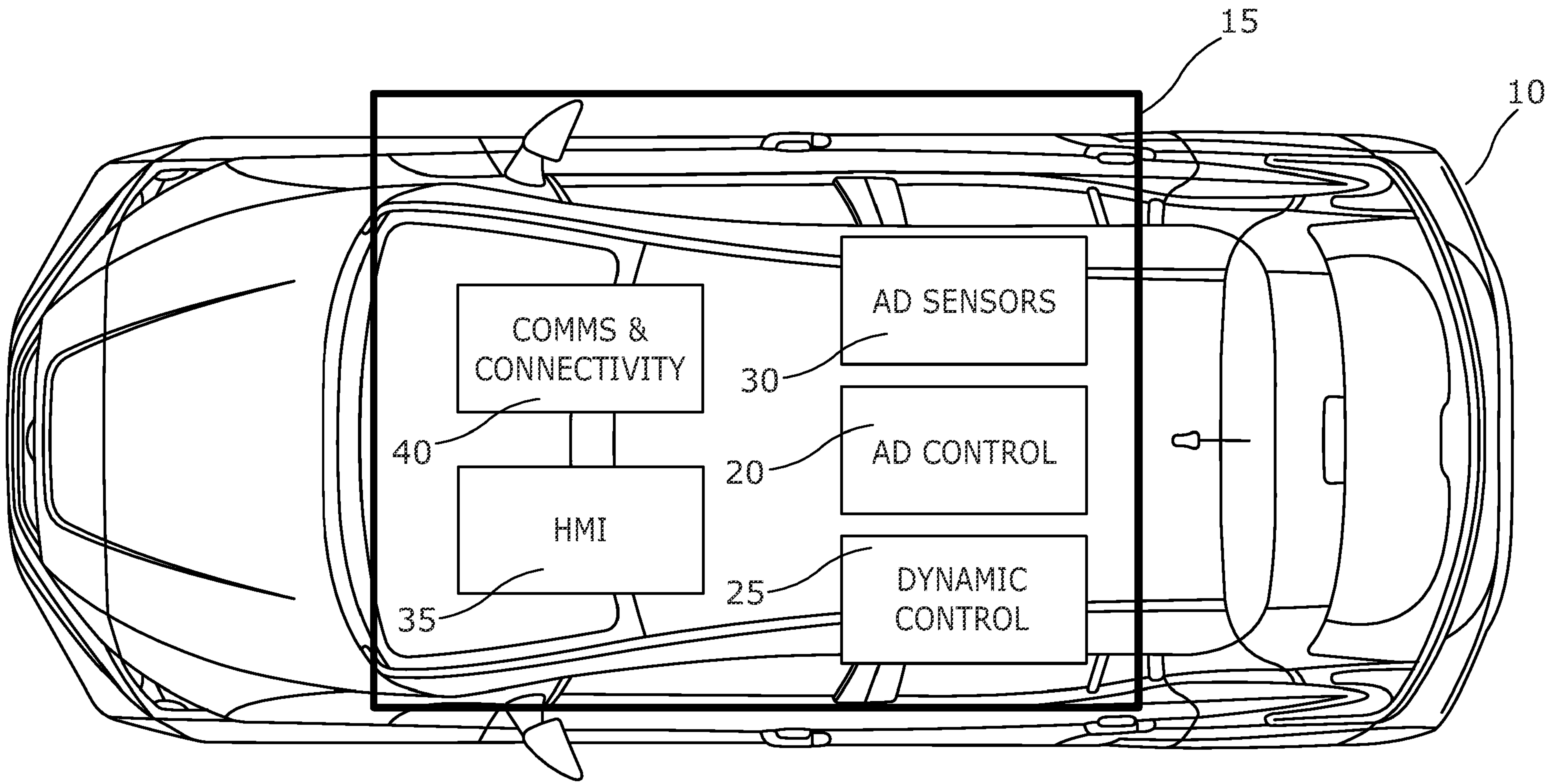

FIGURE 2

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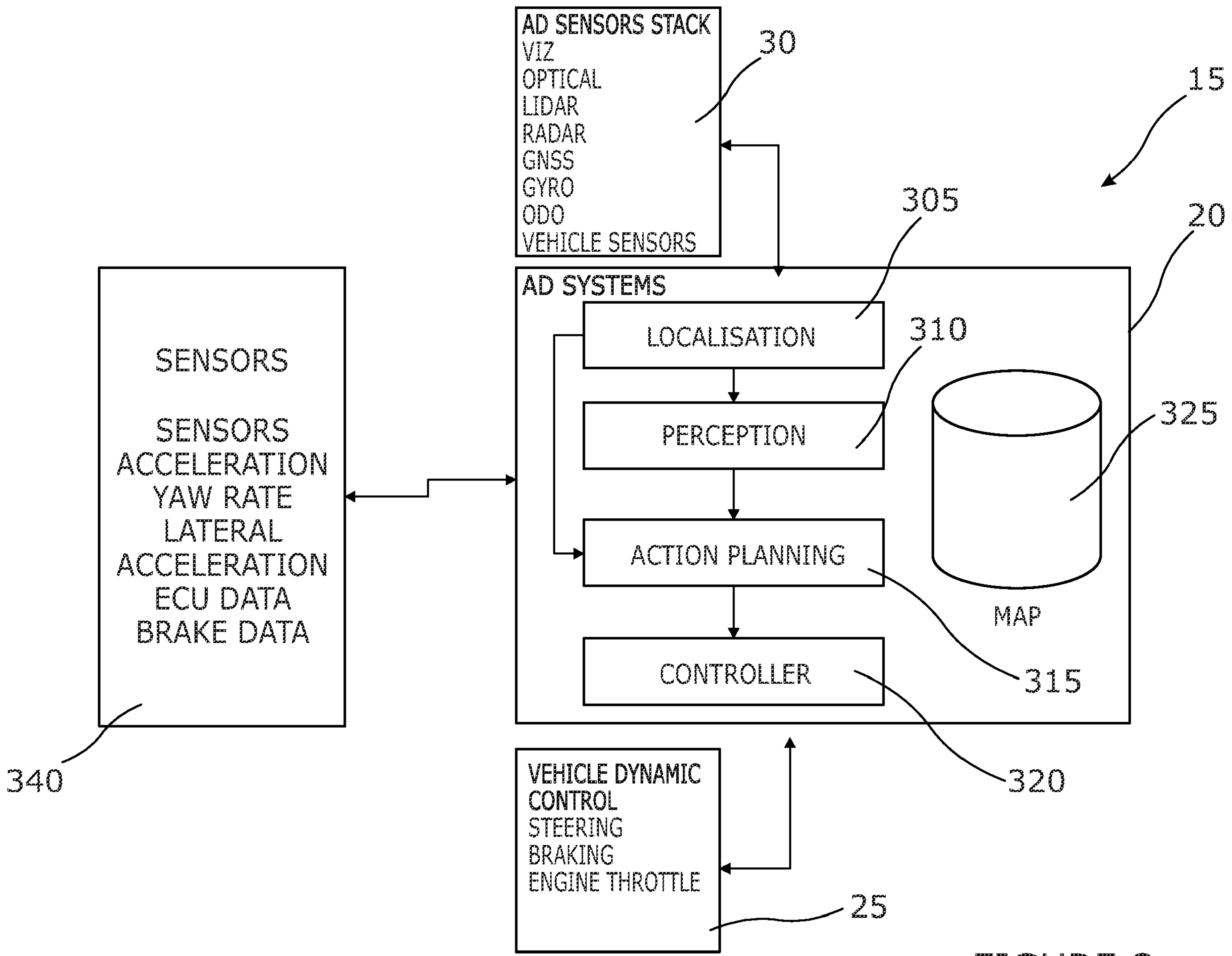

FIGURE 3

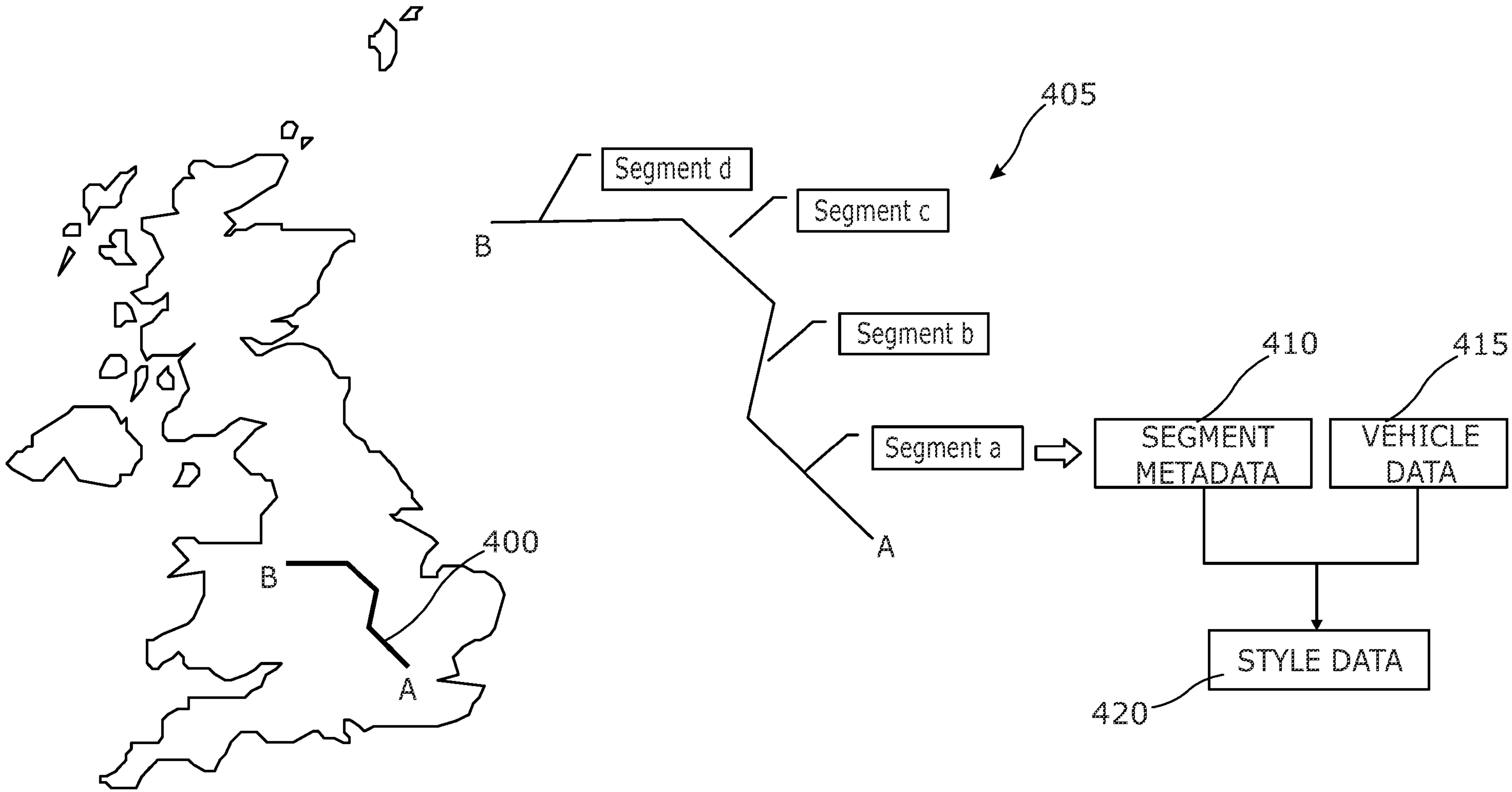
405
Segment d
Segment c
Segment b
Segment a
B
A
400
B
A
410
415
SEGMENT METADATA
VEHICLE DATA
STYLE DATA
420

FIGURE 4

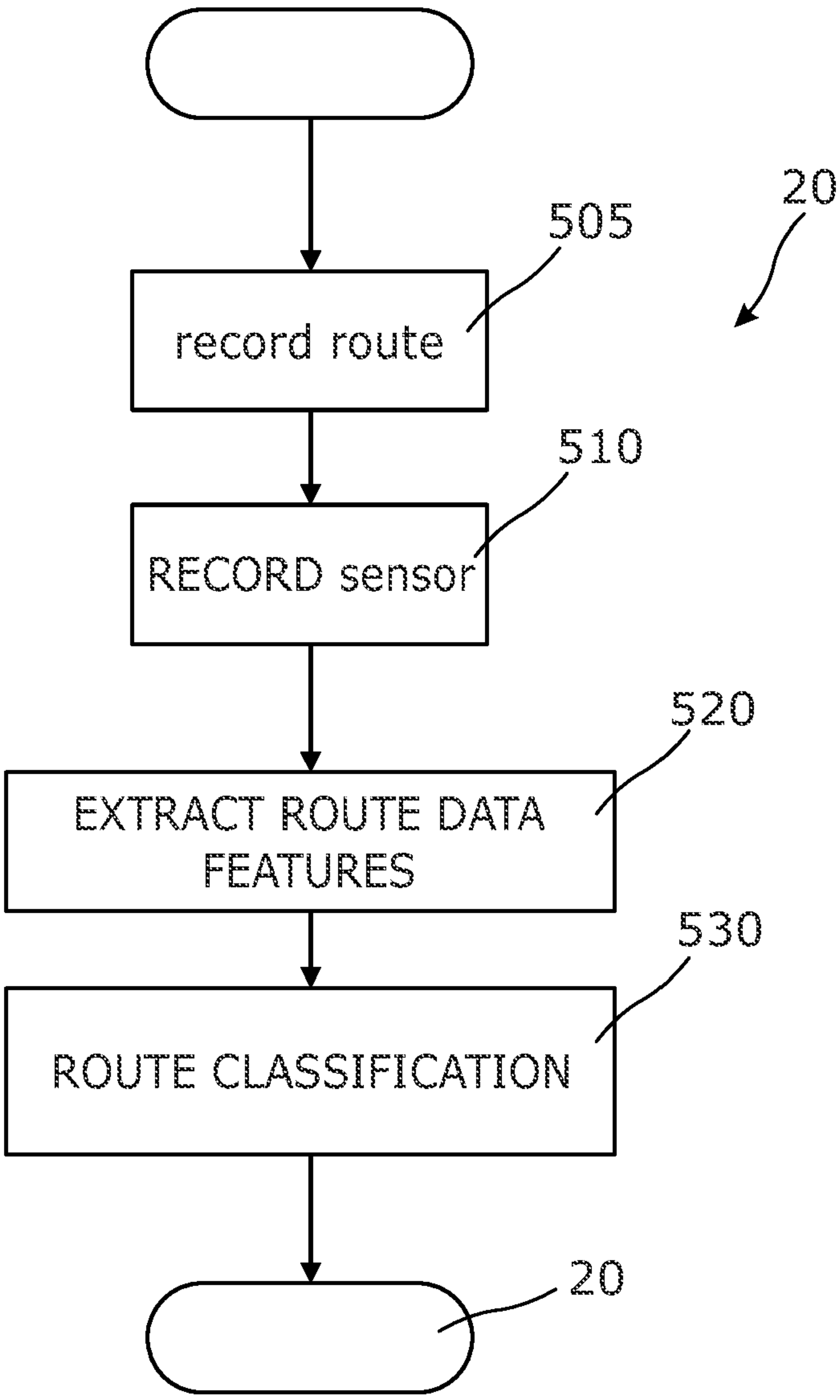
20
505
record route
510
RECORD sensor
520
EXTRACT ROUTE DATA FEATURES
530
ROUTE CLASSIFICATION
20

FIGURE 5

03 10 19

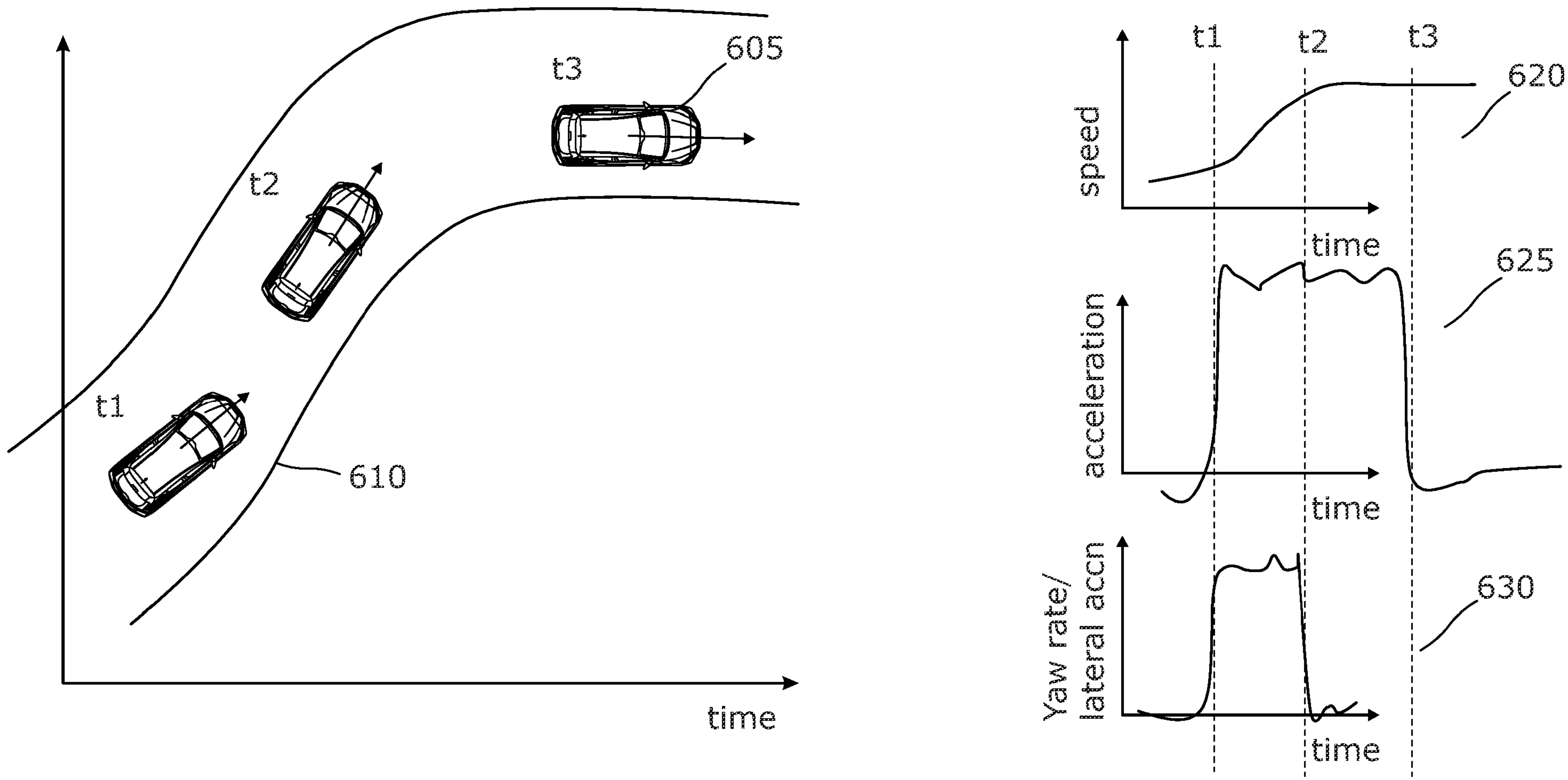

FIGURE 6

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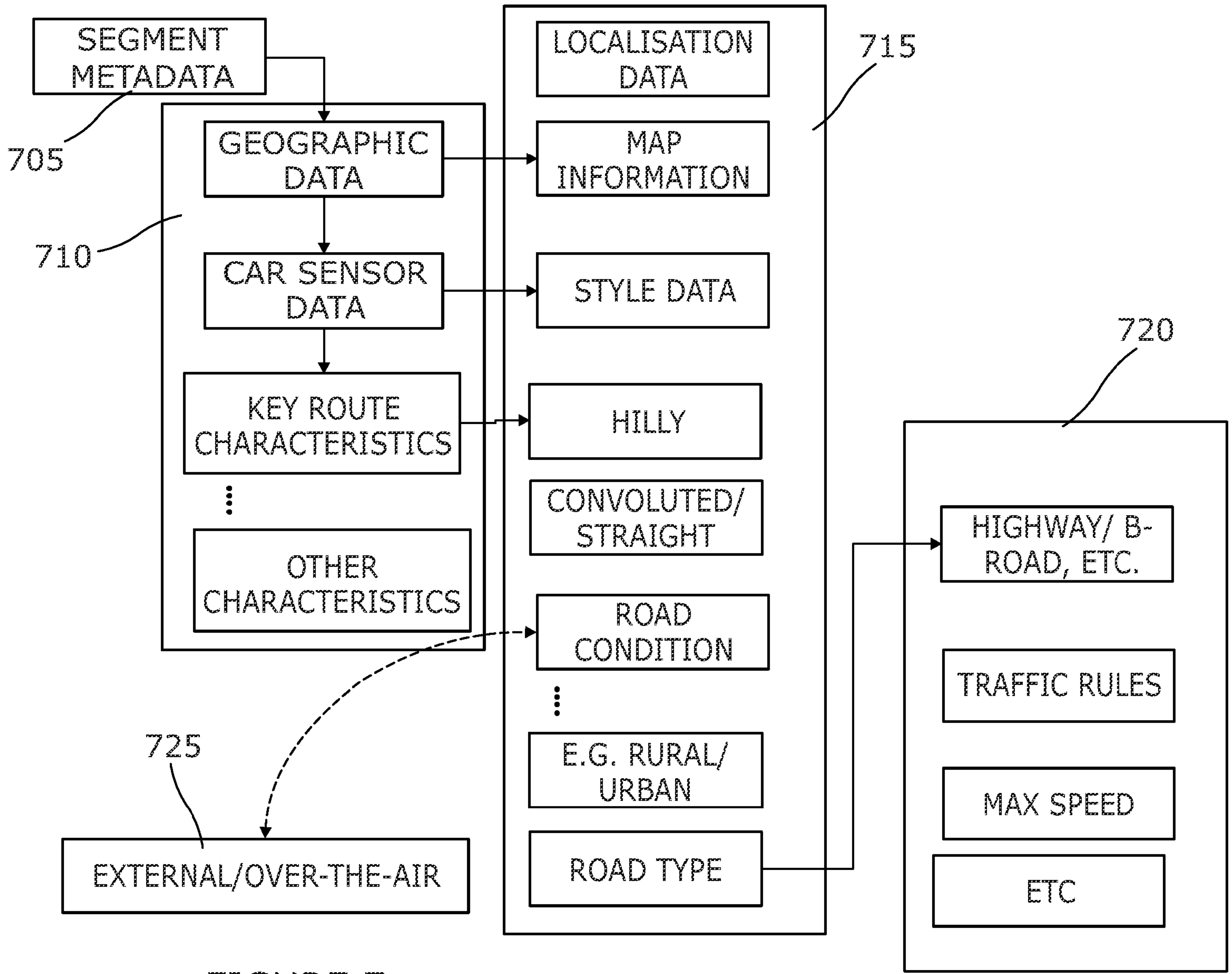

FIGURE 7

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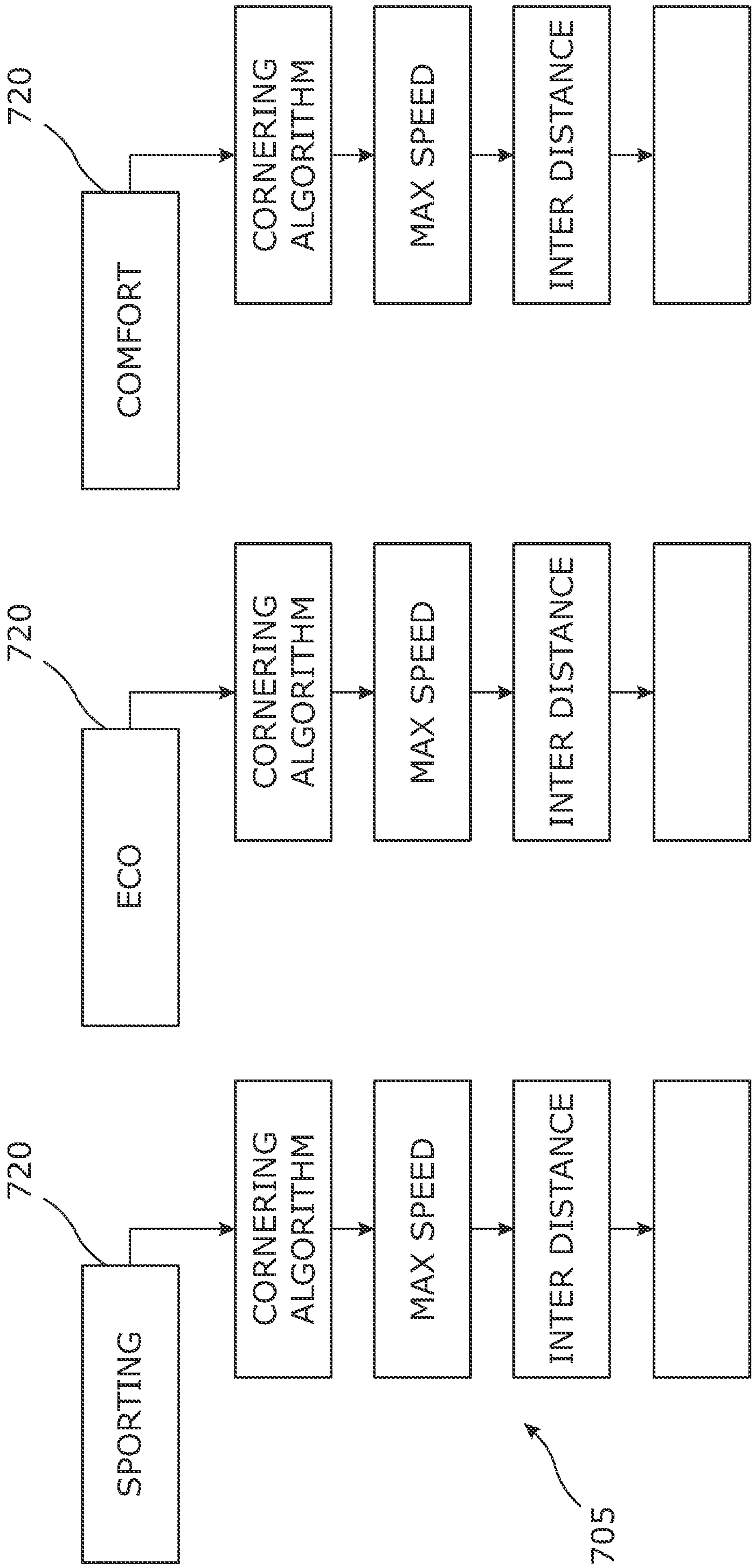

Figure 8

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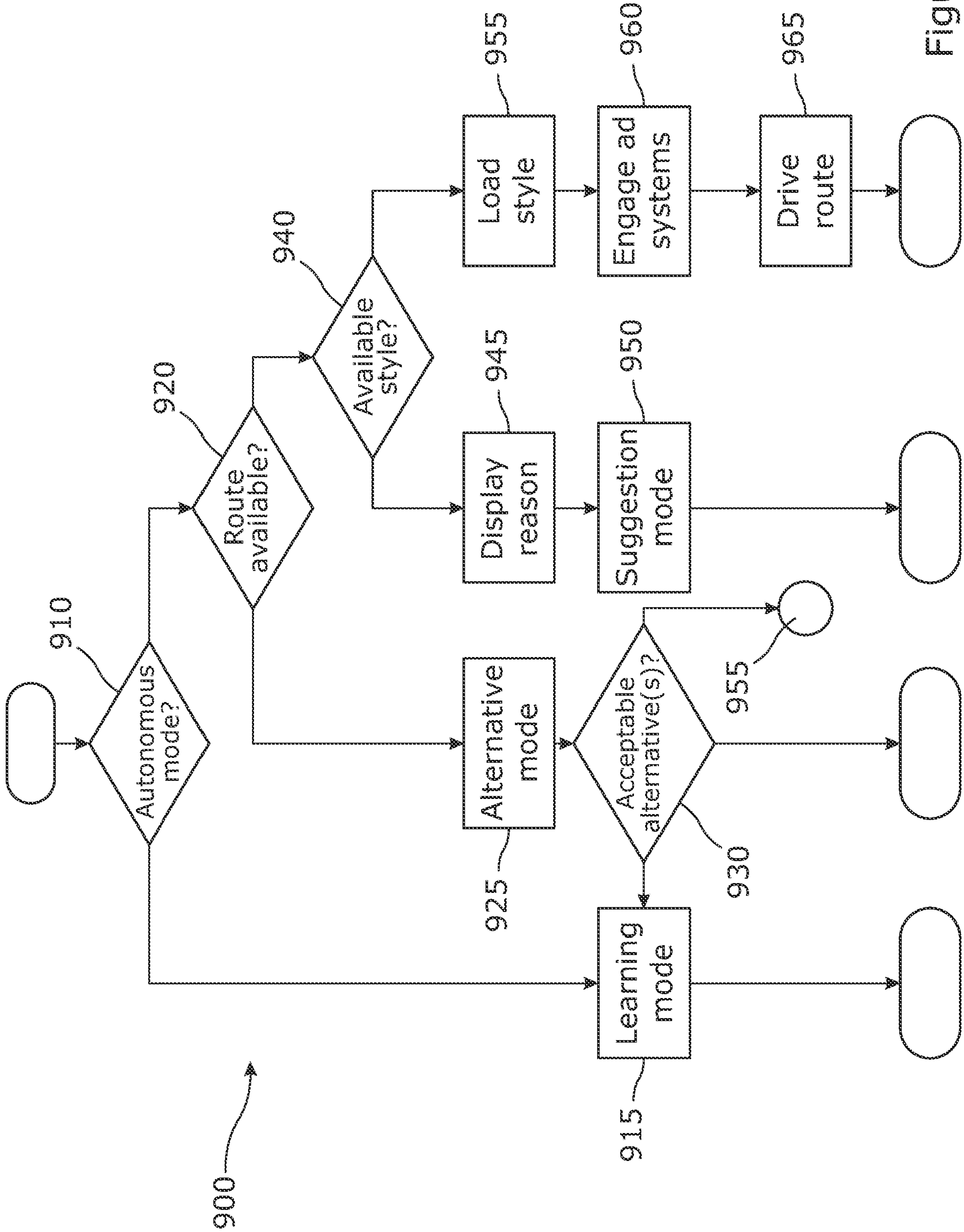

Figure 9

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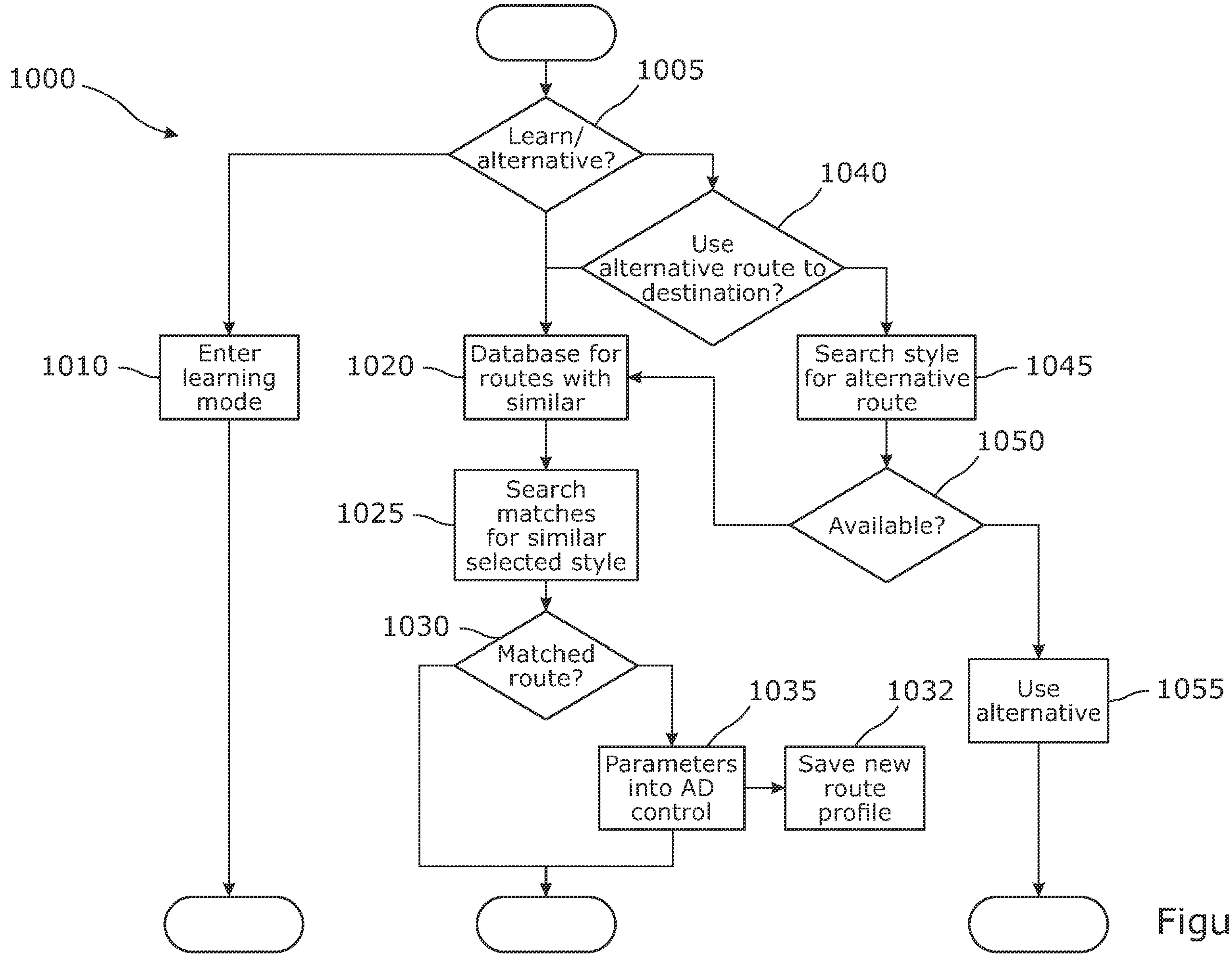

Figure 10

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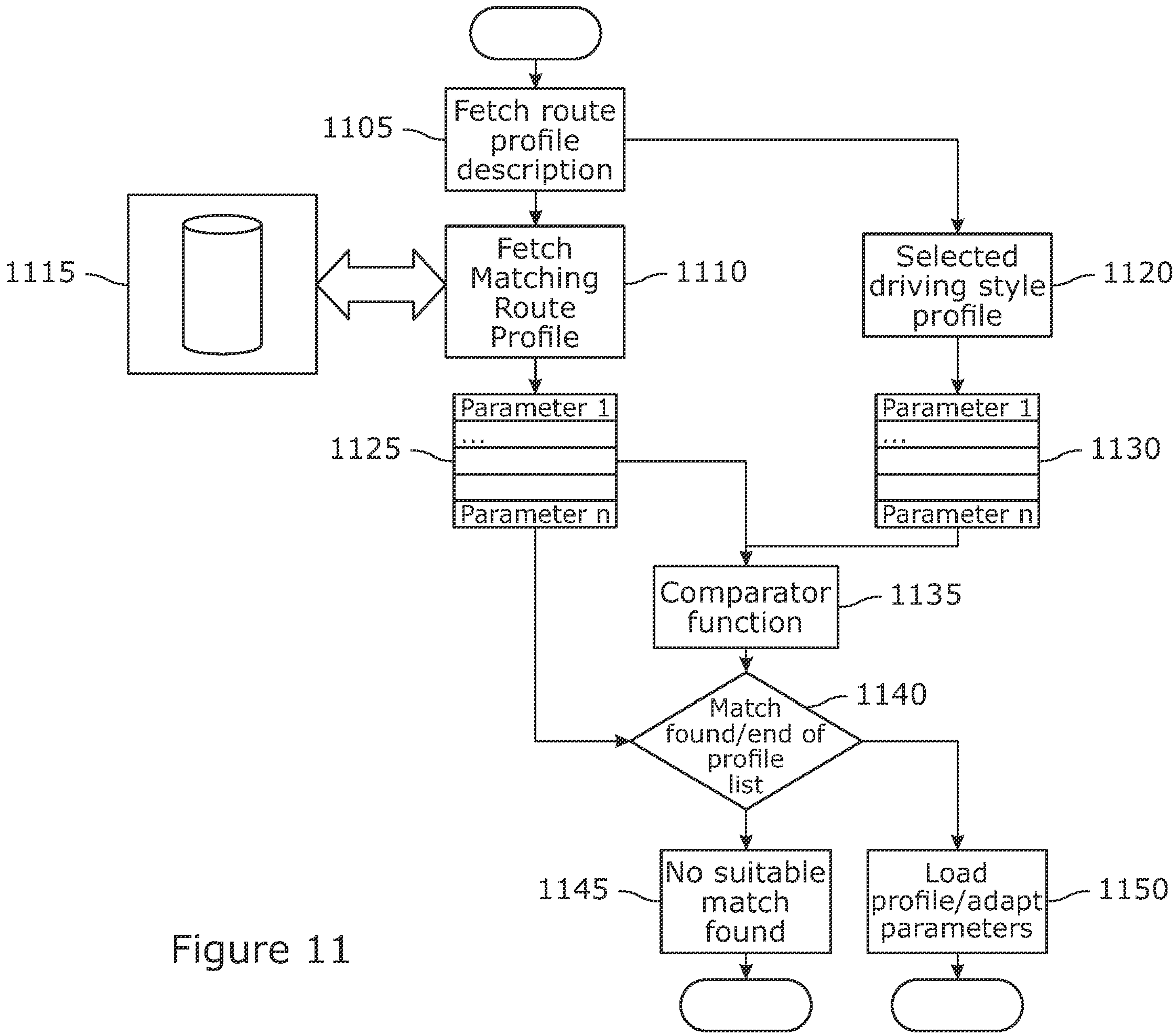

Figure 11

03 10 19

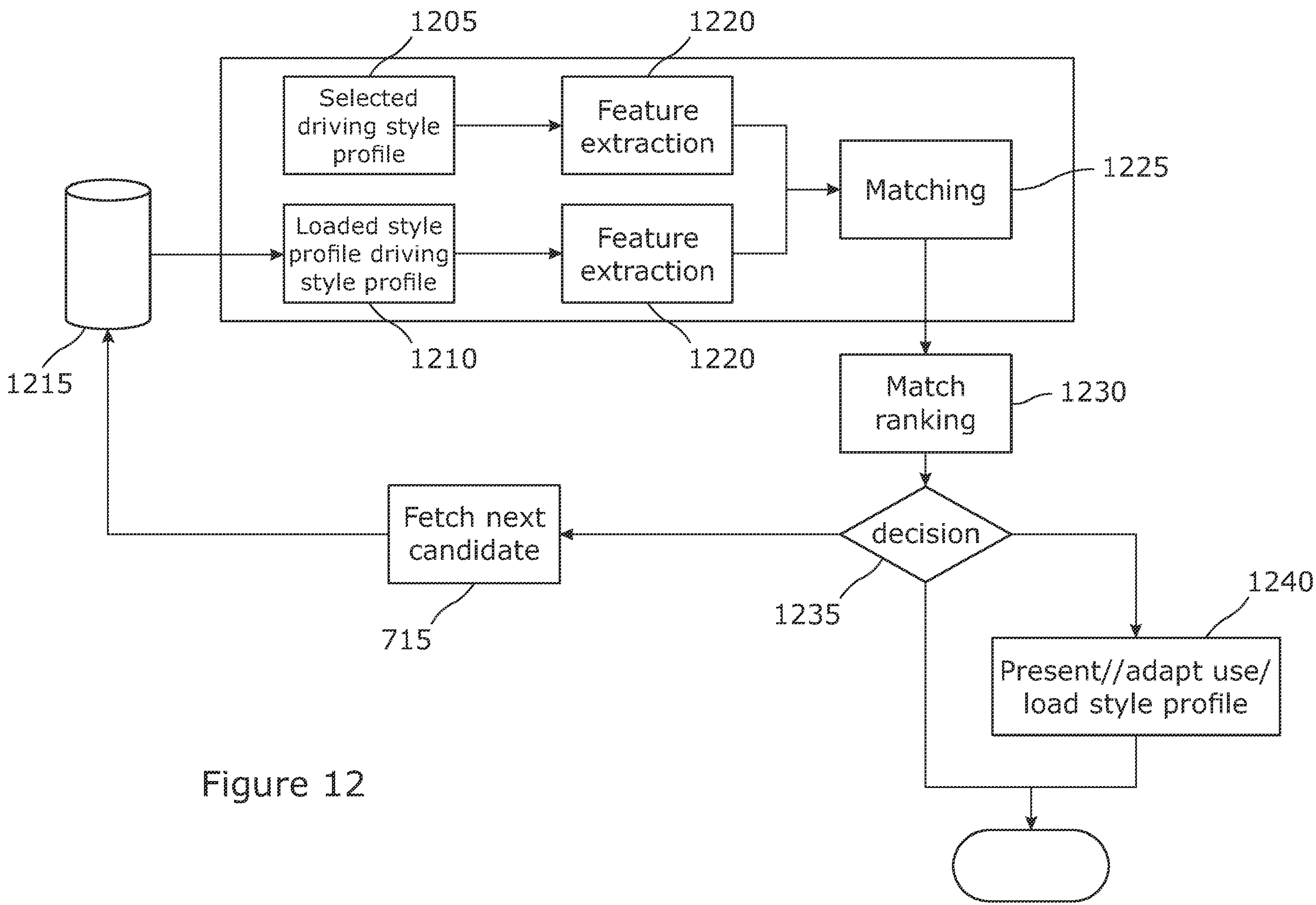

Figure 12

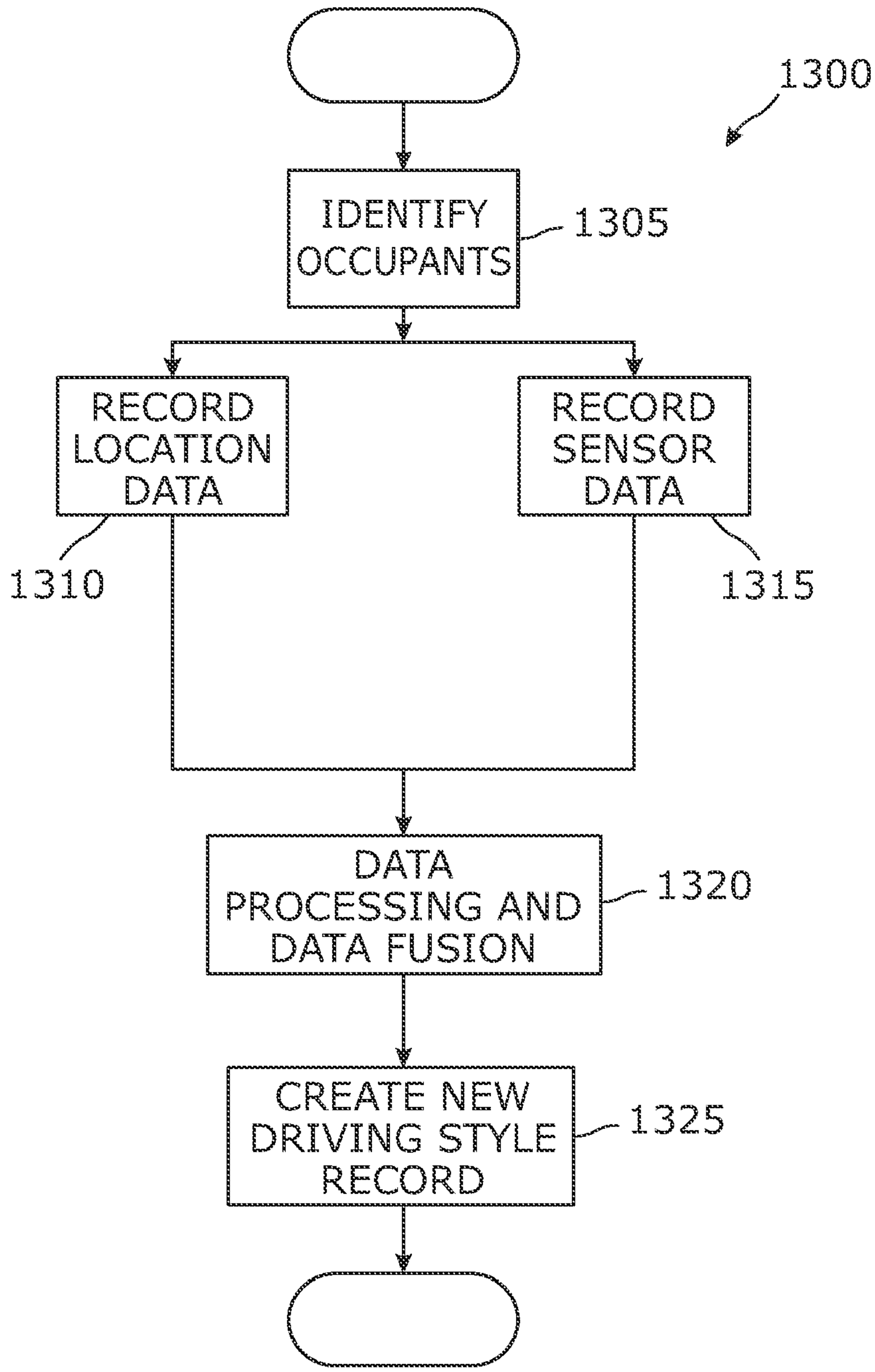
1300
IDENTIFY OCCUPANTS
1305
RECORD LOCATION DATA
1310
RECORD SENSOR DATA
1315
DATA PROCESSING AND DATA FUSION
1320
CREATE NEW DRIVING STYLE RECORD
1325

Figure 13

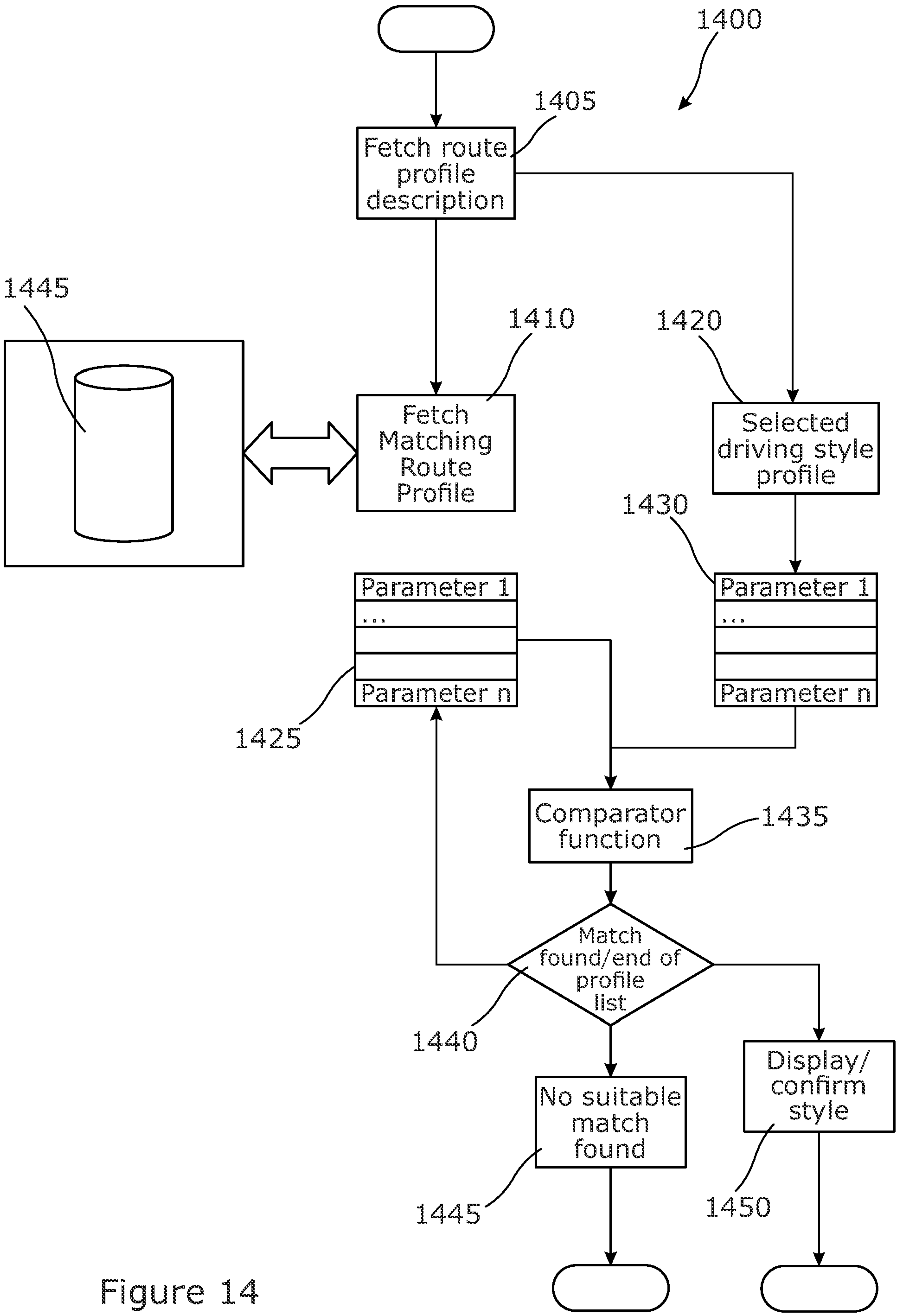

Figure 14

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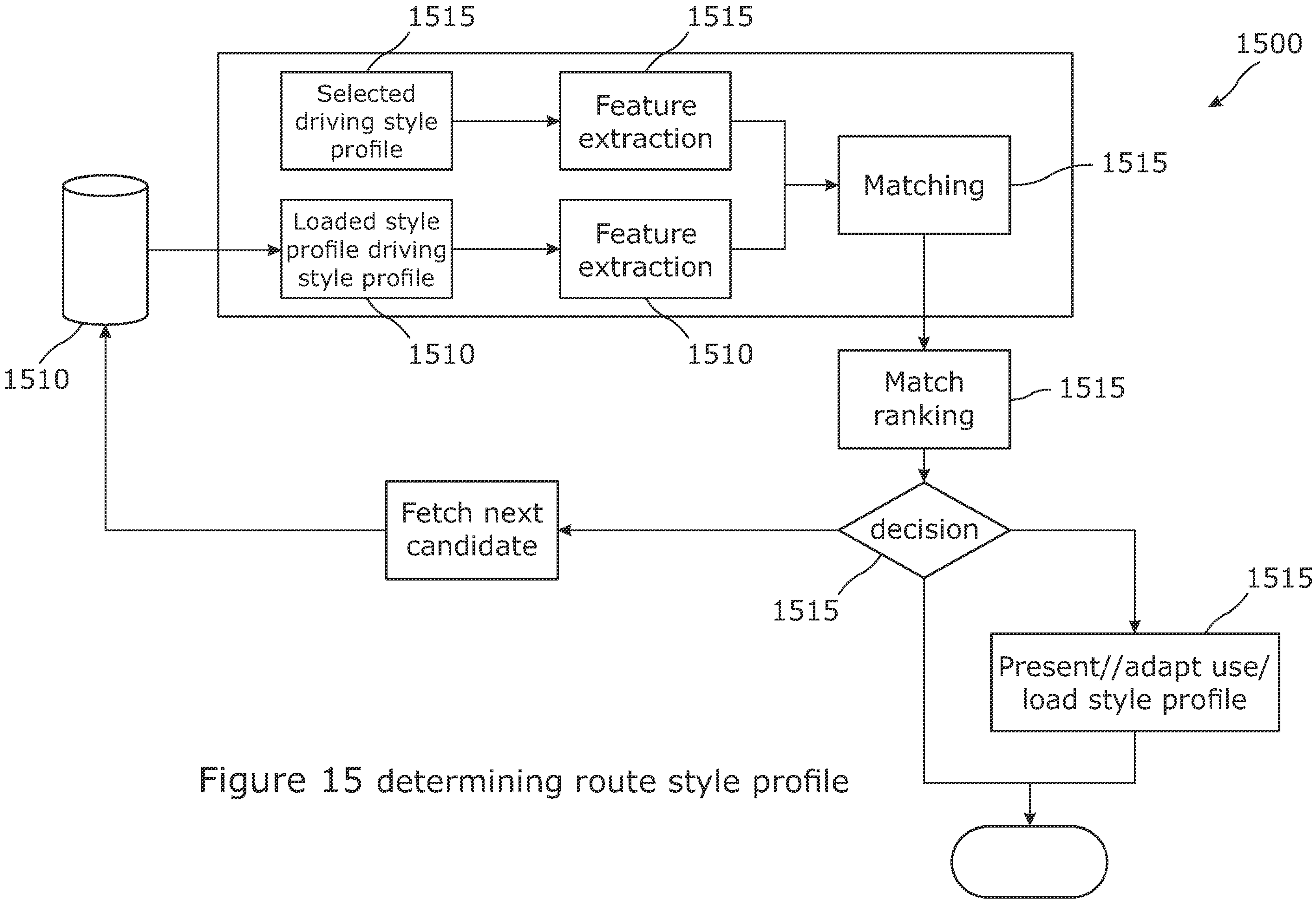
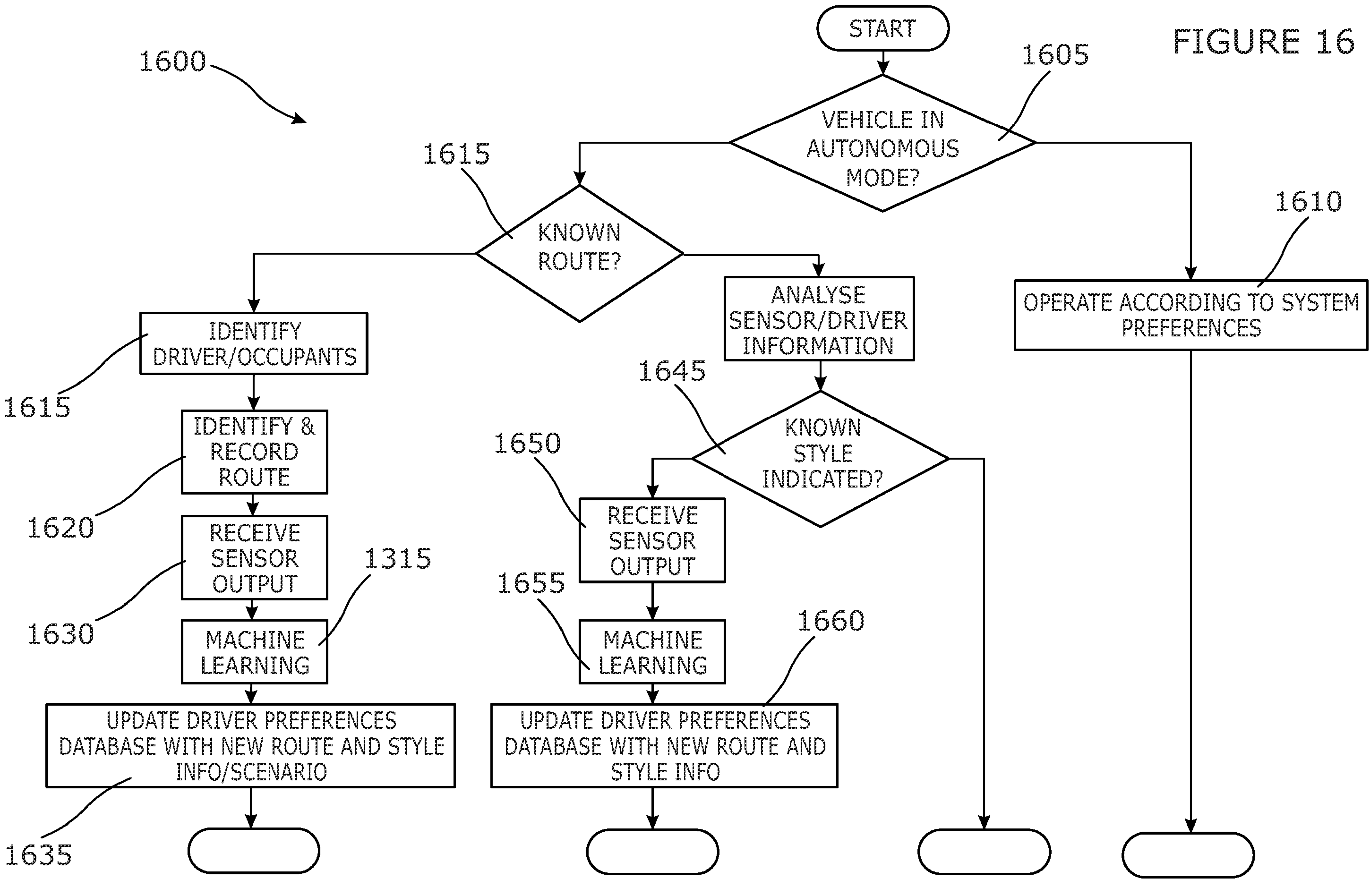


Figure 15 determining route style profile

FIGURE 16


1600
START
VEHICLE IN AUTONOMOUS MODE?
1605
1610
OPERATE ACCORDING TO SYSTEM PREFERENCES
1615
KNOWN ROUTE?
ANALYSE SENSOR/DRIVER INFORMATION
1645
KNOWN STYLE INDICATED?
1650
RECEIVE SENSOR OUTPUT
1655
MACHINE LEARNING
1660
UPDATE DRIVER PREFERENCES DATABASE WITH NEW ROUTE AND STYLE INFO
IDENTIFY DRIVER/OCCUPANTS
1615
IDENTIFY & RECORD ROUTE
1620
RECEIVE SENSOR OUTPUT
1630
MACHINE LEARNING
1315
UPDATE DRIVER PREFERENCES DATABASE WITH NEW ROUTE AND STYLE INFO/SCENARIO
1635

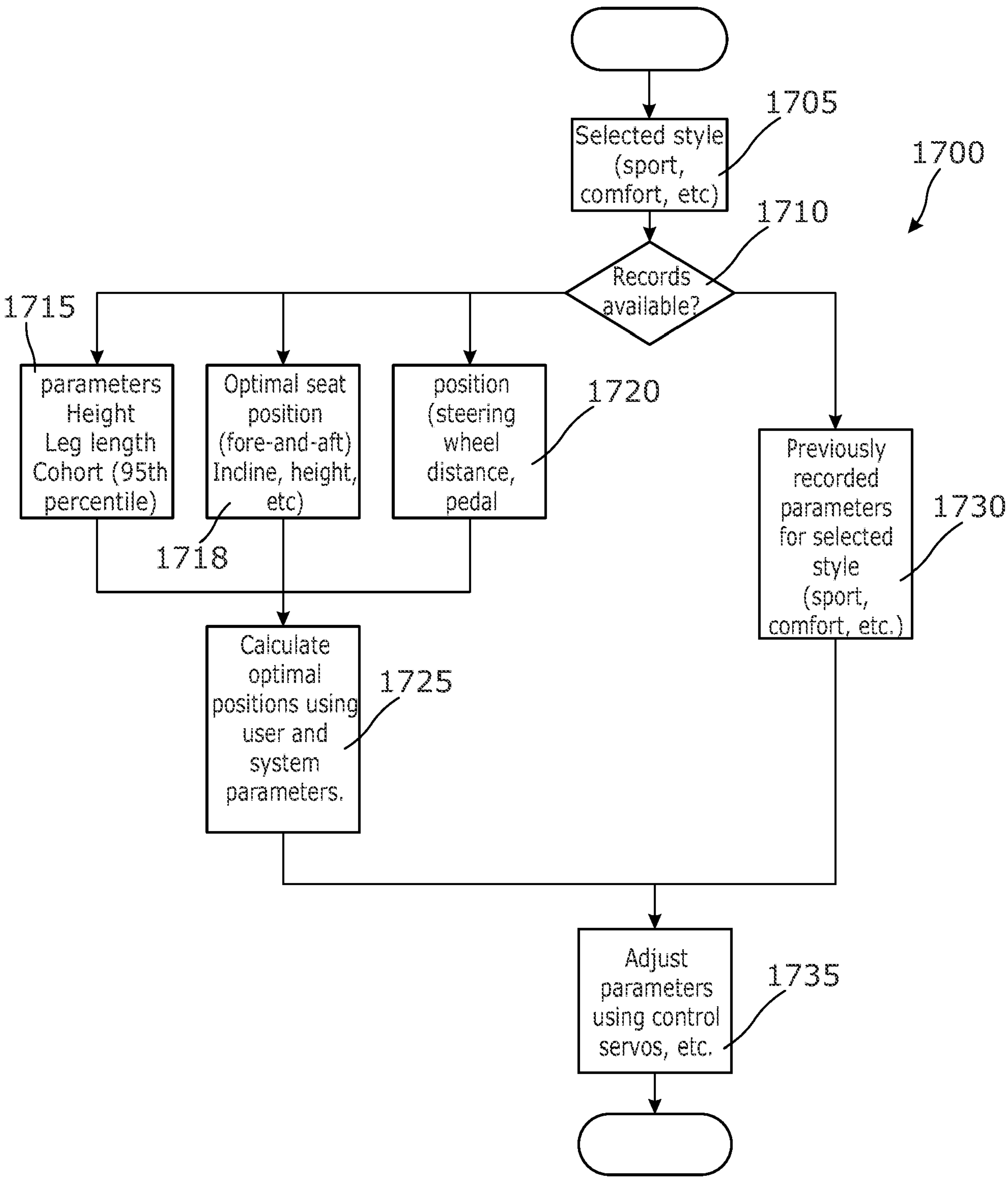


FIGURE 17

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AUTONOMOUS DRIVING MODE SELECTION SYSTEM

Technical Field

The present invention relates to a method and system for controlling a vehicle according to driver preferences. In particular, the invention relates to a method and system for controlling autonomous vehicles according to driver preferences.

Background

Autonomous vehicles (AVs) are vehicles that are controlled by automated systems that perform driving tasks conventionally performed by a human driver. For example, autonomous systems may guide a vehicle from one location to another without intervention by a human driver, negotiating a route that includes straight highways and rural roads.

The driving "style" of autonomously controlled vehicles can often feel very "mechanical" or impersonal, and produce a less enjoyable driving experience compared to human driven cars. Much research has been put into improving the driving experience of AVs, for example, controlling the trajectory of a vehicle around corners to improve comfort. An example of this is Nissan patent US9244462, which plots a more natural and less abrupt trajectory around a corner or bend in the road.

Driving "style" in this context refers to a number of parameters that may contribute to the overall user experience. Typically a large number of parameters, such as acceleration profiles, entry and exit trajectory on corners, and the like, characterise a human driver's style.

Different users may have different preferences as to how they like the car to be piloted by autonomous driving systems (ADSs). Some users may wish to be driven in a more "sport" style of driving, with more aggressive acceleration and deceleration profiles in contrast to more relaxed, or "comfort" styles of driving. Different styles may be more suitable for certain types of roads compared to others, and some styles may not be suitable for some roads/routes at all.

Other users may prefer a highly eco-friendly style of driving, which again may be a more suitable driving style for some routes compared to others.

Additionally, vehicles may encounter a number of different driving environments. A single "style" of autonomous driving may not be suitable for every driving environment on every route. Different drivers may also drive the same route in different styles at different times depending on a number of factors. The same route may be driven in different styles dependent on the driver, the time of day, or other conditions. For example, a route may favour a conservative driving style at a certain time of day, such as school hours. A route may also favour different driving styles according to weather conditions.

Different autonomous driving styles are known in this field. For example US9365218 describes selecting different styles of driving such as “chauffeur” or “race car”. It is also known to learn and emulate driving styles. However, such solutions provide relatively inflexible approaches to choosing driving style in that for each style, the associated parameters will be the same and not customised to each route to be drive, thus keeping a relatively mechanical feeling to the driving style. Known solutions take a “one size fits all” approach, providing the same driving styles applied irrespective of the route to be driven and which do not take into account other factors that would otherwise influence how a human driver would decide to drive a selected route.

Another drawback of known solutions that they do not offer a truly personalised autonomous driving experience that tailors the autonomous driving experience more precisely to the needs of the selected route and the driver preferences.

Accordingly, it is an object of the invention to provide a method of controlling a vehicle according to personalised driver preferences.

Summary of the Invention

According to a first aspect of the invention there is provided a method of controlling an autonomous vehicle according to a driver preference comprising:

- Selecting a route to be driven by the vehicle
- Receiving a selected driving style preference for the selected driving route
- Receiving route data associated with the selected route to be driven
- Analysing the route data to determine if the selected driving style exists for the selected route
- Analysing the route data to determine if the selected driving style is permitted

Wherein if the selected driving style is available and permitted for the selected route then the method further comprises the step of configuring parameters for an autonomous driving control system according to the selected driving style preference.

The method may further comprise receiving driver data and determining if the selected style preferences and or permissions should be modified based on the driver data.

The parameters defining the selected driving style may be derived from previously recorded parameters. The previously recorded parameters can be derived from previous journeys driven by a vehicle on the selected route.

The previously recorded parameters may be derived from previous journeys driven by a vehicle on routes other than the selected route.

If the selected driving style preference is not available or permitted for the selected route then the method may determine alternative driving style preferences.

The alternative driving style preferences may be based on the current route data and driver preferences.

The method may provide alternative driving style preferences for the selected route by:

> Selecting a first group of available and permitted driving styles based on the route data;
> Selecting a second group of available driving styles based on driver preferences, and suggesting driving styles from the intersection of the first and second groups of driving style.

This advantageously allows the method to look up all the available driving styles for the current route to be driven, and find a driving style that best matches the preference selected by the driver. This means that even if the originally selected style is not available, the method can suggest another style that might resemble it and is available to be used on the route. As the available styles are based on route specific data then the experience remains highly personalised.

The suggested driving styles may be based on best match between the driver preferences and the available and permitted driving styles for the selected route.

The best match may be calculated by comparing parameters between the driver preferences and the available and permitted driving styles for the selected route.

The best match calculation may be carried out using a neural network by comparing extracted features of the selected driving style with extracted features of the driving styles form the first group.

The route data may comprise: map data for the route, feature data for the route, driving style data associated with route.

The route data may also comprise current or predicted environmental conditions.

The route data may also comprise current or predicted traffic conditions.

The method may further limit the group of permissible driving styles based upon environmental conditions such as: time of day, weather conditions, and traffic data. For example, fog, snow, rain, congested roads, accident, lane closures, etc.

The suggested driving style preferences may be based upon at least one of: Driver preferences, vehicle resources (fuel, battery, etc.), environment variables. Thus if sport style not available then suggest normal, or if normal not possible then eco, etc. Thus if weather is rainy then suggest slower/safer mode of control.

The method may further comprise suggesting alternative routes where the selected style preference is available and permitted.

The method may further comprise determining style preference options based on the vehicle driver and/or vehicle occupants.

The method may further comprise restricting driving style preference options based on any of: vehicle driver information, vehicle occupants, and passenger data.

For example, if infants are in the car, then access to certain styles of driving such as “sport” are restricted.

The method may further include restricting available style based on temporal data and associated restrictions. For example night/day/ driving restrictions, or other restriction such as weekday speed restrictions on roads close to schools, etc. Route parameters such as Max Speed may vary considerably during different times of the day.

The method provides advantages over known systems because it can determine if a driving style is possible for a selected route. It can suggest the best match between a driver’s preferences and the most suitable driving parameters for the route to be driven, taking into account other factors, e.g. anything that may affect safety.

The method also provides advantages in that it can suggest suitable driving styles for the route to best match the desires of a driver, even if a particular choice is not available, or is not suitable at that time for that route. The driving styles can be based on how the route has been driven in real life rather than a “one size fits all” approach, providing a more human-like feel to the autonomous driving experience. This type of route data can be derived from how the present driver has previously driven the selected route, or, for example, from other drivers who make their driving data available for others to use.

By providing a number of parameters to check against, the system can maximise satisfaction and safety for a given situation, and further may take into account who is in the vehicle. This makes the system very flexible, maintaining user satisfaction and safety.

According to an aspect of the invention there is provided a method of adapting driver style preferences for a first route to be used in a second route.

Advantageously, different routes can be compared to identify similarities and decide if a driving style for a first known route can be used for a second unknown route – that is, adapting known styles for routes that either have not been driven, or have not yet been driven in the selected style. This can be done by comparing route data for a first route with route data for a second route. If the routes are judged to be similar enough then driving style preferences can be substituted for the new route.

For example, if the route permits, the ADS can apply a more “sport” style to navigating bends in the road may be applied. More aggressive acceleration/deceleration profiles may be employed. For example, if the route is judged similar to another eco-style driven route, then suitable eco-friendly driving style parameters may be applied. For example, the method can employ battery conserving or hypermiling techniques to extend range of an electric vehicle.

Further advantages include that the route can be driven in styles that it has not previously been driven. Different autonomous driving systems may navigate the environment in different ways, e.g. some rely on data previously gathered for the route and use the recorded data to assist navigating a route successfully whereas others rely on pure GPS data.

The method includes analysing a first route where the selected style data is not known, then searching a database of routes to identify routes with similar route metadata to the first route, creating a matching driving style for the first route.

If a matching route to the first route is found then the method further includes the step of using parameters from the matching route for creating style parameters for the first route.

In this aspect the method may include providing driving preference parameters where no driver style preference previously exists for the selected route by providing the further steps of:

Analysing metadata for the selected route and searching other route metadata to identify if there is a route with matching metadata that has suitable driver style preferences; and

If a match is found then the matched driving parameters are loaded into the autonomous driving system to control the driving style for the selected route.

The metadata may include number of junctions, max speed, gradients, road conditions, weather conditions, and traffic data, number of bends / corners and distance between such features.

This allows parameters to be matched to a new route to arrive at a best match for existing conditions. This approach allows a route to driven in a different weather conditions from when it has been driven before.

For example, if a route with matching identifying traits (such as hilly etc., or conversely long flat straights) is found then the method may apply driving style parameters to other routes. The driving style parameters may include e.g., max speed, or cornering algorithms that control the car's trajectory around a corner.

Advantageously, this means that driving data for similar types of road in similar conditions may be used, e.g. max speed for a winding country road, or driving a similar route but in wet weather and applying suitable wet weather driving style to the unfamiliar road.

According to an aspect of the invention there is a provided a method of controlling a vehicle wherein the vehicle driving style can be modified according to the occupants detected in the vehicle.

The method includes providing parameters for controlling an autonomous vehicle comprising:

Detecting occupants in car

Determining compatibility of occupants with a selected driving style preferences

Modifying the selected driving style based on the compatibility of the occupants with the selected driving style.

The method may include restricting available styles depending on the occupants of the car.

The method may flag route data as unsuitable / unavailable for the journey depending on analysis of the vehicle occupants. The method may further include suggesting alternative styles and/or routes that are suitable. Choosing alternative routes and or styles can be carried out using the aforementioned methods of suggesting alternatives to a selected driving preference.

Each vehicle may have associated with it a system account listing system privileges. Each account may have at least one administrator. Each administrator may select restrictions on available driving styles.

In another aspect there is provided a method of deriving a driving style model for use in a method of controlling an autonomous vehicle according to driver preferences.

The method comprises monitoring a route being driven and recording and processing associated route data, including the steps of:

- Collecting location data
- Collecting data related to road characteristics
- Collecting car sensor data
- Linking the collected data
- Analysing the route data and identifying key characteristics of the route in order to classify the route
- Creating a driving style model for the route suitable for use in controlling an autonomous driving system, the model comprising route data and metadata required to control an AV.

The route data may include GPS data, map feature data, and route metadata such as max speed data, temporal restriction data and the like.

The route data may include traffic and road condition data.

The car sensor data may include optical camera data, LIDAR data, RADAR data

The car sensor data may include position data. The position data my include GNSS data. The position data may include dead reckoning data, odometer data gyroscopic data.

The car data may further include vehicle dynamic control data such as steering, braking and engine throttle data.

The step of creating a driving model may include analysing the data and linking features and events between the different lists of data, classifying the data according to preset values, and creating a list of parameters associated with the route.

The collected parameters from different sources may be linked to position data.

The data can be classified according to driver specification.

In one aspect the method classifies the route using machine learning.

The route style can be classified using a neural network has been trained on at least one set of data obtained over the same route.

The route style can be classified using a neural network that has been trained on at least one set of data obtained from the same driver.

In another aspect there is provided a training dataset for use in training an autonomous driving system, the training dataset comprising a set of labelled route segments that have been labelled by analysing sensor readings of a vehicle while it is driven on a route, and associating the results of the analysis with a driving style.

A method for training a driving style identification model, comprising:

- Obtaining a training dataset comprising vehicle sensor data and vehicle position data and driving style identification labels;
- Extracting a set of training features from the training dataset based upon the sample vehicle location points, the set of training features indicative of driving style; and
- Training a driving style identification model using the set of training features and the driving style identification labels to create a trained driving style identification model for identifying driving styles based upon vehicle location data and related vehicle sensor data.

The method further comprises:

- Obtaining a dataset comprising vehicle location points;
- Extracting a set of features from the dataset based upon the vehicle location points, the set of features indicative of driving style; and
- Evaluating the set of features using the trained driving style identification model to determine whether a road segment has a characteristic driving style.

The method may further include:

- Obtaining data from a vehicle driven through an environment, the data comprising:
- Vehicle telemetry matched to route information;
- Environmental data; and

A further step of labelling route segment features, wherein vehicle telemetry and vehicle sensor data is matched with each route segment feature to produce a database of driving parameters for the route.

The route and telemetry data may include: Overall route speed, Max speed for route and route segments, number of corners in the route, number of straight runs in the route, and environmental data such as country/urban.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows an autonomous vehicle system in accordance with an embodiment of the invention;

Figure 2 shows an autonomous vehicle in accordance with an embodiment of the invention;

Figure 3 shows aspects of autonomous driving system in accordance with and embodiment of the invention;

Figure 4 shows a driving route and related information;

Figure 5 shows a method of recording metadata associated with driving style in accordance with an embodiment of the invention;

Figure 6: shows an example method of recording metadata for a route for use in recording driving style preference for route;

Figure 7 shows a model for providing autonomous driving control data for a route with related metadata, in accordance with an embodiment of the invention;

Figure 8 illustrates a top level view of metadata associated with different driving styles;

Figure 9 a method for selecting a driver preference of controlling an AV in accordance with an embodiment of the invention;

Figure 10 selecting a driver preference of controlling an AV when route has not been driven previously, in accordance with an embodiment of the invention;

Figure 11 illustrates a method for finding different route with similar usable parameters in accordance with an embodiment of the invention;

Figure 12 illustrates a scheme for using neural network to find different route with similar usable parameters in accordance with an embodiment of the invention;

Figure 13 illustrates a scheme for a learning mode for an autonomous driving system in accordance with an embodiment of the invention;

Figure 14 illustrates a scheme determining route style profile in accordance with an embodiment of the invention;

Figure 15 illustrates a scheme for determining route style profile in accordance with an embodiment of the invention;

Figure 16 shows a method for learning a driver preference for autonomous driving in accordance with an embodiment of the invention;

Figure 17 shows a method for adapting driver comfort position to a driving style in accordance with an embodiment of the invention;

SPECIFIC DESCRIPTION

The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the invention may be practised. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilised, and structural changes may be made without departing from the scope of the invention as defined in the appended claims.

The systems and methods described herein may be used with any vehicle capable of operating partially or fully autonomously, or some combination of both.

The term "driver" may generally refer to any occupant of an autonomous vehicle seated in the driver's conventional driving position, and who operates the controls of the vehicle while in a manual mode, or alternatively provides control input to the vehicle while in an autonomous or semi-autonomous mode operate the vehicle.

Additionally, as used herein, the term "passenger" generally refers to an occupant of an autonomous vehicle who passively rides in the vehicle without contributing to operating the vehicle.

Referring to Figures 1, 2, and 3 there is shown an example of a vehicle 10 with an embodiment of an autonomous driving system (ADS) 15. The vehicle 10 may be any suitable vehicle adapted to be controlled by any suitable ADS.

In the illustrated example, the ADS 15 comprises but is not limited to, autonomous driving control 20, dynamic control 25, autonomous driving (AD) sensor package 30, HMI 35, and communications and connectivity means 40.

In the example illustrated in Figures 1, 2 and 3, the ADS 10 and communications and connectivity means 40 may be used to connect various external resources and modules such as cloud based storage and processing means 60, and may include dedicated server storage/database and processing means 70, 80. The connectivity means 40 may also allow communication between other vehicles 90, either as individual vehicles or as a fleet, and access to traffic control or data resources 92, as well as security resources 94.

Also shown are users 100 who may be the drivers of the vehicle, and sundry mobile devices 105 that may be used to interact and/or control the system.

The components of the ADS including the autonomous driving control means 20, dynamic control 25, AD sensor package 30, HMI 35, and connectivity means 40, along with the other illustrated modules and components that are coupled to each other by known means such as control and data buses (not shown). The use of such control and data buses to enable communication would be known to the person skilled in the art and may either wired or wireless as needed, or as is fit for the purpose at hand. For example, connection to the cloud resources 60, and or server 70, may be through any suitable Wi-Fi protocols, or other communications protocols such 3G, 4G, 5G. Blueooth™ protocols may also be used where appropriate, for example especially for short range communications within the body of the vehicle.

The illustrated modules may be implemented as separate, discrete modules or integrated together, excluding or combining some components or modules. It will be apparent to the skilled person that functionality of each module may be implemented within a computing means such as combinations motherboard, CPU, and memory or as discrete, or as specialised units, for example custom application-specific integrated circuits (ASICs) or the like.

Figure 3 illustrates the on-board ADS 15 in more detail.

The ADS 15 may comprise localisation means 305, perception means 310, action planner 315, and controller 320. The ADS 15 may also have on board map records 325. The maps 325 may additionally be supplemented by off board maps, accessed via the cloud, web, or server, or be stored in permanent means on-board the vehicle. The map may be updated online via cloud, or any other means of update either over the air or by manually updating, e.g. through means of installing a memory card.

The controller 320 may comprise an electronic processor, memory and input/output interfaces to enable it to process signals from other modules, store data as needed, and output signals, data, and control information as required to meet the requirements of the ADS 15. The memory means may include means to store data on a permanent or temporary basis by any a suitable means, either on-board, e.g. RAM, SD card, any suitable electronic or optical storage device. Additionally, storage may include off-board means, e.g. cloud storage.

The controller may include means to read and write data, and to execute software required to provide ADS functionality and to perform any of the operations required to for performing the methods describe herein. Conversely, software functions may also be performed wholly or in part off-board, for example on a cloud based platform, or otherwise server side to enable ADS functionality.

The AD control controls the vehicle dynamic control systems 25, sensors 30, connectivity means 40, and human machine interface (HMI) 35 to autonomously control the vehicle according to the methods described herein.

AD control 20 provides signal input to the vehicle dynamic control 25 to enable the car to be controlled, that is, to drive the car in autonomous/semi-autonomous mode as needed. The dynamic controls 25 may include but are not limited to control systems for steering, braking, and engine throttle. Additionally, such modules may provide feedback to the ADS 20 about the operation of any of these control functions. Such feedback may be recorded either on-board or off-board.

The on-board system may comprise a sensor stack 30 providing a suite of sensor modules to assist the autonomous driving experience.

These sensors may include but are not limited to: optical meals (e.g. camera), LIDAR, RADAR, global navigational satellite system (GNSS). It will be understood by the skilled person that other sensor systems not listed may be used where appropriate to provide input to the ADS 20 to enable the ADS 20 to control the vehicle 10.

It will be understood by the skilled person that GNSS may refer to any suitable radio positioning system such GPS, GALILLEO, etc.

Additional means 340 may provide telemetry data about the car. Such telemetry may include but not limited to velocity, acceleration, yaw, yaw rate, lateral acceleration, and other data about the position, pose, and other telemetry related data.

The various data generated by the aforementioned sensors may be recorded, processed and otherwise analysed to provide information about how car is driven over route by a driver.

Figure 4 shows a route AB 400 driven or to be driven by an AV according to embodiment described herein.

The illustrated route starts at point A and finishes at point B. the route may be divided into route segments. For example, a route may start at a driver's home (i.e., the starting point), and proceed to desired point B, and comprise smaller sub-sections, e.g. segments a, b, c, d. Different segments 405 may have different characteristics, and can be assigned different driving styles.

The present described ADS can record metadata 410 and vehicle data 415 bout a route, so that it can be used at later time to control a car autonomously.

AD systems can be broadly defined in two ways: the first kind may use GPS plus other localisation systems to guide a car through a series of waypoints, using control systems to monitor and control the car between the waypoints. Another type of system may use pre-recorded route information, including GPS records and visual records of the recorded route, and the car is essentially guided along a pre-recorded path to get from point A to point B.

The current system for implementing driving styles as described herein may be applied to both kinds of AD systems.

In order to apply a driving style to control how a route is driven by the ADS, the ADS should have data about the route, i.e. metadata that provides information on how the route should be driven. Such metadata can include maximum speed limit for a stretch of road, best path, acceleration and deceleration profiles for bends in the road, and other such control information. This metadata can be accessed in different ways, to be described later, but the driving style metadata must first be recorded for the route to be driven, or as described later, for a route that can be accurately compared to the present route to be driven.

For example, if a driver has already driven the route AB, the ADS 20 can use the data previously gathered on that driving route to replicate the original driving experience by simply replaying and following the location/ speed, and other control data. Alternatively, this route can be experienced by another driver using the system to access the route driving style data.

Figure 5 shows the basic process to record the route data and metadata for use in the present described AD system. The route is driven by a driver using the system described herein, and route data is recorded 505. This can be GNSS data, and other position data.

Sensor data, for example form the vehicle sensor stack 30, can be recorded 510. Step 520 to analyse the sensor and other data. This analysis may be carried out on-board systems or alternatively of-board, e.g. via cloud computing resources.

When a car is driven on a new route, or on a route in a previously unknown style, the ADS can learn that route and associated driving style by recording information about the route. This new route and or/style may then be replicated when it is driven in an autonomous/semiautonomous mode.

For example, while travelling route AB illustrated in Figure 4, the system may record GPS position data so that the ADS can use this recorded data to guide the vehicle along the route at a later date. It may also record speed, etc. as it travelled the route, and apply these parameters to control the car as it is once again being driven along the same route. Additionally, it may apply other metadata to control the car. For example, the car may have been driven with specific way of handling corners or hill on the route. ADSs often have built in algorithms to control how they handle such route features. For example, specific path following algorithms may be used. These are often optimised for driver/occupant comfort. However, the system may have recorded a route that was driven in a more aggressive approach was used by the driver, and the cornering data etc. can be analysed and a different algorithm used to pilot the vehicle accordingly in this style. This helps to replicate the feel of the original approach of how the human driver navigated the route.

The system can extract, analyse, and process data to produce all the necessary data need to replicate driving styles 530. The driving style learning process is described in more detail below.

Once a route has been recorded and processed the results may be stored locally on-board or uploaded to cloud means 60 or other suitable external storage. It can also be held on server for sharing among suitably authorised users of the system. Thus, driving style data for routes can be shared among drivers.

Figure 6 illustrates collecting data for analysing and recording the driving style for a given route or route segment.

In this example a car 605 is driven along the road 610 by a driver. Data 620, 625, 630 is collected at time intervals t1, t2, t3. Position data can collected, for example, GPS coordinates, as well as other telemetry such as pose (angular orientation). Other car sensor data can be gathered. In this simplified example the speed, acceleration and yaw (angular acceleration) are measured. These can be recorded and or analysed and processed to provide metadata about the route.

Different styles will have different profiles. For example, a “comfort” style will have a different speed profile for a more “sport” style. Similarly, acceleration and lateral acceleration for cornering will be different.

The type of data that can be collected can be anything that the car sensors collect, including data from the engine control unit (ECU) and other similar electronic control units that the car may use. Such control unit data may include information about engine throttle, braking, steering wheel angle, gear control launch control, engine revs, exhaust flow control, accelerometers, occupancy detectors, suspension settings, and the like. Additional information about the car state can be used such as vehicle mode. Many cars have built in modes such as sport, comfort, wet etc. which may enable/disable certain functionality in a vehicle such as traction control, ABS. This information can also be recorded.

Different driving styles may produce different data for the same route, and this data can be recorded and processed to provide the style data for the ADS to replicate the driving style.

For example, if the route is driven in a “sport” style then a higher than average speed may be expected. Gear shifting may be more “aggressive”, and cornering will be faster and more aggressive. By measuring car operating parameters the system can record a driving then use metadata to “play” the style back when it has been chose for that route. Alternatively the metadata may be used to modify parameters of autonomous / semi-autonomous systems.

This recorded data can simply be replicated for the route, using a playback style of ADS that follows the recorded GPS and engine and other control parameters to pilot the car. Alternatively, the data can be analysed to provide general operating parameters for other styles of AD system, for example, to use a “sport” style cornering algorithm on the corner rather than a comfort based algorithm. Such a style will have more aggressive acceleration/deceleration profile compared to comfort styles. The recorded data can also be analysed to determine a driving style, detailed below.

Additionally, other data for the route may be collected. For example weather data can be collected. This is useful as the car can be piloted safely according to known style for driving the route in the, e.g. the wet, or snow, or other weather conditions. Weather data can be used to restrict access to certain types of driving style. A sport style may be restricted to dry conditions only.

Road conditions can also be recorded. For example, if the road is in bad condition then this will affect how it can be driven.

Figure 7 shows an example of how route data can be recorded for later use in an autonomous driving system according the system described herein.

Different types of data can be recorded and associated with the route. Data fusion means (not shown) can be used to associate the data with the route features and/or position data. Additionally, metadata of the route can be produced for use by the ADS.

For example, analysis of the route data can determine what style the route was drive in, and label it thusly. Such labels may be later manually modified, to correct the label or adjust to the taste of the user. Routes, or route segments can therefore be labelled with different styles. Alternatively a record route can be classified by the relevant driver. The method of determining the driving style is described in more detail below.

As can be seen different descriptors help categorise the route, such as hilly, convoluted (many bends in the road), and traffic and weather conditions can also be included.

The system may monitor other variables such as maximum speed (max speed) allowed on the route or route segment, and any traffic rules that must be obeyed. This data helps parametrisation of the AD system. This in turn helps the system choose suitable alternatives for when a specific route driving style is unavailable, the method of which is also described below.

Figures 7 & 8 show how this data and metadata may be utilised in an ADS to generate a model that can be used to apply a driving style to a route.
In these examples metadata for route or route segment 705.

It will be clear to the person skilled in the art that the arrangements in Figure 7 & 8 are for illustration only and other arrangements may be made to record & store the data , and other data than that shown, may be recorded.

Various categories of route data 710 can be recorded, for Example geographic data about the route (GPS points, route features, etc.) ca sensors data (acceleration, pose, etc.), key route characteristics (hills, gradients, convoluted versus straight), and other characteristics.

This can be broken down into more detailed categories 715 including localisation data map information (any relevant route features) road conditions, route type, (rural, urban), and include relevant road data 720 with restrictions, traffic rules and regulations that may apply to that route or route segment.

For each style type there may be further associated control options, as shown in figure 8. In the example shown, each style 810 (sport), 815 (ECO, 820 (comfort) has associated with it parameters controlling different aspects of used to control the car. For example, the cornering algorithm that plots trajectory for corners and bends in the road will be different between sport and comfort style of driving. Other examples are explained below.

Different driving styles will have associated with them parameters defining how the ADS controls the car. As explained, cornering style will differ from one style form another. The average max speed of the car will differ. Some styles may dictate that the “inter distance” or distance between the piloted car and the car in front of it will be different.

A standard driving style may have no special setting that personalise how the car is piloted in autonomous/ semi-autonomous modes. For example, the car will have an algorithm about how to plot a trajectory around a corner. A sport driving style will have a more aggressive cornering algorithm, while a “comfort” based style will have an algorithm that ensures a gentler trajectory around a bend.

The ADS will note the Max Speed limit for a route or route segment and base speed calculations for how fast it should or can travel based off this number, along with other variables. A “comfort” style may set the Max speed parameter lower, while still adhering to legal guidelines and regulations, as well as adjusting braking parameters to ensure a smoother ride.

In another example of how the metadata may be used in piloting autonomous vehicles, a car can record that a turning was taken was taken at appreciable percentage of the max speed allowable for the route segment. The acceleration profile for the route segment may be aggressive, with high rate of attack early, then quickly decelerating at the end of the turn of very a short space of time. This indicates a “sport” style of driving that segment route, and AD control parameters can be modified accordingly.

Alternatively, the acceleration can be less harsh, and the same for deceleration. This produces a different profile, which may be labelled “comfort”. Different degrees can be labelled allowing a number of styles, e.g. conservative style where only lower max speeds are allowed.

Other key route characteristics may be recorded. Temporal and geographic restrictions can also be put in place. For example, from the route metadata the ADS will not allow sport of other higher speed modes to be used in certain urban settings, and may invoke or suggest modes when entering specific traffic zones, e.g. near schools, where the speed limit may vary with the time of day.

In one example, the acceleration can be very slow around the turning and same for deceleration, producing an acceleration curve that is smooth with a low instant gradient given any point. This is distinctive in highly eco-style driving, e.g. “hypermiling”, or used when there is a concerned need to conserve fuel or battery charge. This may especially be the case when driving electric vehicles and the battery is low, or a very long distance must be achieved compare to the charge available.

Therefore, in a first case the recorded data may be used to simply replay how a route was previously driven. For example, it was recorded that that for segment “a” of route AB that the car was driven with a max speed of 65kph on a single carriageway in the UK, close to allowed speed limit. This may be classed as a “comfort” style of driving on this type of road, and if the driver choosing “comfort” style” for the same route, then the system will search for and find the previously driven route that matched comfort parameters and use that recorded data to pilot the car.

Alternatively, in an ADS that does not solely rely on a pre-recorded route, the system can search for a similar route record categorised as comfort and use the recorded speed parameters for that ADS, driving at 65kph for the route.

Of course, all such parameters are subject to intervention. For example, traffic conditions may limit car speed, and other safety and or legal constraints may have to be applied to how the car is controlled.

Figure 9 is a flowchart showing a method of controlling an autonomous vehicle according to a driver preference.

In this example the driver preference system is activated 905 and the system detects 910 if the driver wishes to engage AD modes. If the driver doesn't want to engage AD mode then system can switch to a learning mode 915, described elsewhere herein.

If the driver does engage the AD mode then the system will obtain the driver's preferences for the chosen route. The driver can input in what style the car should be piloted. This can be done through, e.g. an HMI for the ADS.

The system will decide if is possible to drive the selected route in the selected style.

Firstly, the system will check 920 if there are style data available for the route, i.e. it will determine if the route has been driven before.

If the route has no associated data then the system may provide alternative route choices 925. This method of providing alternatives for an untraveled route is described below. If no suggestions are acceptable 930 the system can go into learning mode 915.

If data for the route does exits then the system will check 940 if it is possible to drive the route in the selected style.

The selected style may not exist for the selected route for a number of reasons. If this is the case then the system will provide relevant reasons 945 suggest alternative styles 950 that are available for the route. The system may suggest alternative routes that match the selected criteria in terms of destination and driving style.

The system can provide information on why the selected style is not available for the selected route. The simplest reason is that the selected route has not been driven in the selected style. The system can then suggest to learn the route in that style.

Availability may also be evaluated on restricted access to the selected style. Restriction may occur based upon:

- The driving style is forbidden by law on that route;
- Restrictions are in place e.g. temporal restrictions (not possible at that time of day);
- Other rule based restrictions.

When checking for available styles the system can check current environmental data for the route. This data can include weather and traffic conditions on the route, which may affect availability for certain styles. For example, traffic data indicates that it should be restricted (e.g. reports of heavy traffic makes it unsafe to drive in the selected style), weather restrictions (should not be driven in the wet).

Such data can be accessed from off-board and 3rd party resources. The data may be previously collected and evaluated before collected by the system. One such 3rd party source of real-time data traffic is HERE Global B.V.®.

Additional restrictions may occur due to occupancy. For example, higher speed styles may not be permitted when infants are on board. This method is also detailed below. If such restrictions apply then the system can offer alternative driving styles. The method for this is described below.

When a permitted style has been found and accepted by the driver, the system will then load 960 the appropriate parameters for the style into the AD system 15 and drive 965 the route according to the selected preference.

The AD system is then engaged and will control the car according to the selected style parameters.

As previously detailed metadata can be loaded to the ADS 25: When driven for the first style or better, over a number of times, and classified as sporty, then the metadata for a route can be recorded for a segment.

This data can be recorded from a single journey, e.g. by the current driver. Another method would be to record the characteristics from many journeys, and average characteristics for styles. The data for the segment can be collected via sensors embedded in the car, or be downloaded form a servers or via the cloud.

It is possible to create an average style for a route based on multiple journeys travelled in the same style. This multiple data can obtained for the same car and the same driver, or other data shared by other drivers and cars. Such averages are created from similarly classified styles. Only route data for route styles classified as “sport” are used for to produce averages for “sport” styles, and only route data for route styles classified as “comfort” are used for to produce averages for “comfort” styles.

Additionally, the data can be grouped in terms of the class of car being driven, for example by engine capacity. This can be used to create different suitable profiles deepening on a cars performance. For example, a high performance car with advanced drivetrain specification and brakes, etc., will produce a different “sport” driving style profile from a more basically equipped vehicle. This can also provide the basis of restriction to 3rd party driving styles that could be made available over e.g. social networking attached to the system.

The method may also incorporate temporary metadata that overrides the generally permanent metadata for the route. For example if there has been an accident then emergency traffics regulations can be flagged to be obeyed in place of any existing style data. This can also include forcing the driving style to another more suitable appropriate style, e.g. going to a conservative driving style to ensure maximum traffic throughput where there restrictions in place, ensuring safety and good traffic flow.

The data may be received from local on-board storage or off-board sources e.g. cloud, server side, or exchanged from other cars in the vicinity via wireless methods, or via online providers in a “push data” system.

The basic operation of the ADS under this system is as follows: Typically ADS will apply a set of rules and follow them. One system might be to follow a GPS path. The system will localise the vehicle then plot a trajectory to a next point on the mapped path. Parameters in the ADS may be changed on the fly depending on the instant driving situation.

In a normal system a trajectory may be mapped by any suitable method. This may be set as a default by the ADS to provide a smooth and comfortable ride. However, such a method may limit at what speed the vehicle may travel. Where permitted by traffic laws and other local conditions, it may be possible to substitute a trajectory that plots a shorter, but “harsher” path to the next point.

Thus one or the other option may be flagged to be used for a given style for a route segment. For example, the harsher faster style may be flagged for use in the “sport” style of driving while the smoother version used for “comfort style.”

Additionally the ADS may be programmed to calculate max speed in a specific manner: for example max speed for a segment may be tied to GPS data, or inferred from the last recognised speed limit sign. The ADS may use a combination of such max speed indicators to calculate an acceptable upper limit to drive a route segment.

Some ADS systems work not by following a plotted GPS path but using optical means. That is, they use cameras or detectors such as LIDAR to capture a picture of the car's environment. The system analyses the picture for localization and feature extraction, then decides what to do next. Such AD systems include those that follow a pre-recorded route. It can use various means, e.g. optical or LIDAR, to judge accuracy of current localisation and to make any corrections to trajectory by adjusting, e.g. steering control.

Even though such systems essentially are following pre-recorded routes they can still be adjusted to provide the feeling of different driving styles.

For example, such systems still employ algorithmic methods to calculate what should be the maximum speed of the car for different situations. Different driving styles will employ different approaches to interpreting what should be the maximum speed allowable by the car, for example, cruising style will use different approach to sticking to eco styles, which are different from spurt styles. The same will apply to cornering, and acceleration/deceleration profiles for accelerating and braking.

Thus even this type of autonomous vehicle on apparently strictly controlled pre-recorded parameters can be provided with different styles.

Although the route may have been driven before and this data used to provide e.g. better localisation and object/feature recognition, it will be understood that such and ADS that relies on recorded route will still have elements of parametrisation to it, e.g. for the max speed mentioned above and use of what algorithm to keep to a path.

Therefore the system can be adapted to different types of ADSs.

In another example of the method, in a GPS based system where the ADS calculates trajectories on a point to point/feature basis, different parameters can be adapted or substituted to adapt a standard driving style to a different style, e.g. aggressive cornering. The parameters may include using different algorithms to plot trajectories providing more aggressive or more relaxed trajectories according to the chosen style.

For AD systems that follow pre-recorded routes, the system can operate in as follows: Identifying a previously recorded session of the route being driven, and using the recording "as is" to drive the route. That is, the driving controls follows a pre-plotted path. The route may have been driven several times before, in different styles. The driver chooses a "sport" preference, and a suitable recording of being driven in a style that is identified. Therefore, the route can be driven in sport style using only pre-recorded data. The pre-recorded data has been classified as the selected driving style, as discussed later.

The ADS may employ a mix of these modes and switch between the two depending what system is most suitable for the route segment. That is, if a route segment has no pre-recorded data the it can switch to pure GPS style ADS, or if the GPS signal is lost and recorded data is available then the system be switched to follow the pre-recorded data.

As discussed above, the system may find that the driver has chosen a driving style for the route which either does not exist for the route or is otherwise restricted or forbidden. The reason for this may be that the route has not been driven yet or has not been driven in the selected style.

When the route is unknown to the system, and has not been driven before, the system can provide alternatives to the original selected style and route. This method is illustrated in Figure 10.

The system suggests 1005 that the “learning mode” be entered and the route be driven in manual mode the route data etc., be recorded for later use by the system. The systems then suggests 1020 an alternative route that has the selected style available. The s system then will search 1025 for similar routes and adapts style parameters where possible to the existing route. If a matching route is found 1030 then the system loads 1035 adapted route parameters for the ADS to use. This mode of operation is suitable where the route can be piloted using GPS based systems or similar, and is the route does not have explicitly pre-recorded data to follow.

The system can suggest that the system applies learning mode to learn how the route is driven by present driver. This can be for a route that is never driven before, wherein a whole new route profile will be created. Alternatively, where the route is known but has not been driven in the selected style, the system can suggest that system will learn a new style for the known route.

The system will check if the route is known or not. If not then the system will provide the option of learning the new route or seeking an alternative route with the same style, or to find known and similar routes with the same style and adapt key parameters to the current route

If the route is known then the system will check if an unknown style has been selected. If the answer to this is no, then the reason for not allowing this route can be provided. For example, the selected route style may be forbidden to a particular driver. Other reasons may include: adverse weather conditions, traffic restrictions, temporal restrictions, etc. not limited to these. The system can be programmed to inform the driver why the selected style was rejected and then ask if the driver want to select another style, or have one selected for the driver.

The process steps may be carried out on-board the vehicle within the ADS or by any suitable processing means. The process may be carried out off-board, e.g. via cloud based processing means or dedicated servers, or by mobile computer processing means, e.g. mobile device applications.

Figure 11 shows a scheme for finding a route with similar usable parameters to selected style.

The system will try to find a route with a style that matches the user's preferred style for the present route. The selected style may not exist for the selected route but may exist for a similar route. This provides a method of providing a more precisely tailored driving style that other systems that may use the same modified parameter's for every route. For example, a "sport" style of driving may vary considerably for different types of route. A generalised "sport" style may not be suitable for all terrains and environments. A generally hilly route with many turnings can be driven in a "sport" that is generally fast and aggressive for that rote, but the individual style control parameters (e.g. max speed) will vary considerably from a "sport" route that is generally flat and straight.

Thus the present system can find similar routes and apply AD control parameters that are more suitable for the selected route to be driven, providing a high degree of tailored control to the autonomous driving experience, rather than a more generalised application of driving style.

The system loads available styles 1105 for comparison with the original selected route. These may be obtained for off-board data server 1115 or other suitable means. Any route with a matching profile can be measured against the style profile 1120 of the originally selected style the user wishes to drive the route in.

The system will then compare 1135 the different metadata 1125 of available driving styles with the metadata 1130 of the original selected style. This can be carried out by iteratively stepping through the metadata to build a score with the highest scoring route being suggested.

Different metadata can be weighted in accordance to its importance to the driving style. For example, some metadata will be more important for certain style compared to other parameters. For example, for an "eco" style then parameters concerned with fuel conservation/battery charge will be relevant and have more weighting.

Thus a final weighted score can be provided to the system with the highest score being the first suggested route, the second highest the next suggestion, and so on according the score for each alternative route.

Alternatively, a neural network may be employed to select the best match. A suitable scheme for using a neural network to find different routes with similar parameters is shown in Figure 12.

In such a scheme the original selected driving route parameters 1205 can be matched 1225 and ranked 1130 against. This is carried out by conventional feature extraction 1220 process for each set of data and comparing using a neural networks.

If no suggested route can be found then the system will then suggest that it should learn the original selected style.

Figure 13 shows the top level process for learning new driving style for a route. Figure 16 shows the process in more detail.

The system will “learn” a route and create a route profile from data while travelling a new route, or route that has not been driven a specified style.

This means that the driver, if presented with a new route, or no known style for a route, can elect to drive that route, and specify what the driving style for that route was. This enables the system to build a new route driving style profiles. Additionally, the data can be used to train the system to recognise driving profiles, e.g. for machine learning, which shall be explained later.

The system monitors the AV activity. The system can record location data 1310, and other vehicle sensor data 1315. Once the route is begun then the system will input data from available sensors. These may include but not be limited to those illustrated in previous figures, such as position (GNSS data), pose data, vehicle control data, LIDAR, RADAR camera data, as well as traffic, road conditions and legislation, and any other relevant environmental data required for developing the driving style profile, including temporal data.

The system can process the data and perform data fusion. That is, the system can process and integrate multiple data sources to produce consistent and useful information.

The system can record the various data received, matching them to waypoints in e.g. GPS, or alternatively to other mapping means associated with particular ADSs, such as visual or LIDAR snapshots observed on the route.

The system can associate AV operating parameters with features. Features can be identified such as bends in the road, junctions, etc., using known methods classification methods.

The system can then create 1325 a new driving style profile for the route.

The profile may comprise a detailed visual record of the route, GPS data, and any associated data, including but not limited to the metadata described in Figure 7.

At the end of the route the system can identify the driving style the route has been driven in and store it accordingly. The determination step is detailed below. The determination step can include inviting the driver for feedback. This step can be used to help confirm the style determined by the system.

The system can determine the driving style of a route.

Referring Figure 14, the process effectively uses a similar procedure to finding routes with matching styles. The newly driven route data is first processed to bring it into line with a standardised route profile format, which will produce a number of metadata, then compared to a data base of existing route profiles.

The new route profile metadata 1425 is compared 1435 to existing route metadata 1425, from a database 1415 of available route style profiles.

The output result can be judged by the driver and accepted rejected or otherwise modified to driver satisfaction. The driver can name a route/ route style with descriptor e.g. sporty/ comfort hill drive.

If no match is found the system can ask the driver/user to 1445 to provide a style, and then label the route and style appropriately.

Alternatively, the route style can be ascertained by comparator stage can be carried out by a neural network based system as illustrated in Figure 15. The newly driven route can be compared to existing style profiles, and through use of feature extraction stage 1520 and match and ranking 1525, 1530, the system can find the closest (i.e. highest ranked) match for the style that the present route was driven in.

The system can also adapt what AD driving styles are available according to the driver and or occupants of the car.

Sensors within the car can detect and identify the driver and occupants. Such sensors are well known are not described here in detail.

The type of sensors include seat occupancy sensors, seat belt tension sensors, seat position sensors, and the like. The sensors can also use facial recognition sensors to individually identify occupants.

Driver recognition can also be carried through known methods such identifying a driver by ignition key signal. Alternatively the car can identify the driver through pairing mobile devices.

The system can then adapt the aforementioned parameters for controlling an autonomous vehicle comprising: Identifying occupants in car, determining compatibility of occupants with any selected driving style preferences, and then accepting or rejecting a new driving style based on the compatibility of the occupants with the selected driving style. The system proceeds loading and utilising the selected style, if permitted, as hereinbefore described.

The system may be set to restrict access to certain driving styles based upon the user profile associated with a driver. For example, the system can be set to allow or deny access to a particular driving styles depending on the driver.

Additionally, the system can permit or deny driving styles depending on who else is in the vehicle. For example, driving styles with higher speeds, more aggressive acceleration profiles, and aggressive cornering, may be restricted when there are younger occupants, e.g. infants, detected in the vehicle.

For example if a baby or infant is detected then the system may restrict access to e.g. “sport” driving styles, and may automatically apply restrictions on max speed, and apply “comfort” style settings to parts of the route segment. For example, the system may identify an infant in a baby seat and apply “comfort” cornering algorithms in place of other algorithms, and apply a more modest max speed to the journey than might otherwise been expected for a given style.

The system further provides the option of a user with administrative access to flag certain driving styles as unsuitable / unavailable for certain vehicle occupants and/or users.

Another feature for the system is that it can adapt the car for a chosen route and driving style. This is illustrated in figure 17. Automatic adjustment systems for adjusting seats are well known. Such systems can use motorised servos to adjust fore-and-aft position of a seat, seat incline, and seat height for passengers. In an embodiment, the system can identify a driving style and match adjust seat parameters to match the driving style. Additionally, the steering wheel position may be adjusted to best suit the driving style. Additionally, other physical parameters of the control mechanisms, such as peal, can be adjusted.

This can be achieved by recording the seat and control point positions when the driver has previously driven a route in this style.

For example, the driver may have driven a route in “sport” style. The driver chose his position in the car with a more upright seat position, and also set the seat position closer to the wheel (fore-and-aft position). This also provides better control of the deals when driving in such a style.

Similarly, when driving in a relaxed “comfort” style, the seat may be in a more reclined position, and have additional bolster support to boost comfort.

For example, a for a “sport” driving style, the car can automatically adjust seat and other parameters in the car to aid enjoying this style of driving. In “sport” mode the system will adjust the seat to a more upright position, move it closer to the steering wheel, and bring the seat into a forward position so that the legs are not at a full stretch to access the pedal controls. Although the steering, etc. controls may not be used in full autonomous mode, they may be utilised in semi-autonomous modes, so these adjust will lead to comfort and ease in assisted driving modes.

For long journeys and comfort styles the car can adjust the seat and other parameters accordingly. For example, ensuring seat is positioned so that the occupant has hips at knee height, and can comfortable bend knees, etc. the system can control adjustable side and back bolsters for great comfort.

Additionally, when the driver may have to take over driving switching from autonomous to manual modes, the driver will be optimally positioned to take over control of the car.

The system can further optimise these parameters according to driver recognition, described above.

The system may adjust seat and control position to optimum position using standardised parameters, both detected and or calculated by the system using in car sensors, or chosen by user. For example, the system can use in car sensors to check the height of the driver in the seat an at a known positions and calculate the driver to be in the e.g. 99^{th} percentile male, and provide setting accordingly, or use customised settings based on user input setting.

The system can deploy an optimised driving position depending on driving mode (autonomous/semi-autonomous) and driver parameters such as height, gender etc. the system can access a database of parameters such optimum seat height, fore-and-aft position.

The system accesses adaption data for the selected style. For example, if sport mode is selected and permitted for the route, the system can move the seat to a fore-and-aft position, and more upright piston that will enhance the “sport” driving style experience. However, different people have different length legs, etc. so if the system knows the driver parameters, as simply derived using known percentile charts, or user input parameters, then the system can apply an adjustment factor to tailor the seat, etc. positions to provide the best adjusted positon for that driver for that style.

The system obviously produces a great deal of user generated data on driving styles. This data and this can be utilised to train autonomous driving systems.

For example, a specific driver may drive a route many times in the same style. This data can be used to obtain averaged ADS parameters for that style. This produces a more representative parameters for that style than just a single unadjusted recording of the route driven in one style.

For example, taking an average of a parameter such as “max speed” for a route will produce a much better representation of the max speed for route driven in e.g. comfort or sport mode, than just the data from a single drive of a route. The additionally, anomalies in driving style can be eliminated. For example, a route can be driven in a style confirmed by the driver to “comfort” style, but it may have manoeuvres that were taken more aggressively driven than to be expected for this style. Averaging several journeys will produce a more realistic in comfort style for this route.

It will be appreciated that various changes and modifications can be made to the present invention without departing from the scope of the present application. It will be understood that the examples descried herein and sample values, types and configurations of data described and shown in the figures are for the purposes of illustration and that systems and methods in accordance with aspects of the invention may include various types of sensors, communication devices, user interfaces, vehicle control systems, data values, data types and configurations.

Claims

1. A method of controlling an autonomous vehicle according to a driver preference comprising:

- Selecting a route to be driven by the vehicle
- Receiving a selected driving style preference for the selected driving route
- Receiving route data associated with the route to be driven
- Analysing the route data to determine if the selected driving style exists for the selected route
- Analysing the route data to determine if the selected driving style is permitted

Wherein if the selected driving style is available and permitted for the selected route then the method further comprises the step of configuring parameters for an autonomous driving control system according to the selected driving style preference.

2. The method of claim 1 further comprising receiving driver data and determining if the selected style preferences and or permissions should be modified based on the driver data.

3. The method of claim 1 or 2 wherein the parameters defining the selected driving style may be derived from previously recorded parameters.

4. The method of claims 3 wherein the previously recorded parameters can be derived from previous journeys driven by a vehicle on the selected route.

5. The method of claim 3 wherein the previously recorded parameters may be derived from previous journeys driven by a vehicle on routes other than the selected route.

6. The method of any previous claim wherein if the original selected driving style preference is not available or permitted for the selected route then the method may determine alternative driving style preferences.

7. The method of claim 6 wherein the alternative driving style preferences may be based on the current route data and driver preferences.

8. The method of claim 7 wherein alternative driving style preferences for the selected route are determined by:

Selecting a first group of available and permitted driving styles based on the route data;

Selecting a second group of available driving styles based on driver preferences; and

Suggesting driving styles from the intersection of the first and second groups of driving style to find a best match with the original selected driving style.

9. The method of claim 8 wherein the suggested driving styles may be based on best match between the driver preferences and the available and permitted driving styles for the selected route.

10. The method of claim 9 wherein the best match is calculated by comparing similar parameters between the driver preferences and the available and permitted driving styles for the selected route.

11. The method of claims 9 or 10 wherein the best match calculation may be carried out using a neural network by comparing extracted features of the selected driving style with extracted features of the driving styles form the first group.

12. The method of any preceding claim wherein the route data may comprise: map data for the route, feature data for the route, current or predicted environmental conditions, driving style data associated with route.

13. The method of claim 12 wherein the route data may also comprise current or predicted traffic conditions.

14. The method of any preceding claim wherein the method may further limit the group of permissible driving styles based upon environmental conditions such as: time of day, weather conditions, and traffic data.

15. The method of claims 6 to 14 wherein the suggested driving style preferences is based upon at least one of: Driver preferences, vehicle resources (fuel, battery, etc.), environment variables.

16. The method of any preceding claim wherein the method further comprises suggesting alternative routes where the selected style preference is available and permitted.

17. The method of any preceding claim wherein the method further comprises determining style preference options based on the vehicle driver and/or vehicle occupants.

18. The method of any preceding claim wherein the further comprises restricting driving style preference options based on any of: vehicle driver information, vehicle occupants, and passenger data.

19. The method of any preceding claim wherein the further includes restricting available style based on temporal data and associated restrictions.

20. A method of adapting driver style preferences for a first route to be used in a second route.

21. The method of claim 20 wherein the method comprises analysing a first route where the selected style data is not known, then searching a database of routes to identify routes with similar route metadata to the first route, creating a matching driving style for the first route.

22. The method of claim 21 wherein if a matching route to the first route is found then the method further includes the step of using parameters from the matching route for creating style parameters for the first route.

23. The method of claims 20 to 22 wherein the metadata comprises any of: number of junctions, max speed, gradients, road conditions, weather conditions, and traffic data, number of bends / corners and distance between such features.

24. A method of controlling a vehicle wherein the vehicle driving style can be modified according to the occupants detected in the vehicle, the method comprising:

Detecting occupants in car

Determining compatibility of occupants with a selected driving style preferences

Modifying the selected driving style based on the compatibility of the occupants with the selected driving style.

25. The method of claim 24 wherein the method restricts available styles depending on the occupants of the car.

26. The method of claims 24 or 25 wherein the method flags route data as unsuitable / unavailable for the journey depending on analysis of the vehicle occupants.

27. The method of claims 24 to 26 wherein the method suggesting suitable alternative styles and/or routes that are suitable.

28. A method of deriving a driving style model for use in a method of controlling an autonomous vehicle according to driver preferences, the method comprising, monitoring a route being driven and recording and processing associated route data, and:

- Collecting location data
- Collecting data related to road characteristics
- Collecting car sensor data
- Linking the collected data

- Analysing the route data and identifying key characteristics of the route in order to classify the route
- Creating a driving style model for the route suitable for use in controlling an autonomous driving system, the model comprising route data and metadata required to control an AV.

29. The method of claim 28 wherein the route data may be any of GPS data, map feature data, and route metadata such as max speed data, traffic and road condition data, and temporal restriction data.

30. The method of claim 28 wherein the car sensor data comprises any of: optical camera data, LIDAR data, RADAR data

31. The method of claims 28 to 30 wherein the car sensor data comprises any of position data.

32. The method of claim 31 wherein the position data comprises any of: GNSS data, dead reckoning data, odometer data gyroscopic data.

33. The method of claims 28 to 32 wherein the car data comprises vehicle dynamic control data such as steering, braking and engine throttle data.

34. The method of claim 28 to 33 wherein the step of creating a driving model comprises analysing the data and linking features and events between the different lists of data, classifying the data according to preset values, and creating a list of parameters associated with the route.

36. In another aspect there is provided a training dataset for use in training an autonomous driving system, the training dataset comprising a set of labelled route segments that have been labelled by analysing sensor readings of a vehicle while it is driven on a route, and associating the results of the analysis with a driving style.

37. A method for training a driving style identification model, comprising:
- Obtaining a training dataset comprising vehicle sensor data and vehicle position data and driving style identification labels;
- Extracting a set of training features from the training dataset based upon the sample vehicle location points, the set of training features indicative of driving style; and
- Training a driving style identification model using the set of training features and the driving style identification labels to create a trained driving style identification model for identifying driving styles based upon vehicle location data and related vehicle sensor data.

38. The method of claim 37 further comprising:

- Obtaining a dataset comprising vehicle location points;
- Extracting a set of features from the dataset based upon the vehicle location points, the set of features indicative of driving style; and
- Evaluating the set of features using the trained driving style identification model to determine whether a road segment has a characteristic driving style.

38. The method of claim 37 further comprising:

Obtaining data from a vehicle driven through an environment, the data comprising:

Vehicle telemetry matched to route information;

Environmental data; and

A further step of labelling route segment features, wherein vehicle telemetry and vehicle sensor data is matched with each route segment feature to produce a database of driving parameters for the route.

39. The method of claims 37 and 38 wherein the route and telemetry data comprises any of: Overall route speed, Max speed for route and route segments, number of corners in the route, number of straight runs in the route, and environmental data such as country/urban.

Intellectual Property Office

Application No:	GB1912005.4	**Examiner:**	Mr Ben Hampson
Claims searched:	1-19	**Date of search:**	21 February 2020

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-19	WO 2018/094384 A1 (COX et al.) See whole document, particularly paragraphs 27-30 & 165-166 and figures.
X	1-15 & 17-19	US 2015/149017 A1 (YOPP et al.) See whole document, particularly paragraphs 17-19 and figures.
X	1-15 & 17-19	US 2014/025259 A1 (LU et al.) See whole document, particularly paragraphs 22-32 and figures.
X	1-3 & 6-19	US 2018/239359 A1 (JIAN) See whole document, particularly paragraphs 20-33 and figures.
X	1-6 & 12-19	US 8634980 B1 (NEMEC et al.) See whole document, particularly columns 11-12 and figures.
X	1-3, 12-15 & 17-19	US 2018/361972 A1 (ZAGORSKI) See whole document, particularly paragraphs 43-47 and figures.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B60W; G01C

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

Intellectual Property Office

International Classification:

Subclass	**Subgroup**	**Valid From**
B60W	0050/08	01/01/2020
B60W	0030/182	01/01/2020
B60W	0060/00	01/01/2020
G01C	0021/34	01/01/2006