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(54) METHOD, APPARATUS, STORAGE MEDIUM, AND VEHICLE FOR PREDICTING TRAFFIC FLOW

(57) The disclosure relates to the field of intelligent driving, and specifically provides a method, apparatus, storage medium, and a vehicle for predicting traffic flow, comprising: selecting a target vehicle and a reference vehicle, and obtaining corresponding vehicle information; determining whether the target vehicle is in a following state based on the vehicle information and a non-free driving state of the target vehicle relative to the reference vehicle, and predicting traffic flow of a target lane. By the method of the disclosure, whether a moving speed of the target vehicle can represent an average speed of vehicles in the lane is determined based on a car-following theory, thereby obtaining more accurate lane-level traffic flow information and providing more accurate data support for intelligent driving.

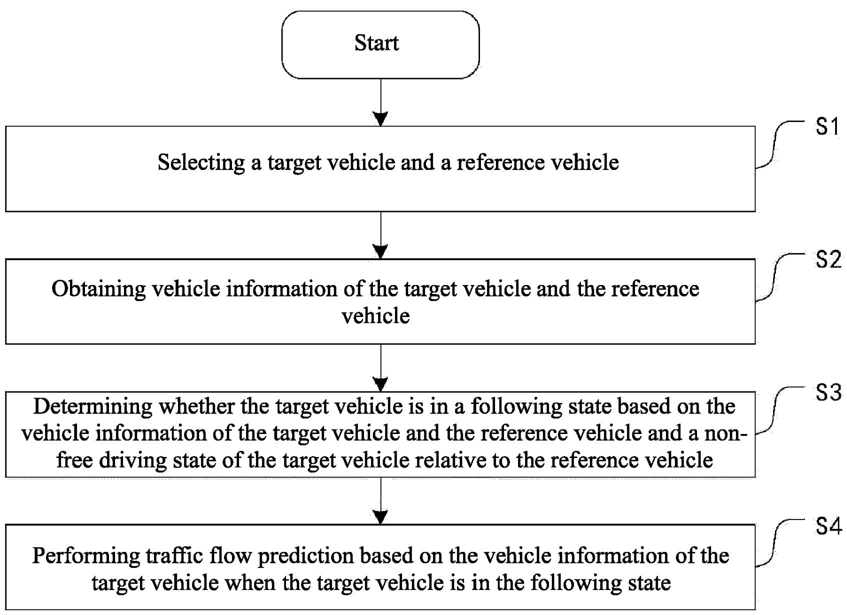


FIG. 2

EP 4 181 101 A1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese Patent Application NO.CN202111334849.9, titled "METHOD, APPARATUS, STORAGE MEDIUM, AND VEHICLE FOR PREDICTING TRAFFIC FLOW", filed Nov. the 11th, 2021, the entire contents of which are incorporated herein by reference.

Technical Field

[0002] The disclosure relates to the field of intelligent driving, and specifically provides a method, apparatus, storage medium, and a vehicle for predicting traffic flow.

Background Art

[0003] In intelligent driving applications, traffic flow is an important type of input information, which can assist a vehicle in making a better decision, including: adjusting a maximum driving speed limit in real time, such as where when there is congestion ahead, the maximum speed limit may be lowered in advance, to avoid poor passenger experience due to sudden deceleration; making a lane-level decision, such as to prevent a lane change to a lane with a similar or lower traffic speed; and assisting target prediction, such as where when the traffic flow of a lane next to a current lane is significantly lower than that of the current lane, a target vehicle on the front side has a greater probability of invading the current lane, in which case predicting a behavior of a neighboring vehicle in advance can effectively avoid a collision risk.

[0004] As an important source of traffic flow information, a high-definition map can be used to provide roadside-based traffic congestion information. However, the high-definition map depends on statistical data, and has a lower real-time performance than a sensing result from a sensor on the vehicle. In addition, the congestion information is provided mostly based on roads, which results in a failure to describe the traffic flow in each lane in a subdivided manner. How to obtain vehicle information through a vehicle sensor to accurately predict lane-level traffic flow information has become an urgent problem to be solved.

[0005] Accordingly, there is a need for a new solution to solve the foregoing problem in the art.

Summary of the Disclosure

[0006] The disclosure aims to solve the foregoing technical problem, that is, to solve the problem of how to obtain vehicle information of a target lane through a sensor on the vehicle and accurately predict lane-level traffic flow.

[0007] In a first aspect, the disclosure provides a method for predicting traffic flow on the vehicle. The method includes:

S1, selecting a target vehicle and a reference vehicle, wherein the reference vehicle and the target vehicle are both located in a target lane, and the reference vehicle is located in front of the target vehicle and is adjacent to the target vehicle;
S2, obtaining vehicle information of the target vehicle and the reference vehicle, and the vehicle information at least includes a vehicle code, an acceleration, and a speed;
S3, determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle, and
if not, step S4, or
if so, step S5;
S4, returning to step S2 when the target vehicle is not in the following state; and
S5, performing traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state.

[0008] In an implementation of the foregoing the method for predicting traffic flow on the vehicle, the step of "determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle" specifically includes:

S31, obtaining the vehicle information of the target vehicle and the reference vehicle in real time at a set time interval;
S32, comparing whether a real-time vehicle code of the reference vehicle that is obtained in real time is the same as a historical vehicle code of the reference vehicle, and
if not, adjusting a following state determination counter to a preset minimum value, wherein the following state

determination counter comprises an acceleration following state determination counter and a deceleration following state determination counter, then updating the historical vehicle code of the reference vehicle, and returning to step S31, or
if so, performing step S33;
S33, calculating a non-free driving state determination identifier;
S34, determining whether the non-free driving state determination identifier is greater than a preset identifier value, and
if not, decreasing both the acceleration following state determination counter and the deceleration following state determination counter by a first preset count value, and returning to step S31, or
if so, determining that the target vehicle is in the non-free driving state, and performing step S35;
S35, determining whether the acceleration of the target vehicle is positive or negative, and
if the acceleration of the target vehicle is positive, increasing the acceleration following state determination counter by a second preset count value, and performing step S36, or
if the acceleration of the target vehicle is negative, increasing the deceleration following state determination counter by a third preset count value, and performing step S36; and
S36, determining whether the acceleration following state determination counter with the second preset count value added is greater than a first following state determination threshold, and determining whether the deceleration following state determination counter with the third preset count value added is greater than a second following state determination threshold, and
if so for both cases, determining that the target vehicle is in the following state relative to the reference vehicle, otherwise, returning to step S31.

[0009] In an implementation of the foregoing the method for predicting traffic flow on the vehicle , the step of "performing traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state" specifically includes:
taking the speed of the target vehicle as an average speed of the vehicles in the target lane.

[0010] In an implementation of the foregoing the method for predicting traffic flow on the vehicle, the calculation method for the non-free driving state determination identifier is:

$$a = \frac{\dot{x}_n(t-T) - \dot{x}_{n+1}(t-T)}{\ddot{x}_{n+1}(t)}$$

wherein α is the non-free driving state determination identifier, $\dot{x}_n(t-T)$ is a speed value of the target vehicle at a moment $t-T$, $\dot{x}_{n+1}(t-T)$ is a speed value of the reference vehicle at a moment $t-T$, $\ddot{x}_{n+1}(t)$ is an acceleration value at a moment t, and T is a reaction time constant of a driver.

[0011] In an implementation of the foregoing the method for predicting traffic flow on the vehicle, step S34 further includes:

after performing the step of "decreasing both the acceleration following state determination counter and the deceleration following state determination counter by a first preset count value" and before returning to step S31,
determining whether the acceleration following state determination counter with the first preset count value subtracted is less than the preset minimum value, and if so, assigning the acceleration following state determination counter to the preset minimum value, and then returning to perform step S31; and
determining whether the deceleration following state determination counter with the first preset count value subtracted is less than the preset minimum value, and if so, assigning the deceleration following state determination counter to the preset minimum value, and then returning to perform step S31; and
before performing step S36, the following steps are further comprised:

determining whether the acceleration following state determination counter with the second preset count value added exceeds a first preset threshold, and if so, assigning the acceleration following state determination counter to the first preset threshold, and then performing step S36; and
determining whether the deceleration following state determination counter with the third preset count value added exceeds a second preset threshold, and if so, assigning the deceleration following state determination counter to the second preset threshold, and then performing step S36.

[0012] In a second aspect, the disclosure provides apparatus for predicting traffic flow on the vehicle. The apparatus includes:

a vehicle information obtaining module configured to obtain vehicle information of a target vehicle and a reference vehicle, and the vehicle information at least includes a vehicle code, an acceleration, and a speed;
a following state determination module configured to perform the following operations:

selecting the target vehicle and the reference vehicle, wherein the reference vehicle and the target vehicle are both located in a target lane, and the reference vehicle is located in front of the target vehicle and is adjacent to the target vehicle; and
determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle; and
a traffic flow prediction module configured to perform traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state.

[0013] In an implementation of the foregoing the apparatus for predicting traffic flow on the vehicle, the following state determination module is further configured to perform the following operations:

obtaining the vehicle information of the target vehicle and the reference vehicle in real time at a set time interval;
comparing whether a real-time vehicle code of the reference vehicle that is obtained in real time is the same as a historical vehicle code of the reference vehicle, and
if not, adjusting a following state determination counter to a preset minimum value, wherein the following state determination counter comprises an acceleration following state determination counter and a deceleration following state determination counter, then updating the historical vehicle code of the reference vehicle, and returning to step of "obtaining the vehicle information of the target vehicle and the reference vehicle in real time at a set time interval", or
if so, calculating a non-free driving state determination identifier;
determining whether the non-free driving state determination identifier is greater than a preset identifier value, and
if not, decreasing both the acceleration following state determination counter and the deceleration following state determination counter by a first preset count value, and returning to the step of "obtaining the vehicle information of the target vehicle and the reference vehicle in real time at a set time interval", or
if so, determining that the target vehicle is in the non-free driving state; and
determining whether the acceleration of the target vehicle is positive or negative, and
if the acceleration of the target vehicle is positive, increasing the acceleration following state determination counter by a second preset count value, and performing "following state determination", or
if the acceleration of the target vehicle is negative, increasing the deceleration following state determination counter by a third preset count value, and performing "following state determination",
wherein the following state determination involves determining whether the acceleration following state determination counter with the second preset count value added is greater than a first following state determination threshold, and determining whether the deceleration following state determination counter with the third preset count value added is greater than a second following state determination threshold, and
if so for both cases, determining that the target vehicle is in the following state relative to the reference vehicle,
otherwise, returning to the step of "obtaining the vehicle information of the target vehicle and the reference vehicle in real time at a set time interval".

[0014] In an implementation of the foregoing the apparatus for predicting traffic flow on the vehicle, the traffic flow prediction module is further configured to perform the following operation:
taking the speed of the target vehicle as an average speed of the vehicles in the target lane.

[0015] In a third aspect, the disclosure provides a storage medium adapted to store a plurality of program codes, where the program codes are adapted to be loaded and run by a processor to perform a method for predicting traffic flow on the vehicle according to any one of the foregoing solutions.

[0016] In a fourth aspect, the disclosure provides a vehicle including a vehicle body, a processor, and a memory, where the memory is adapted to store a plurality of program codes, and the program codes are adapted to be loaded and run by the processor to perform a method for predicting traffic flow on the vehicle according to any one of the foregoing solutions.

[0017] With the foregoing technical solutions, the disclosure makes it possible to obtain vehicle data of a vehicle in the target lane through a sensor on the vehicle, and determine whether a moving speed of the target vehicle may represent average vehicle traffic of the lane by analyzing a motion state between the target vehicle and an adjacent vehicle, that is, a vehicle that has a following relationship with the target vehicle, thereby obtaining more accurate average lane-level traffic flow and providing more accurate data support for intelligent driving.

Brief Description of the Drawings

[0018] Preferred implementations of the disclosure are described below with reference to drawings. Among the drawings:

FIG. 1 is a schematic diagram of positions of vehicles on a road according to an embodiment of the disclosure;
FIG. 2 is a flowchart of main steps of a method for predicting traffic flow on the vehicle according to an embodiment of the disclosure;
FIG. 3 is a flowchart of specific implementation of step S3 in FIG. 2;
FIG. 4 is a first schematic diagram of a compositional structure of a apparatus for predicting traffic flow on the vehicle according to an embodiment of the disclosure; and
FIG. 5 is a second schematic diagram of a compositional structure of a apparatus for predicting traffic flow on the vehicle according to an embodiment of the disclosure.

Detailed Description of Embodiments

[0019] First referring to FIG. 1, FIG. 1 is a schematic diagram of positions of vehicles on a road according to an embodiment of the disclosure. In many existing vehicle-side traffic flow calculation strategies, simply a driving speed of a vehicle closest to an ego vehicle or an average speed of vehicles in a detected lane is used to represent a traffic flow rate. However, each vehicle on a road is diverse in terms of motion, and the above processing method is often one-sided, which may sometimes result in a misleading to an accurate determination of the traffic flow, and then causes a driving assistance system to make some inappropriate decisions, thereby affecting the user experience.

[0020] In FIG. 1, there is a large difference in driving speed between a vehicle Veh1 in a left lane that is adjacent to a vehicle Ego1 and a plurality of vehicles far away from the adjacent vehicle. In this case, if traffic flow of the lane is determined simply based on the speed of the adjacent vehicle, there may be inaccurate predictions, which will prevent the driving assistance system from making a correct decision. For example, in a scenario of the Ego1, the Ego1 may mistakenly consider that the traffic flow speed in the left lane is high due to a high speed of the Veh1. When congestion occurs in the lane in which Ego1 is located, the driving assistance system may give inappropriate prompt information indicating a lane change to the left side, in order to achieve a higher driving speed.

[0021] Aiming at such an impact on the determination of the overall traffic flow of the lane due to simply use of the moving state of a single target, the method for predicting traffic flow on the vehicle based on an analysis of a non-free moving state of a vehicle of the disclosure is desired to determine whether the motion of one of vehicles in the target lane that have a leading-and-following relationship is representative by determining whether there is a restrictive relationship between the motions of the vehicles, thereby obtaining predicted traffic flow information of the target lane.

[0022] Still referring to FIG. 2, FIG. 2 is a flowchart of main steps of a method for predicting traffic flow on the vehicle according to an embodiment of the disclosure. As shown in FIG. 2, the method for predicting traffic flow on the vehicle of the disclosure includes:

Step S1: selecting a target vehicle and a reference vehicle;
Step S2: obtaining vehicle information of the target vehicle and the reference vehicle;
Step S3: determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle; and
Step S4: performing traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state.

[0023] In step S1, both the target vehicle and the reference vehicle should be located in a same lane, and the reference vehicle is located in front of the target vehicle and is adjacent to the target vehicle. Preferably, an adjacent vehicle on the front side of an ego vehicle that may have a great influence on the driving of the ego vehicle is selected as the target vehicle. As an example, as shown in FIG. 1, the ego vehicle is Ego1, and a vehicle Veh1 in an adjacent lane on the left side of the ego vehicle is selected as the target vehicle. An adjacent vehicle Veh2 in the same lane as and in front of the vehicle Veh1 is selected as the reference vehicle, and there should be no other vehicles between the vehicle Veh1 and the vehicle Veh2.

[0024] In step S2, the vehicle information of the target vehicle and the reference vehicle is obtained, where the vehicle information includes a vehicle code, an acceleration, and a speed. A method for obtaining the vehicle information is not limited in the disclosure. As an example, a vehicle sensor (such as one or more of an acceleration sensor, a speed sensor, a vehicle image sensor, an onboard laser radar, an onboard ultrasonic radar, etc.) may be used to obtain data, such as license plate numbers, exterior characteristics, and colors, of a plurality of vehicles in a detection area, and the data is fused with the speed, acceleration and other data of the ego vehicle, to obtain the characteristics of each vehicle. Each vehicle is assigned a unique vehicle code, that is, unique ID data, and speed, acceleration and other information of the vehicle are obtained.

[0025] It should be noted that the vehicle characteristics obtained by processing data from the vehicle sensor need to be compared with vehicle characteristics recorded at a previous moment. If they are the same, a same vehicle code is assigned, and if they are different, a new vehicle code is assigned.

[0026] Still referring to FIG. 3, FIG. 3 is a specific implementation method of step S3.

[0027] In step S31, the vehicle information of the target vehicle and the reference vehicle are obtained in real time at a set time interval, the vehicle information including: a current ID (vehicle code) of the target vehicle, an acceleration of the target vehicle, a speed of the target vehicle, a current ID (vehicle code) of the reference vehicle, an acceleration of the reference vehicle, a speed of the reference vehicle, etc. The time interval at which the vehicle information is obtained may be set depending on factors such as the type of a vehicle sensor, a processing speed of sensor data, and a current speed of the ego vehicle. For example, the time interval may be set to 50 milliseconds.

[0028] It should be noted that, if the vehicle code of the target vehicle is not obtained in step S31, it indicates that the target vehicle may have moved away from the target lane or not be within a detection range of the vehicle sensor. In this case, there is a need to return to step S1 for reselection of the target vehicle and the reference vehicle.

[0029] In steps S32 and S33, a comparison is made as to whether a real-time vehicle code of the reference vehicle that is obtained in real time is the same as a historical vehicle code of the reference vehicle, that is, a comparison is made as to whether the current ID of the reference vehicle is the same as a historical ID of the reference vehicle, and whether the reference vehicle in front of the target vehicle at the current moment and the reference vehicle at a previous moment are the same vehicle is checked.

[0030] If the current ID of the reference vehicle is not the same as the historical ID of the reference vehicle, it indicates that the current reference vehicle may be changed due to the reference vehicle having moved away from the target lane or other vehicles entering the target lane, and an original motion restrictive relationship between the target vehicle and the reference vehicle no longer exists. Therefore, in step S34, both the acceleration following state determination counter and the deceleration following state determination counter are adjusted to a preset minimum value (in this embodiment, the preset minimum value is set to 0).

[0031] In addition, before returning to step S31 for loop detection, the historical vehicle code of the reference vehicle is updated, and an association relationship between the target vehicle and the reference vehicle is re-established.

[0032] If the current ID of the reference vehicle is the same as the historical ID of the reference vehicle, it indicates that the reference vehicle has not changed and the motion restrictive relationship between the target vehicle and the reference vehicle is still valid. In this case, step S35 is performed, in which a non-free driving state determination identifier is calculated.

[0033] A vehicle in a non-free driving state has the following three main characteristics: restriction, latency, and transfer. It is the three characteristics that are exactly used in the disclosure to determine a motion relationship between leading and following vehicles. In the embodiments of the disclosure, the most robust first-order kinematic model is used to determine the motion state of the leading and following vehicles, that is

$$\ddot{x}_{n+1}(t) = F\,(\dot{x}_n(t-T) - \dot{x}_{n+1}(t-T)) \qquad (1)$$

in formula (1), F is a constant, $\dot{x}_n(t - T)$ is a speed value of the target vehicle at a moment $t - T$, $\dot{x}_{n+1}(t - T)$ is a speed value of the reference vehicle at a moment $t - T$, $\ddot{x}_{n+1}(t)$ is an acceleration value at a moment t, and T is a reaction time constant of a driver. T is a parameter related to the driver's responsiveness. As an example, it is usually set to 1 second, which is suitable for most scenarios.

[0034] Formula (1) reflects that a difference in speeds between the leading and following vehicles may affect the acceleration of subsequent vehicles (restriction), with a delay of T time (latency), and the value of the constant F reflects the association between the leading and following vehicles.

[0035] In actual applications, considering errors and fluctuations in data from the vehicle sensor, the value of the constant F will also fluctuate greatly even if there is an obvious constraint relationship between two motor vehicles. Therefore, in the disclosure, to improve the determination robustness, the condition, in formula (2), for determining whether the leading and following vehicles are in a non-free motion state is relaxed to: There is a certain value F greater than 0, so that formula (1) is established, and F is no longer required to remain relatively unchanged between a plurality of frames. Therefore, the calculation method for the non-free driving state determination identifier f may be defined as:

$$f = \frac{\ddot{x}_{n+1}(t)}{\dot{x}_n(t-T)-\dot{x}_{n+1}(t-T)} \qquad (2)$$

[0036] In step S36, it is determined whether the non-free driving state determination identifier f is greater than 0.

[0037] If f is less than 0, step S37 is performed, in which both the acceleration following state determination counter and the deceleration following state determination counter are decreased by a first preset count value (in this embodiment, the first preset count value is 1). In addition, before returning to step S31, whether the acceleration following state determination counter and the deceleration following state determination counter are respectively less than the preset minimum value is checked. If less than the preset minimum value, the acceleration following state determination counter and/or the deceleration following state determination counter are/is adjusted to the preset minimum value.

[0038] If f is greater than 0, which indicates that the target vehicle is in a non-free driving state relative to the reference vehicle, step S38 is perform, in which it is determined whether the acceleration of the target vehicle is positive or negative.

[0039] If the acceleration of the target vehicle is greater than 0, which indicates that the acceleration of the target vehicle is positive, the acceleration following state determination counter is increased by a second preset count value (in this embodiment, the second preset count value is 1) in step S39; in addition, whether the acceleration following state determination counter with the second preset count value added exceeds a first preset threshold is checked, and if so, the acceleration following state determination counter is assigned the first preset threshold, and step S3B is performed.

[0040] If the acceleration of the target vehicle is less than 0, which indicates that the acceleration of the target vehicle is negative, the deceleration following state determination counter is increased by a third preset count value (in this embodiment, the third preset count value is 1) in step S3A; in addition, whether the deceleration following state determination counter with the third preset count value added exceeds a second preset threshold is checked, and if so, the deceleration following state determination counter is assigned the second preset threshold, and step S3B is performed.

[0041] In step S3B, it is determined whether the acceleration following state determination counter with the second preset count value added is greater than a first following state determination threshold, and it is also determined whether the deceleration following state determination counter with the third preset count value added is greater than a second following state determination threshold.

[0042] If so for both cases, that is, the acceleration following state determination counter is greater than the first following state determination threshold and the deceleration following state determination counter is greater than the second following state determination threshold, step S3C is performed, in which it is determined that the target vehicle is in the following state relative to the reference vehicle.

[0043] Otherwise, when the following cases 1, 2 or 3 are met, step S31 is returned for loop detection.

[0044] Case 1: the acceleration following state determination counter is less than the first following state determination threshold, and the deceleration following state determination counter is greater than the second following state determination threshold.

[0045] Case 2: the deceleration following state determination counter is greater than the second following state determination threshold, and the acceleration following state determination counter is greater than the first following state determination threshold.

[0046] Case 3: the acceleration following state determination counter is less than the first following state determination threshold, and the deceleration following state determination counter is less than the second following state determination threshold.

[0047] It should be noted that the preset minimum value, the first preset threshold, and the second preset threshold are set to delimit a valid value range of the acceleration following state determination counter and the deceleration following state determination counter, thereby ensuring the real-time performance of following state determination while ensuring the accuracy of following state determination, and thus providing more adaptability to practical applications.

[0048] The preset minimum value, the first preset threshold, the second preset threshold, the first following state determination threshold, the second following state determination threshold, etc. may be set in combination with the set time interval in step S31, road conditions, etc., and therefore, they are set by practical experience. As an example, when the set time at which the vehicle information is obtained is 50 milliseconds, the first following state determination threshold and the second following state determination threshold may be both set to 10, the preset minimum value may be set to 0, and the first preset threshold and the third threshold may be set to 20. In addition, the first preset count value, the second preset count value, and the third preset count value are all set to 1. Inventors in the art may also set the above preset values according to actual conditions, but such settings of different values should not be considered as going beyond the scope of the disclosure.

[0049] Upon determining that the target vehicle is in the following state relative to the reference vehicle, traffic flow prediction on the vehicle may be performed based on the information of the target vehicle, that is, by taking the speed of the target vehicle as an average speed of the vehicles in the target lane.

[0050] Further, the disclosure also provides a apparatus for predicting traffic flow on the vehicle. As shown in FIG. 4, the apparatus for predicting traffic flow on the vehicle 4 in an embodiment of the disclosure mainly includes: a vehicle information obtaining module 41, a following state determination module 42, and a traffic flow prediction module 43.

[0051] The vehicle information obtaining module 41 is configured to obtain, by a vehicle sensor, vehicle information of a target vehicle and a reference vehicle on a vehicle driving road and of other vehicles within a detection range of the vehicle sensor. As shown in FIG. 5, in an embodiment, the vehicle information obtaining module 41 may further include a sensor sub-module 41a and a sensor data processing sub-module 41b.

[0052] The sensor sub-module 41a may be one or more of an acceleration sensor, a speed sensor, a vehicle image sensor, an onboard laser radar, an onboard ultrasonic radar, etc. The sensor sub-module 41a obtains data, such as license plate numbers, exterior features, colors, speeds, and accelerations, of the ego vehicle within the detection range of the vehicle sensor and the plurality of surrounding vehicles. Then, the sensor data processing sub-module 41b performs data fusion to obtain the characteristics of each vehicle, assigns a unique vehicle code to each vehicle, that is, unique ID data, and obtains speed, acceleration and other information of the vehicle.

[0053] The following state determination module 42 is configured to select a target vehicle and a reference vehicle, and determine whether the target vehicle is in a following state by detecting a non-free driving state of the target vehicle relative to the reference vehicle based on vehicle information, such as a vehicle code, an acceleration, and a speed, of the target vehicle and the reference vehicle. As shown in FIG. 5, in an embodiment, the following state determination module 42 may further include a target selection sub-module 42a, a data calculation sub-module 42b, and a determination sub-module 42c.

[0054] The target selection sub-module 42a is configured to select a target vehicle and a reference vehicle from the vehicle information obtained by the vehicle information obtaining module 41. Preferably, an adjacent vehicle on the front side of an ego vehicle that may have a great influence on the driving of the ego vehicle is generally selected as the target vehicle. A vehicle that is located in a same lane as the target vehicle and is in front of the target vehicle is selected as the reference vehicle, and the target vehicle is adjacent to the reference vehicle, that is, there are no other vehicles between the target vehicle and the reference vehicle.

[0055] The data calculation sub-module 42b is configured to calculate a non-free driving state determination identifier by using formula (2) based on the speed, acceleration, and other information of the target vehicle and the reference vehicle.

[0056] The determination sub-module 42c is configured to determine whether the target vehicle is in a following state based on ID data of the reference vehicle, the non-free driving state determination identifier, and the acceleration information of the target vehicle. Specific determination conditions include: the ID of the reference vehicle needs to remain unchanged, the target vehicle needs to be in a non-free driving state relative to the reference vehicle, and both the count values of acceleration and deceleration of the target vehicle need to exceed the set determination thresholds. For specific technical details, reference may be made to the content of steps S32 to S3C in the method part of the embodiment of the disclosure.

[0057] The traffic flow prediction module 43 is configured to perform traffic flow prediction on the vehicle according to the information of the target vehicle upon determining that the target vehicle is in the following state relative to the reference vehicle, that is, by taking the speed of the target vehicle as an average speed of the vehicles in the target lane.

[0058] Further, the disclosure further provides a storage medium. The storage medium may be configured to store a program for performing the method for predicting traffic flow on the vehicle in the foregoing method embodiments, where the program may be loaded and run by a processor to implement the foregoing the method for predicting traffic flow on the vehicle. For ease of description, only parts related to the embodiments of the disclosure are shown. For specific technical details that are not disclosed, reference may be made to the method part of the embodiments of the disclosure. The storage medium may be a storage device formed by various electronic devices. Optionally, the storage medium in the embodiments of the disclosure is a non-transitory computer-readable storage medium.

[0059] Further, the disclosure further provides a vehicle including a vehicle body, a processor, and a memory. Optionally, the vehicle body may be an electric vehicle; the processor and the memory are mounted on the vehicle body and are powered by the vehicle body; and the memory may be configured to store a program for performing the method for predicting traffic flow on the vehiclein the foregoing method embodiments, where the program may be loaded and run by the processor to implement the foregoing the method for predicting traffic flow on the vehicle. For ease of description, only parts related to the embodiments of the disclosure are shown. For specific technical details that are not disclosed, reference may be made to the method part of the embodiments of the disclosure. The memory may be a storage device formed by various electronic devices. Optionally, the memory in the embodiments of the disclosure is a non-transitory readable storage medium.

[0060] Those skilled in the art should be able to realize that the method steps of the various examples described in conjunction with the embodiments disclosed herein can be implemented in electronic hardware, computer software or a combination of both. To clearly illustrate the interchangeability of electronic hardware and software, the compositions and steps of the various examples have been generally described in terms of functionality in the above description. Whether these functions are performed in electronic hardware or software depends on the specific application and design constraints of the technical solution. Those skilled in the art can implement the described functions by using different methods for each particular application, but such implementation should not be considered as going beyond the scope of the disclosure.

[0061] It should be noted that the terms "first", "second", "third", and other ordinal numbers in the description, claims, and drawings of the disclosure are only intended to distinguish between similar objects, not to describe or indicate a particular order or sequence. It should be understood that the data termed in such a way are interchangeable in proper circumstances so that the embodiments of the disclosure described herein can be implemented in other orders than the order illustrated or described herein.

[0062] Heretofore, the technical solutions of the disclosure have been described with reference to the preferred embodiments shown in the accompanying drawings. However, those skilled in the art can readily understand that the scope of protection of the disclosure is apparently not limited to these specific embodiments. Those skilled in the art can make equivalent changes or substitutions to the related technical features without departing from the principle of the disclosure, and all the technical solutions with such changes or substitutions shall fall within the scope of protection

Claims

1. A method for predicting traffic flow on the vehicle, comprising:

S1, selecting a target vehicle and a reference vehicle, wherein the reference vehicle and the target vehicle are both located in a target lane, and the reference vehicle is located in front of the target vehicle and is adjacent to the target vehicle;
S2, obtaining vehicle information of the target vehicle and the reference vehicle, wherein the vehicle information at least includes a vehicle code, an acceleration, and a speed;
S3, determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle, and
if not, step S4 or
if so, step S5;
S4, returning to step S2 when the target vehicle is not in the following state; and
S5, performing traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state.

2. The method for predicting traffic flow on the vehicle according to claim 1, wherein the step of "determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle" specifically comprises:

S31, obtaining the vehicle information of the target vehicle and the reference vehicle in real time at a set time interval;
S32, comparing whether a real-time vehicle code of the reference vehicle that is obtained in real time is the same as a historical vehicle code of the reference vehicle, and
if not, adjusting a following state determination counter to a preset minimum value, which comprises an acceleration following state determination counter and a deceleration following state determination counter, then updating the historical vehicle code of the reference vehicle, and returning to step S31, or
if so, step S33;
S33, calculating a non-free driving state determination identifier;
S34, determining whether the non-free driving state determination identifier is greater than a preset identifier value, and
if no, decreasing both the acceleration following state determination counter and the deceleration following state determination counter by a first preset count value, and returning to step S31, or
if so, determining that the target vehicle is in the non-free driving state, and performing step S35;
S35, determining whether the acceleration of the target vehicle is positive or negative, and
if the acceleration of the target vehicle is positive, increasing the acceleration following state determination counter by a second preset count value, and performing step S36, or
if the acceleration of the target vehicle is negative, increasing the deceleration following state determination counter by a third preset count value, and performing step S36; and
S36, determining whether the acceleration following state determination counter with the second preset count value added is greater than a first following state determination threshold, and determining whether the deceleration following state determination counter with the third preset count value added is greater than a second

following state determination threshold, and
if so for both cases, determining that the target vehicle is in the following state relative to the reference vehicle, otherwise, returning to step S31.

3. The method for predicting traffic flow on the vehicle according to claim 1 or 2, wherein the step of "performing traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state" specifically comprises:
taking the speed of the target vehicle as an average speed of the vehicles in the target lane.

4. The method for predicting traffic flow on the vehicle according to claim 1, 2, or 3, wherein the calculation method for the non-free driving state determination identifier is:

$$f = \frac{\dot{x}_n(t-T) - \dot{x}_{n+1}(t-T)}{\ddot{x}_{n+1}(t)}$$

wherein f is the non-free driving state determination identifier, $\dot{x}_n(t - T)$ is a speed value of the target vehicle at the moment $t - T$, $\dot{x}_{n+1}(t - T)$ is a speed value of the reference vehicle at the moment $t - T$, $\ddot{x}_{n+1}(t)$ is an acceleration value at the moment t, and T is a reaction time constant of a driver.

5. The method for predicting traffic flow on the vehicle according to any one of claims 2 to 4, wherein

step S34 further comprises:

after performing the step of "decreasing both the acceleration following state determination counter and the deceleration following state determination counter by a first preset count value" and before returning to step S31,
determining whether the acceleration following state determination counter with the first preset count value subtracted is less than the preset minimum value, and if so, assigning the acceleration following state determination counter to the preset minimum value, and then returning to perform step S31; and
determining whether the deceleration following state determination counter with the first preset count value subtracted is less than the preset minimum value, and if so, assigning the deceleration following state determination counter to the preset minimum value, and then returning to perform step S31; and

before performing step S36, the following steps are further comprised:

determining whether the acceleration following state determination counter with the second preset count value added exceeds a first preset threshold, and if so, assigning the acceleration following state determination counter to the first preset threshold, and then performing step S36; and
determining whether the deceleration following state determination counter with the third preset count value added exceeds a second preset threshold, and if so, assigning the deceleration following state determination counter to the second preset threshold, and then performing step S36.

6. A non-transitory computer-readable medium having instructions for execution by a processor, the instructions when executed by the processor causing the processor toperform a method for predicting traffic flow on the vehicle, the method preferably being the method according to any one of claims 1 to 5, the method comprising:

S1, selecting a target vehicle and a reference vehicle, wherein the reference vehicle and the target vehicle are both located in a target lane, and the reference vehicle is located in front of the target vehicle and is adjacent to the target vehicle;
S2, obtaining vehicle information of the target vehicle and the reference vehicle, and the vehicle information at least includes a vehicle code, an acceleration, and a speed;
S3, determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle, and
if not, step S4 or
if so, step S5;

S4, returning to step S2 when the target vehicle is not in the following state; and
S5, performing traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state.

7. The non-transitory computer-readable medium according to claim 6, wherein the step of "determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle" specifically comprises:

S31, obtaining the vehicle information of the target vehicle and the reference vehicle in real time at a set time interval;
S32, comparing whether a real-time vehicle code of the reference vehicle that is obtained in real time is the same as a historical vehicle code of the reference vehicle, and
if not, adjusting a following state determination counter to a preset minimum value, which comprises an acceleration following state determination counter and a deceleration following state determination counter, then updating the historical vehicle code of the reference vehicle, and returning to step S31, or
if so, step S33;
S33, calculating a non-free driving state determination identifier;
S34, determining whether the non-free driving state determination identifier is greater than a preset identifier value, and
if no, decreasing both the acceleration following state determination counter and the deceleration following state determination counter by a first preset count value, and returning to step S31, or
if so, determining that the target vehicle is in the non-free driving state, and performing step S35;
S35, determining whether the acceleration of the target vehicle is positive or negative, and
if the acceleration of the target vehicle is positive, increasing the acceleration following state determination counter by a second preset count value, and performing step S36, or
if the acceleration of the target vehicle is negative, increasing the deceleration following state determination counter by a third preset count value, and performing step S36; and
S36, determining whether the acceleration following state determination counter with the second preset count value added is greater than a first following state determination threshold, and determining whether the deceleration following state determination counter with the third preset count value added is greater than a second following state determination threshold, and
if so for both cases, determining that the target vehicle is in the following state relative to the reference vehicle, otherwise, returning to step S31.

8. The non-transitory computer-readable medium according to according to claim 6 or 7, wherein the step of "performing traffic flow prediction on the vehicle based on the vehicle information of the target vehicle when the target vehicle is in the following state" specifically comprises:
taking the speed of the target vehicle as an average speed of the vehicles in the target lane.

9. The non-transitory computer-readable medium according to claim 6, 7, or 8, wherein the calculation method for the non-free driving state determination identifier is:

$$f = \frac{\dot{x}_n(t-T) - \dot{x}_{n+1}(t-T)}{\ddot{x}_{n+1}(t)}$$

wherein f is the non-free driving state determination identifier, $\dot{x}_n(t - T)$ is a speed value of the target vehicle at the moment $t - T$, $\dot{x}_{n+1}(t - T)$ is a speed value of the reference vehicle at the moment $t - T$, $\ddot{x}_{n+1}(t)$ is an acceleration value at the moment t, and T is a reaction time constant of a driver.

10. The non-transitory computer-readable medium according to claim 7, 8, or 9, wherein step S34 further comprises:

after performing the step of "decreasing both the acceleration following state determination counter and the deceleration following state determination counter by a first preset count value" and before returning to step S31, determining whether the acceleration following state determination counter with the first preset count value subtracted is less than the preset minimum value, and if so, assigning the acceleration following state determination counter to the preset minimum value, and then returning to perform step S31; and

determining whether the deceleration following state determination counter with the first preset count value subtracted is less than the preset minimum value, and if so, assigning the deceleration following state determination counter to the preset minimum value, and then returning to perform step S31; and
before performing step S36, the following steps are further comprised:

determining whether the acceleration following state determination counter with the second preset count value added exceeds a first preset threshold, and if so, assigning the acceleration following state determination counter to the first preset threshold, and then performing step S36; and
determining whether the deceleration following state determination counter with the third preset count value added exceeds a second preset threshold, and if so, assigning the deceleration following state determination counter to the second preset threshold, and then performing step S36.

11. A vehicle, comprising a vehicle body, a processor, and a memory, wherein the memory stores a plurality of program codes, and the program codes are loaded and run by the processor to perform a method for predicting traffic flow on the vehicle according to any one of claims 1 to 5.

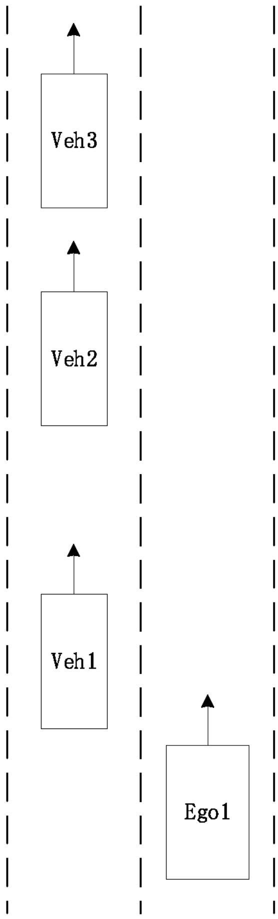


FIG. 1

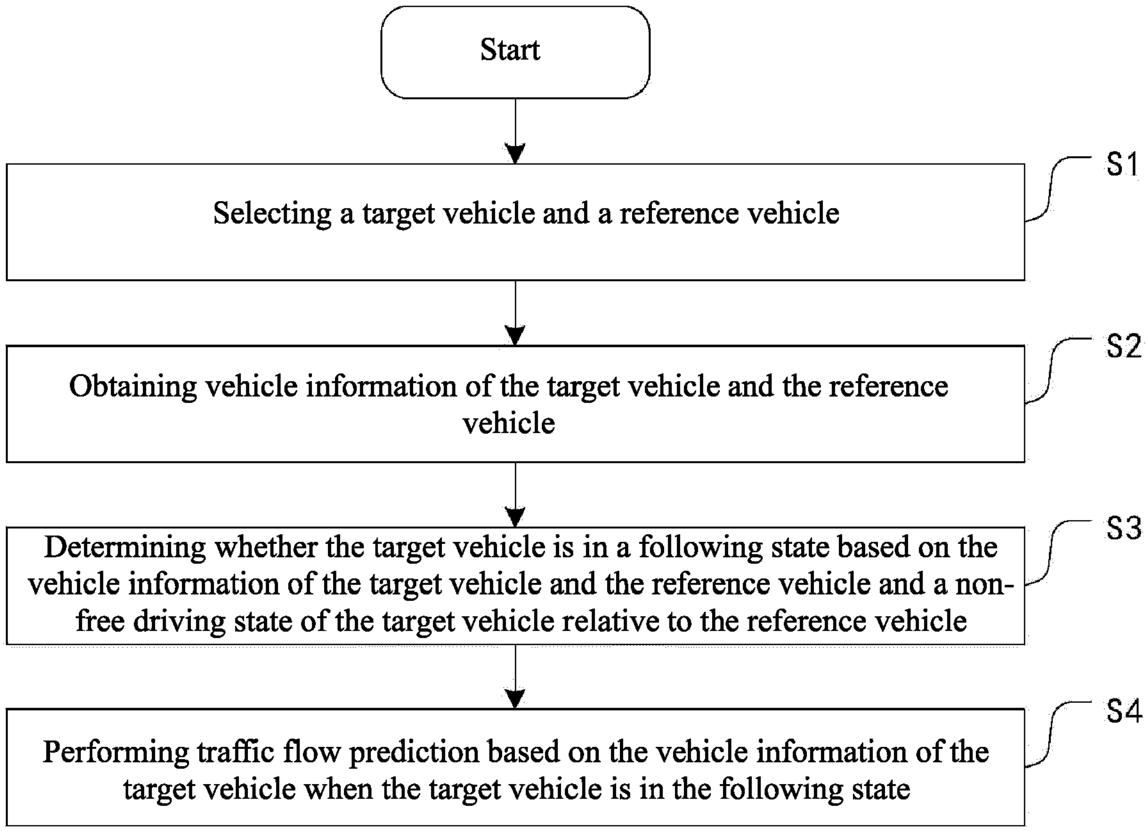
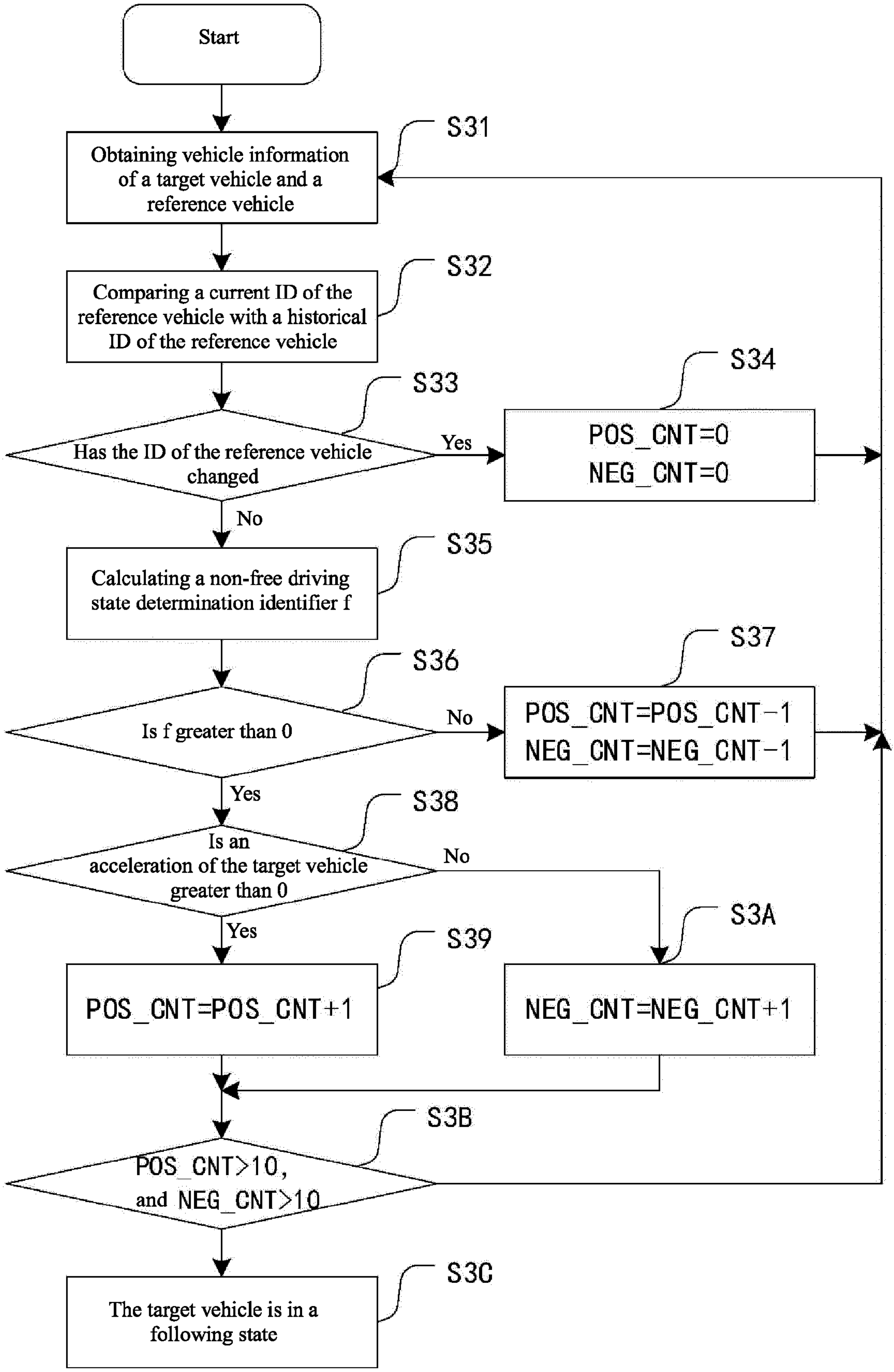

Start
Selecting a target vehicle and a reference vehicle
S1
Obtaining vehicle information of the target vehicle and the reference vehicle
S2
Determining whether the target vehicle is in a following state based on the vehicle information of the target vehicle and the reference vehicle and a non-free driving state of the target vehicle relative to the reference vehicle
S3
Performing traffic flow prediction based on the vehicle information of the target vehicle when the target vehicle is in the following state
S4

FIG. 2



Start
S31
Obtaining vehicle information of a target vehicle and a reference vehicle
S32
Comparing a current ID of the reference vehicle with a historical ID of the reference vehicle
S33
Has the ID of the reference vehicle changed
Yes
S34
POS_CNT=0
NEG_CNT=0
No
S35
Calculating a non-free driving state determination identifier f
S36
Is f greater than 0
No
S37
POS_CNT=POS_CNT-1
NEG_CNT=NEG_CNT-1
Yes
S38
Is an acceleration of the target vehicle greater than 0
No
S3A
Yes
S39
POS_CNT=POS_CNT+1
NEG_CNT=NEG_CNT+1
S3B
POS_CNT>10, and NEG_CNT>10
S3C
The target vehicle is in a following state

FIG. 3

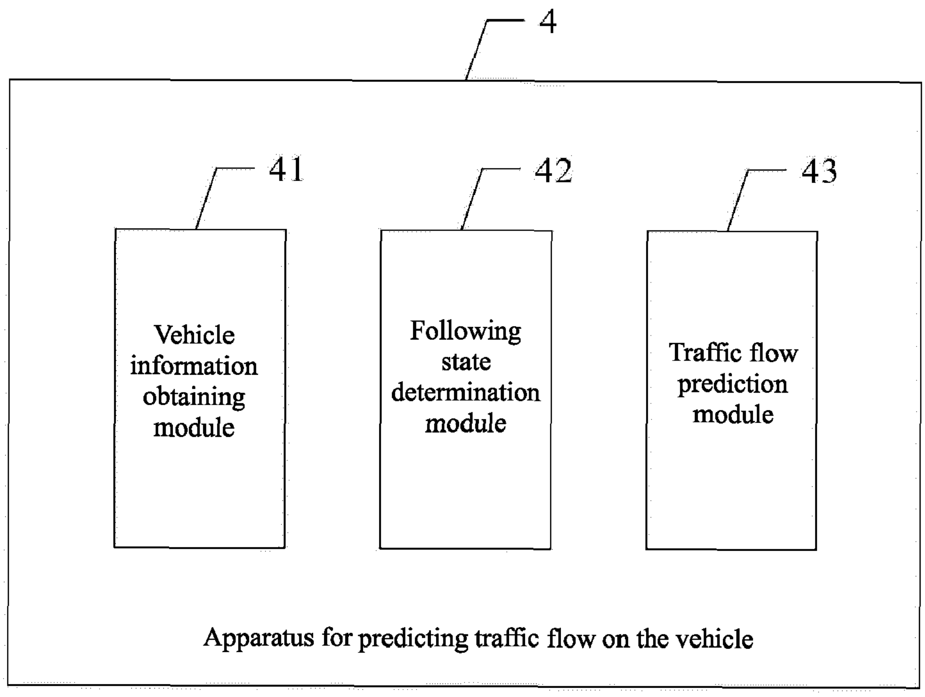

4
41
42
43
Vehicle information obtaining module
Following state determination module
Traffic flow prediction module
Apparatus for predicting traffic flow on the vehicle

FIG. 4

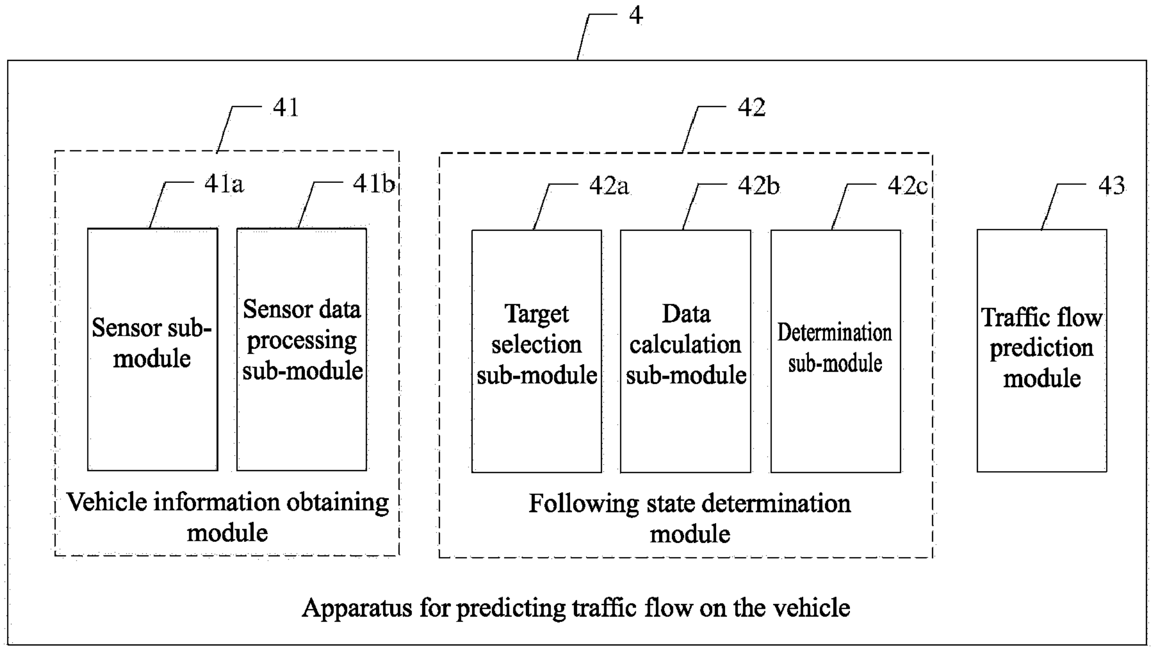

4
41
42
41a
41b
42a
42b
42c
43
Sensor sub-module
Sensor data processing sub-module
Target selection sub-module
Data calculation sub-module
Determination sub-module
Traffic flow prediction module
Vehicle information obtaining module
Following state determination module
Apparatus for predicting traffic flow on the vehicle

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 6769

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	24 February 2023	Quartier, Frank

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 6769

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	24 February 2023	Quartier, Frank

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