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(54) **TRAFFIC LIGHT PREDICTION**

(57) A method for detecting patterns in traffic light behaviours. The method comprises scanning (110) an intersection by a cloud connected vehicle using on-board sensors and analysing (130) the scanning information in the cloud. The method further comprises predicting (140) a traffic light state in the cloud based on the analysis of the scanning information and displaying (160) the predicted traffic light state in the vehicle.

Corresponding apparatus, service and system are also disclosed.

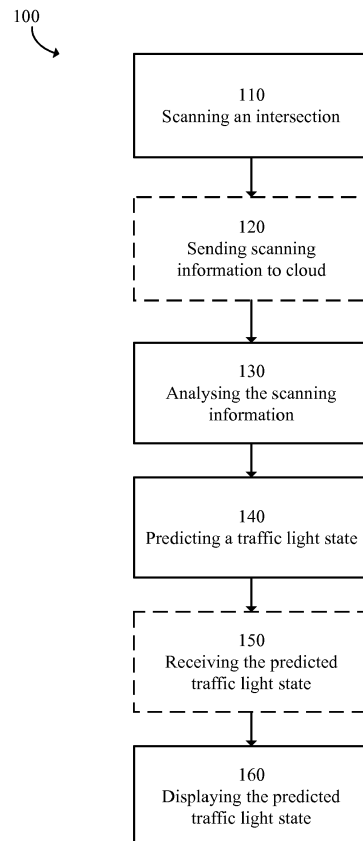


FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates generally to the field of traffic light prediction. More particularly, it relates to detecting patterns in traffic light behaviours.

BACKGROUND

[0002] An objective of traffic lights may typically be to control competing flows of traffic. Conventional traffic light systems use pre-programmed timing schedules.

[0003] In areas where traffic flows are unpredictable or rapidly changing, smoother flows can be created by means of adaptive traffic signals. Such signals adjust signal timing parameters in real-time, to adapt to traffic conditions.

[0004] Another way to improve traffic flow where pre-programmed timing schedules are used is to suggest suitable speeds to vehicles, allowing them to pass through an intersection during the green interval. For this to work, information about the traffic light state must be available. Typically, this information is provided either by infrastructure-to-vehicle communication or infrastructure-to-cloud-to-vehicle communication meaning that the traffic light must be connected in some way to the infrastructure.

[0005] Therefore, there is a need for alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to the infrastructure.

SUMMARY

[0006] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps, or components, but does not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0007] Generally, when an arrangement is referred to herein, it is to be understood as a physical product; e.g., an apparatus. The physical product may comprise one or more parts, such as controlling circuitry in the form of one or more controllers, one or more processors, or the like.

[0008] An object of some embodiments is to provide alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to the infrastructure.

[0009] According to a first aspect, this is achieved by a method for detecting patterns in traffic light behaviours.

[0010] The method comprises scanning an intersection by a cloud connected vehicle using on-board sensors

and analysing the scanning information in the cloud.

[0011] The method further comprises predicting a traffic light state in the cloud based on the analysis of the scanning information and displaying the predicted traffic light state in the vehicle.

[0012] An advantage of some embodiments is that alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to the infrastructure are provided.

[0013] Another advantage of some embodiments is that a real-time adaption to traffic conditions and competing flows of traffic is provided even for environments where traffic lights are not connected to the infrastructure. The real-time adaption ensures for detecting faults in traffic lights which are not connected to the infrastructure as well as any potential changes and existence of road works e.g. in situations where the traffic lights signals only yellow.

[0014] Yet an advantage of some embodiments is that a predictability is provided even for environments with traffic lights which are not connected to the infrastructure. The predictability ensures a safer traffic situation especially in environments such as intersections.

[0015] Yet another advantage of some embodiments is that a non-dependence of a connection to the infrastructure is provided.

[0016] In some embodiments, the scanning of the intersection comprises scanning traffic light states and traffic flows.

[0017] An advantage of some embodiments is that the scanning information provides data for training the modelling of the traffic conditions and competing flows of traffic in the cloud.

[0018] In some embodiments, the scanning information of the traffic flows comprises time, position of vehicles, number of vehicles and direction of vehicles.

[0019] An advantage of some embodiments is that the scanning information provides further detailed data for further training the modelling of the traffic conditions and competing flows of traffic in the cloud.

[0020] In some embodiments, the scanning of the intersection comprises any one of scanning as the vehicle approaches the intersection, as the vehicle passes through the intersection, and as the vehicle leaves the intersection.

[0021] An advantage of some embodiments is that the scanning information provides data at different points in time and at different points in the intersection for further training the modelling of the traffic conditions and competing flows of traffic in the cloud.

[0022] In some embodiments, the method further comprises sending a continuous stream of scanning information from the vehicle to the cloud in response to the scanning of the intersection.

[0023] An advantage of some embodiments is that the continuous scanning information provides a non-interrupted stream of data for a more correct training of the modelling of the traffic conditions and competing flows

of traffic in the cloud.

[0024] In some embodiments, the analysing of the scanning information in the cloud comprises analysis patterns.

[0025] An advantage of some embodiments is that patterns in traffic light behaviours may be discerned.

[0026] In some embodiments, the method further comprises receiving at the vehicle the predicted traffic light state from the cloud.

[0027] An advantage of some embodiments is that the vehicle speed may be adapted according to the predicted traffic light state e.g. for autonomous driving.

[0028] In some embodiments, the predicted traffic light state comprises a recommended velocity so that that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green.

[0029] An advantage of some embodiments is that the vehicle speed may be adapted according to the recommended velocity and a probability value provides a realistic expectation of reaching the traffic light at green.

[0030] A second aspect is a computer program product comprising a non-transitory computer readable medium, having thereon a computer program comprising program instructions. The computer program is loadable into a data processing unit and configured to cause execution of the method according to the first aspect when the computer program is run by the data processing unit.

[0031] A third aspect is an apparatus for detecting patterns in traffic light behaviours.

[0032] The apparatus comprises a memory comprising executable instructions and one or more processors configured to communicate with the memory.

[0033] The one or more processors are configured to cause the apparatus to scan an intersection using on-board sensors and send a continuous stream of scanning information to a cloud in response to the scan.

[0034] The one or more processors are further configured to cause the apparatus to receive a predicted traffic light state from the cloud and display the predicted traffic light state.

[0035] An advantage of some embodiments is that alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to the infrastructure are provided.

[0036] Another advantage of some embodiments is that a real-time adaption to traffic conditions and competing flows of traffic is provided even for environments where traffic lights are not connected to the infrastructure. The real-time adaption ensures for detecting faults in traffic lights which are not connected to the infrastructure as well as any potential changes and existence of road works e.g. in situations where the traffic lights signals only yellow.

[0037] Yet an advantage of some embodiments is that a predictability is provided even for environments with traffic lights which are not connected to the infrastructure. The predictability ensures a safer traffic situation especially in environments such as intersections.

[0038] Yet another advantage of some embodiments is that a non-dependence of a connection to the infrastructure is provided.

[0039] In some embodiments, the one or more processors are further configured to cause the apparatus to further receive a recommended velocity to keep such that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green.

[0040] An advantage of some embodiments is that the vehicle speed may be adapted according to the recommended velocity and a probability value provides a realistic expectation of reaching the traffic light at green.

[0041] In some embodiments, the one or more processors are further configured to cause the apparatus to display the recommended velocity to keep such that vehicle reaches the traffic light at green and/or the probability value of reaching the traffic light at green.

[0042] An advantage of some embodiments is that the vehicle speed may be adapted by a driver according to the recommended velocity and a probability value provides a realistic expectation for the driver of reaching the traffic light at green.

[0043] A fourth aspect is a vehicle comprising the apparatus of the third aspect.

[0044] An advantage of some embodiments is that alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to the infrastructure are provided.

[0045] Another advantage of some embodiments is that a real-time adaption to traffic conditions and competing flows of traffic is provided even for environments where traffic lights are not connected to the infrastructure. The real-time adaption ensures for detecting faults in traffic lights which are not connected to the infrastructure as well as any potential changes and existence of road works e.g. in situations where the traffic lights signals only yellow.

[0046] Yet an advantage of some embodiments is that a predictability is provided even for environments with traffic lights which are not connected to the infrastructure. The predictability ensures a safer traffic situation especially in environments such as intersections.

[0047] Yet another advantage of some embodiments is that a non-dependence of a connection to the infrastructure is provided.

[0048] The cloud service comprises controlling circuitry configured to receive a continuous stream of scanning information of an intersection obtained from on-board sensors from a cloud connected vehicle and analyse the scanning information in response to reception of the stream of scanning information.

[0049] The controlling circuitry of the cloud service is further configured to predict a traffic light state based on the analysis of the scanning information and provide the predicted traffic light state to the cloud connected vehicle.

[0050] An advantage of some embodiments is that alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to

the infrastructure are provided.

[0051] Another advantage of some embodiments is that a real-time adaption to traffic conditions and competing flows of traffic is provided even for environments where traffic lights are not connected to the infrastructure. The real-time adaption ensures for detecting faults in traffic lights which are not connected to the infrastructure as well as any potential changes and existence of road works e.g. in situations where the traffic lights signals only yellow.

[0052] Yet an advantage of some embodiments is that a predictability is provided even for environments with traffic lights which are not connected to the infrastructure. The predictability ensures a safer traffic situation especially in environments such as intersections.

[0053] Yet another advantage of some embodiments is that a non-dependence of a connection to the infrastructure is provided.

[0054] In some embodiments, the controlling circuitry of the cloud service is further configured to provide a recommended velocity to keep such that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green.

[0055] An advantage of some embodiments is that the vehicle speed may be adapted according to the recommended velocity and a probability value provides a realistic expectation of reaching the traffic light at green.

[0056] A sixth aspect is a system for detecting patterns in traffic light behaviours.

[0057] The system comprises a scanning module configured to scan an intersection and a transmitting module configured to send a continuous stream of scanning information.

[0058] The system further comprises an analysis module configured to analyse the scanning information and a prediction module configured to predict a traffic light state based on the analysis of the scanning information.

[0059] The system furthermore comprises a receiving module configured to receive the predicted traffic light state and a display module configured to display the predicted traffic light state.

[0060] An advantage of some embodiments is that alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to the infrastructure are provided.

[0061] Another advantage of some embodiments is that a real-time adaption to traffic conditions and competing flows of traffic is provided even for environments where traffic lights are not connected to the infrastructure. The real-time adaption ensures for detecting faults in traffic lights which are not connected to the infrastructure as well as any potential changes and existence of road works e.g. in situations where the traffic lights signals only yellow.

[0062] Yet an advantage of some embodiments is that a predictability is provided even for environments with traffic lights which are not connected to the infrastructure. The predictability ensures a safer traffic situation espe-

cially in environments such as intersections.

[0063] Yet another advantage of some embodiments is that a non-dependence of a connection to the infrastructure is provided.

[0064] In some embodiments, the receiving module is further configured to receive a recommended velocity to keep such that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green.

[0065] An advantage of some embodiments is that the vehicle speed may be adapted according to the recommended velocity and a probability value provides a realistic expectation of reaching the traffic light at green e.g. for autonomous driving.

[0066] In some embodiments, the display module is further configured to display the recommended velocity to keep such that vehicle reaches the traffic light at green and/or the probability value of reaching the traffic light at green.

[0067] An advantage of some embodiments is that the vehicle speed may be adapted by a driver according to the recommended velocity and a probability value provides a realistic expectation for the driver of reaching the traffic light at green.

[0068] In some embodiments, any of the above aspects may additionally have features identical with or corresponding to any of the various features as explained above for any of the other aspects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0069] Further objects, features and advantages will appear from the following detailed description of embodiments, with reference being made to the accompanying drawings. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the example embodiments.

Figure 1 is a flowchart illustrating example method steps according to some embodiments;

Figure 2 is a schematic overview illustrating an example system according to some embodiments;

Figure 3a is a schematic drawing illustrating an example environment according to some embodiments;

Figure 3b is a schematic drawing illustrating an example environment according to some embodiments;

Figure 4 is a schematic block diagram illustrating an example arrangement according to some embodiments; and

Figure 5 is a schematic drawing illustrating an example computer readable medium according to

some embodiments.

DETAILED DESCRIPTION

[0070] As already mentioned above, it should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps, or components, but does not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0071] Embodiments of the present disclosure will be described and exemplified more fully hereinafter with reference to the accompanying drawings. The solutions disclosed herein can, however, be realized in many different forms and should not be construed as being limited to the embodiments set forth herein.

[0072] In the following, embodiments will be described where alternative approaches to detecting patterns in traffic light behaviours for traffic lights which are not connected to the infrastructure are provided.

[0073] Traffic lights which are not connected to the infrastructure are hereinafter denoted as non-connected traffic lights.

[0074] A pattern comprises regularities in data and classification of data into different categories to discern the way in which something happens or is done.

[0075] Figure 1 is a flowchart illustrating example method steps according to some embodiments. The pattern detection method 100 is for detecting patterns in traffic light behaviours. Thus, the pattern detection method 100 may, for example, be performed by the pattern detection system 200 of Figure 2 for detecting patterns in traffic light behaviours.

[0076] The pattern detection method 100 comprises following steps.

[0077] In step 110, an intersection is scanned, i.e., monitored, by a cloud connected vehicle using on-board sensors.

[0078] A cloud connected vehicle is capable of Vehicle to Cloud (V2C) communication. The V2C technology enables an exchange of information of the vehicle or information obtained by the vehicle with a cloud system or a cloud service. This allows the vehicle to use information from other cloud connected vehicles, though the common cloud system or cloud service.

[0079] The on-board sensors may comprise detectors, cameras, 360-degree radar, LIDAR, ultrasonic sensors or any other vehicle compatible sensor for obtaining information about the environment in proximity of the vehicle.

[0080] In addition, the cloud connected vehicle may comprise an Internet connection, Advanced Driver Assistance Systems and high definition maps for more accurate object detection and localization.

[0081] In step 130, the scanning information is ana-

lysed in the cloud.

[0082] The analysis may be performed in a scalable cloud system or cloud service configured for big data analytics. Big data analytics is often a complex process of examining large and varied data sets, i.e., big data, to uncover information including hidden patterns, unknown correlations, trends and preferences for making informed decisions or predictions.

[0083] In step 140, a traffic light state is predicted in the cloud based on the analysis of the scanning information.

[0084] In step 160, the predicted traffic light state is displayed in the cloud connected vehicle e.g. on the dashboard, in a head-up display or in a Human Machine Interface in the vehicle.

[0085] In some embodiments, the pattern detection method 100 further comprises the following step.

[0086] In step 120, a continuous stream of scanning information is sent from the cloud connected vehicle to the cloud in response to the scanning of the intersection. The continuous stream of scanning information may form part of big data to be analysed by a cloud service.

[0087] In some embodiments, the pattern detection method 100 further comprises the following step.

[0088] In step 150, the predicted traffic light state from the cloud is received at the cloud connected vehicle. The receiving may be performed by receiving circuitry configured for V2C comprised in the vehicle.

[0089] In some embodiments, the scanning of the intersection may comprise scanning traffic light states and traffic flows.

[0090] In some embodiments, the scanning information of the traffic flows may comprise time, position of vehicles, number of vehicles and direction of vehicles.

[0091] In some embodiments, the scanning of the intersection may comprise any one of scanning as the vehicle approaches the intersection, as the vehicle passes through the intersection, and as the vehicle leaves the intersection.

[0092] In some embodiments, the analysing of the scanning information in the cloud may comprise analysis patterns, i.e., software analysis patterns in software engineering being conceptual models, which capture an abstraction of a situation often encountered in modelling. An analysis pattern can be represented as a group of related, generic objects (e.g. meta-classes) with stereotypical attributes (e.g. data definitions), behaviours (e.g. method signatures), and expected interactions defined in a domain-neutral manner.

[0093] Examples of analysis patterns may be a time to change traffic light state, a sequence of traffic light states (depending on e.g. time, date, holidays etc.), discrepancies of patterns, cause of discrepancies of patterns (e.g. priority to busses, road construction, emergency vehicles, pedestrian crossing road etc.)

[0094] In some embodiments, the predicted traffic light state may comprise a recommended velocity so that that cloud connected vehicle reaches the traffic light at green

and/or a probability value of reaching the traffic light at green. An example of the recommended velocity may be "Maintain speed at 30km/h" and an example of a probability value may be "95%", i.e., a probability of 95% that the traffic light state will be green at arrival at the intersection.

[0095] Figure 2 is a schematic overview illustrating an example system according to some embodiments. The pattern detection system 200 is for detecting patterns in traffic light behaviours. Thus, the pattern detection system 200 may, for example, be utilized for an environment 300a of Figure 3a and/or for an environment 300b of Figure 3b.

[0096] A cloud connected vehicle 201 comprises an apparatus for detecting patterns in traffic light behaviours. The apparatus comprises a memory comprising executable instructions, wherein one or more processors are configured to communicate with the memory.

[0097] The one or more processors are configured to cause the apparatus to scan an intersection using on-board sensors and send a continuous stream of scanning information to a cloud 202 in response to the scan.

[0098] The one or more processors are further configured to cause the apparatus to receive a predicted traffic light state from the cloud 202 and display the predicted traffic light state in the vehicle 201.

[0099] The cloud connected vehicle 201 scans, i.e., monitors, the environment in proximity of the vehicle 201, e.g. lane markings, other vehicles in other lanes or in the same lane, pedestrians, cyclists, road signs, the intersection, the non-connected traffic lights 205 and their current states using the on-board sensors which may comprise e.g. detectors, cameras, 360-degree radar, LIDAR, ultrasonic sensors or any other vehicle compatible sensor for obtaining information about the environment in proximity of the vehicle.

[0100] The cloud connected vehicle 201 may, in addition, comprise an Internet connection, Advanced Driver Assistance Systems and high definition maps for more accurate object detection and localization.

[0101] The cloud connected vehicle 201 may send a continuous stream of scanning information 206 obtained by the on-board sensors, as described above, to the cloud 202 for analysis and prediction.

[0102] The cloud 202 comprises at least one cloud database 204 and/or at least one server database 203 which are databases that typically run on a cloud computing platform and access to it is provided as a service. The database services may provide scalability and high availability of the at least one database. The cloud 202 may be comprised in a one separate cloud service or in a plurality of associated cloud services.

[0103] Any cloud connected vehicle 201 may be connected to the cloud 202 for data measuring and information consumption. The cloud connected vehicle 201 may obtain data e.g. via the on-board sensors, and send the data to the cloud 202 for data measuring. The cloud connected vehicle 201 may consume data/information from

the cloud 202 even if the cloud connected vehicle 201 has not sent data to the cloud 202, e.g. because of lack of on-board sensors, but is still capable of consuming data/information from the cloud 202 as long as it is connected to the cloud 202 and able to position itself. An example of a data/information consuming connected vehicle 201 may be a bus or a truck etc.

[0104] In the cloud 202, algorithms, e.g. machine learning algorithms or statistical algorithms with crowd sourcing approaches, create a model capable of predicting the state of the traffic lights including a probability estimate for an environment, e.g. an intersection, based on input parameters, i.e., scanning information, such as where other vehicles are detected in relation to the cloud connected vehicle 201 and how many other vehicles there are, which vehicles are currently driving through e.g. an intersection indicating which traffic light 205 is green, time of day, pedestrians at crosswalks (waiting or walking) and how many pedestrians there are.

[0105] The cloud 202 can then provide other cloud connected vehicles approaching the same non-connected traffic light 205 a prediction of the state of the non-connected traffic light 205 so that the cloud connected vehicle 201 is able to adapt by e.g. adapting its speed (manually or automatically) to an optimal speed from e.g. an energy or an environment perspective.

[0106] The cloud 202 receives a continuous stream of scanning information 206 of an environment, e.g. an intersection, obtained from the on-board sensors from the cloud connected vehicle 201.

[0107] The cloud 202 analyses the scanning information in response to reception of the stream of scanning information. The cloud 202 predicts a traffic light state based on the analysis of the scanning information. The cloud 202 may predict the traffic light state based on the scanning information obtained from the cloud connected vehicle 201 and also from scanning information obtained by other cloud connected vehicles of which scanning information may be comprised in the databases 203, 204.

[0108] More specifically, the analysis of the scanning information is performed by algorithms, e.g. machine learning algorithms or statistical algorithms with crowd sourcing approaches, which create a model of the intersection's traffic lights statuses which is continuously improved, i.e. trained, as long as new scanning information becomes available.

[0109] Until the model is fully trained, a more rudimentary model one will be used. An example of this may be a cloud connected vehicle 201 that is capable of detecting necessary parameters of e.g. an intersection reports that it is standing still at a red non-connected traffic light but no other vehicles are detected, a rudimentary model in this case is to just assume (or based on previous experience from other intersections) that non-connected traffic light will turn green shortly. This information can be used to roughly estimate a recommended vehicle speed for other cloud connected vehicles that are approaching the intersection in the same direction.

[0110] The cloud 202 provides the predicted traffic light state 207 to the cloud connected vehicle 201.

[0111] In some embodiments, the cloud connected vehicle 201 may further receive a recommended velocity to keep such that cloud connected vehicle 201 reaches the non-connected traffic light 205 at green and/or a probability value of reaching the traffic light at green.

[0112] In some embodiments, the cloud connected vehicle 201 may further display the recommended velocity to keep such that cloud connected vehicle 201 reaches the non-connected traffic light 205 at green and/or the probability value of reaching the traffic light at green.

[0113] Figure 3a is a schematic drawing illustrating an example environment according to some embodiments. The pattern detection system 200 illustrated in Figure 2 may, for example, be utilized for an environment 300a of Figure 3a.

[0114] Figure 3a illustrates an environment comprising a cloud connected vehicle 301, connected to cloud 302, driving on a road towards a non-connected traffic light 305. The cloud connected vehicle 301 receives from the cloud 302 a predicted traffic light state e.g. a recommended velocity to keep such that cloud connected vehicle 301 reaches the non-connected traffic light 305 at green and/or a probability value of reaching the non-connected traffic light 305 at green. The cloud connected vehicle 301 is further configured to display the received recommended velocity to keep such that cloud connected vehicle 301 reaches the non-connected traffic light 305 at green and/or the probability value of reaching the non-connected traffic light 305 at green. The predicted traffic light state may also comprise a recommended velocity to accelerate to or decelerate to such that the cloud connected vehicle 301 reaches the non-connected traffic light 305 at green and/or the probability value of reaching the non-connected traffic light 305 at green.

[0115] Figure 3b is a schematic drawing illustrating an example environment according to some embodiments. The pattern detection system 200 illustrated in Figure 2 may, for example, be utilized for an environment 300b of Figure 3b.

[0116] Figure 3b illustrates an environment comprising a plurality of cloud connected vehicles 301, connected to cloud 302, driving towards/through/leaving an intersection in different directions.

[0117] When a cloud connected vehicle 301 approaches the intersection, the cloud connected vehicle 301 scans, i.e., monitors, the state of the non-connected traffic lights 305 for each direction, senses or approximates the number of other vehicles in its proximity with respect to the non-connected traffic lights 305 and senses any pedestrians next to the road or crossing the road, including their position.

[0118] Further, the cloud connected vehicle 301 may sense arrows on the road or on road signs, indicating e.g. a lane direction, or any other relevant signs for modelling a traffic light behaviour of an intersection e.g. yield signs such as OK to turn at red etc.

[0119] The cloud connected vehicle 301 may continuously send the scanning information to the cloud 302. The cloud connected vehicle 301 may alternatively send the scanning information to the cloud 302 at specifically determined points in time or at regular time intervals e.g. each 5 seconds.

[0120] When the cloud connected vehicle 301 reaches the non-connected traffic lights 305 and when driving through the intersection, the cloud connected vehicle 301 senses or approximates the number of other vehicles and their locations in the intersection as well as other vehicles driving through the intersection including their position, direction and vehicle speed. Also all visible non-connected traffic lights 305 are sensed around the cloud connected vehicle 301.

[0121] Further, the cloud connected vehicle 301 senses pedestrians next to the road or crossing the road, including their position.

[0122] When the cloud connected vehicle 301 leaves the intersection, the cloud connected vehicle 301 senses the number of oncoming vehicles i.e. vehicles that are about to enter the intersection, senses the state of the non-connected traffic lights 305 behind the vehicle (e.g. using rearward facing vision sensors).

[0123] The cloud connected vehicle 301 may continuously send the scanning information to the cloud 302 until e.g. 200 meters after the intersection or until end of sight.

[0124] The cloud connected vehicles 301 receive from the cloud 302 predicted traffic light states e.g. a recommended velocity for each cloud connected vehicle 301 to keep such that cloud connected vehicle 301 reaches the non-connected traffic light 305 at green and/or a probability value of reaching the non-connected traffic light 305 at green. The cloud connected vehicles 301 are further configured to display the received recommended velocity to keep such that cloud connected vehicle 301 reaches the non-connected traffic light 305 at green and/or the probability value of reaching the non-connected traffic light 305 at green. The predicted traffic light state may also comprise a recommended velocity to accelerate to or decelerate to such that the cloud connected vehicle 301 reaches the non-connected traffic light 305 at green and/or the probability value of reaching the non-connected traffic light at green.

[0125] Figure 4 is a schematic block diagram illustrating an example arrangement according to some embodiments. The example arrangement is a pattern detection arrangement 410 for detecting patterns in traffic light behaviours.

[0126] The pattern detection arrangement 410 comprises controlling circuitry CNTR 400, which may in turn comprise a scanning arrangement SCAN 401, e.g. scanning circuitry, configured to scan or monitor an intersection, an analysing arrangement ANLS 402, e.g. analysing circuitry, configured to analyse the scanning information, an prediction arrangement PRED 403, e.g. prediction circuitry, configured to predict a traffic light state, a receiving arrangement REC 404, e.g. receiving circuitry, config-

ured to receive the predicted traffic light state, and a display arrangement DSPL 405, e.g. display circuitry, configured to display the received traffic light state.

[0127] The pattern detection arrangement 410 may be comprised in the pattern detection system 200 described in connection with Figure 2 and/or the pattern detection arrangement 410 may be configured to perform method steps of any of the methods described in connection with Figure 1.

[0128] Figure 5 is a schematic drawing illustrating an example computer readable medium according to some embodiments. The computer program product comprises a non-transitory computer readable medium 500 having thereon a computer program 510 comprising program instructions, wherein the computer program being loadable into a data processing unit and configured to cause execution of the method steps of any of the methods described in connection with Figure 1.

[0129] Generally, when an arrangement is referred to herein, it is to be understood as a physical product; e.g., an apparatus. The physical product may comprise one or more parts, such as controlling circuitry in the form of one or more controllers, one or more processors, or the like.

[0130] The described embodiments and their equivalents may be realized in software or hardware or a combination thereof. The embodiments may be performed by general purpose circuitry. Examples of general purpose circuitry include digital signal processors (DSP), central processing units (CPU), co-processor units, field programmable gate arrays (FPGA) and other programmable hardware. Alternatively or additionally, the embodiments may be performed by specialized circuitry, such as application specific integrated circuits (ASIC). The general purpose circuitry and/or the specialized circuitry may, for example, be associated with or comprised in an apparatus such as a vehicle.

[0131] Embodiments may appear within an electronic apparatus (associated with or comprised in a vehicle) comprising arrangements, circuitry, and/or logic according to any of the embodiments described herein. Alternatively or additionally, an electronic apparatus (associated with or comprised in a vehicle) may be configured to perform methods according to any of the embodiments described herein.

[0132] According to some embodiments, a computer program product comprises a computer readable medium such as, for example a universal serial bus (USB) memory, a plug-in card, an embedded drive or a read only memory (ROM). Figure 5 illustrates an example computer readable medium in the form of a compact disc (CD) ROM 500. The computer readable medium has stored thereon a computer program comprising program instructions. The computer program is loadable into a data processor (PROC) 520, which may, for example, be comprised in an apparatus or vehicle 510. When loaded into the data processing unit, the computer program may be stored in a memory (MEM) 530 associated with or

comprised in the data-processing unit. According to some embodiments, the computer program may, when loaded into and run by the data processing unit, cause execution of method steps according to, for example, any of the methods illustrated in Figure 1 or otherwise described herein.

[0133] Generally, all terms used herein are to be interpreted according to their ordinary meaning in the relevant technical field, unless a different meaning is clearly given and/or is implied from the context in which it is used.

[0134] Reference has been made herein to various embodiments. However, a person skilled in the art would recognize numerous variations to the described embodiments that would still fall within the scope of the claims.

[0135] For example, the method embodiments described herein discloses example methods through steps being performed in a certain order. However, it is recognized that these sequences of events may take place in another order without departing from the scope of the claims. Furthermore, some method steps may be performed in parallel even though they have been described as being performed in sequence. Thus, the steps of any methods disclosed herein do not have to be performed in the exact order disclosed, unless a step is explicitly described as following or preceding another step and/or where it is implicit that a step must follow or precede another step.

[0136] In the same manner, it should be noted that in the description of embodiments, the partition of functional blocks into particular units is by no means intended as limiting. Contrarily, these partitions are merely examples. Functional blocks described herein as one unit may be split into two or more units. Furthermore, functional blocks described herein as being implemented as two or more units may be merged into fewer (e.g. a single) unit.

[0137] Any feature of any of the embodiments disclosed herein may be applied to any other embodiment, wherever suitable. Likewise, any advantage of any of the embodiments may apply to any other embodiments, and vice versa.

[0138] Hence, it should be understood that the details of the described embodiments are merely examples brought forward for illustrative purposes, and that all variations that fall within the scope of the claims are intended to be embraced therein.

Claims

1. A method for detecting patterns in traffic light behaviours, comprising the steps of:

scanning (110) an intersection by a cloud connected vehicle using on-board sensors,
analysing (130) the scanning information in the cloud,
predicting (140) a traffic light state in the cloud based on the analysis of the scanning informa-

- tion, and
displaying (160) the predicted traffic light state
in the vehicle.
2. The method according to claim 1, wherein the scanning of the intersection comprises scanning traffic light states and traffic flows. 5
 3. The method according to claim 2, wherein the scanning information of the traffic flows comprises time, position of vehicles, number of vehicles and direction of vehicles. 10
 4. The method according to any of claims 1-3, wherein the scanning of the intersection comprises any one of: scanning as the vehicle approaches the intersection, as the vehicle passes through the intersection, and as the vehicle leaves the intersection. 15
 5. The method according to any of claims 1-4, further comprising the step of: 20

sending (120) a continuous stream of scanning information from the vehicle to the cloud in response to the scanning of the intersection. 25
 6. The method according to any of claims 1-5, wherein the analysing of the scanning information in the cloud comprises analysis patterns. 30
 7. The method according to any of claims 1-6, further comprising the step of: 35

receiving (150) at the vehicle the predicted traffic light state from the cloud. 35
 8. The method according to any of claims 1-7, wherein the predicted traffic light state comprises a recommended velocity so that that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green. 40
 9. A computer program product comprising a non-transitory computer readable medium (500), having thereon a computer program (510) comprising program instructions, the computer program being loadable into a data processing unit and configured to cause execution of the method according to any of claims 1 through 8 when the computer program is run by the data processing unit. 45 50
 10. An apparatus for detecting patterns in traffic light behaviours, comprising: 55

a memory comprising executable instructions, one or more processors configured to communicate with the memory wherein the one or more processors are configured to cause the apparatus to:
- scan an intersection using on-board sensors,
send a continuous stream of scanning information to a cloud in response to the scan,
receive a predicted traffic light state from the cloud, and
display the predicted traffic light state.
11. The apparatus according to claim 10, wherein the one or more processors are further configured to cause the apparatus to further receive a recommended velocity to keep such that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green.
 12. The apparatus according to any of claims 10-11, wherein the one or more processors are further configured to cause the apparatus to display the recommended velocity to keep such that vehicle reaches the traffic light at green and/or the probability value of reaching the traffic light at green.
 13. A vehicle (201) comprising the apparatus according to any of claims 10-12.
 14. A cloud service (202) for detecting patterns in traffic light behaviours, wherein the cloud service comprises controlling circuitry configured to:

receive (206) a continuous stream of scanning information of an intersection obtained from on-board sensors from a cloud connected vehicle,
analyse (203,204) the scanning information in response to reception of the stream of scanning information,
predict (203, 204) a traffic light state based on the analysis of the scanning information, and
provide (207) the predicted traffic light state to the cloud connected vehicle.
 15. The cloud service 202 according to claim 14, wherein the controlling circuitry of the cloud service is further configured to:

provide a recommended velocity to keep such that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green.
 16. A system for detecting patterns in traffic light behaviours, comprising:

a scanning module (401) configured to scan an intersection,
a transmitting module (430) configured to send a continuous stream of scanning information,

an analysis module (402) configured to analyse the scanning information,
a prediction module (403) configured to predict a traffic light state based on the analysis of the scanning information,
a receiving module (404) configured to receive the predicted traffic light state, and
a display module (405) configured to display the predicted traffic light state.

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17. The system according to claim 16, wherein the receiving module (404) is further configured to receive a recommended velocity to keep such that vehicle reaches the traffic light at green and/or a probability value of reaching the traffic light at green.

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18. The system according to any of claims 16-17, wherein the display module (405) is further configured to display the recommended velocity to keep such that vehicle reaches the traffic light at green and/or the probability value of reaching the traffic light at green.

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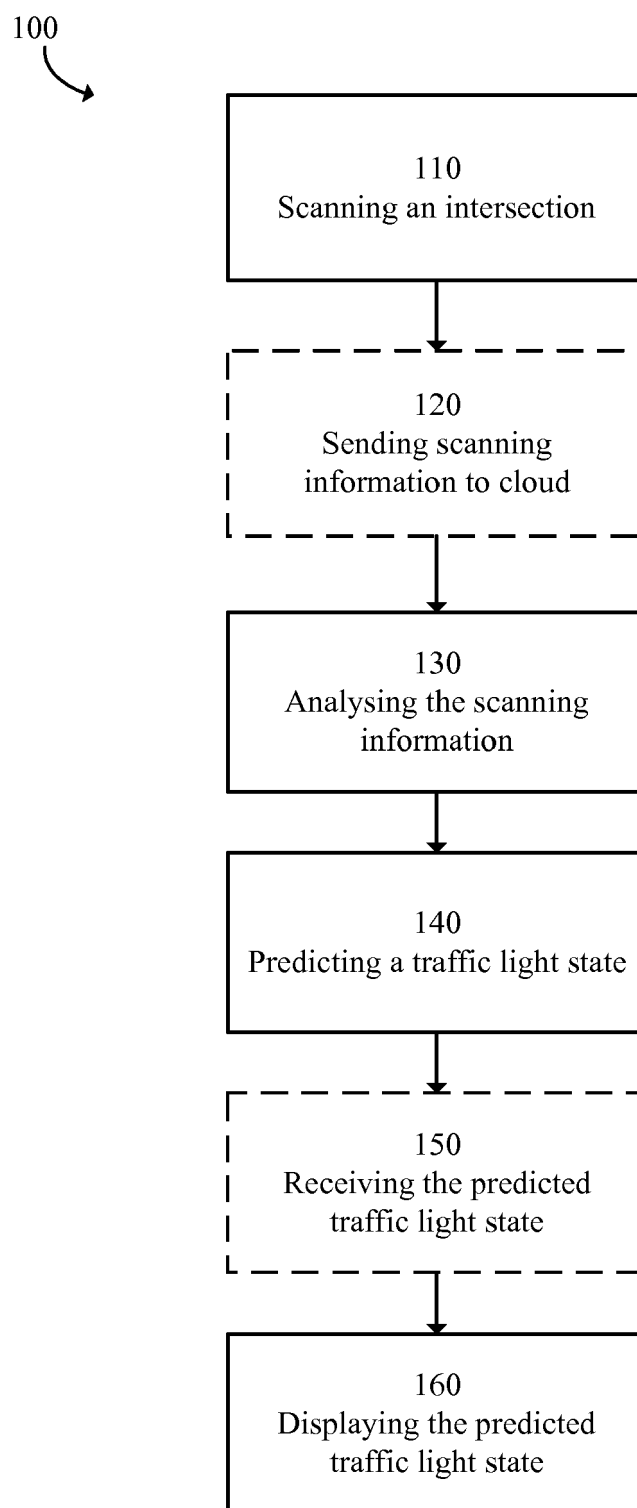


FIG. 1

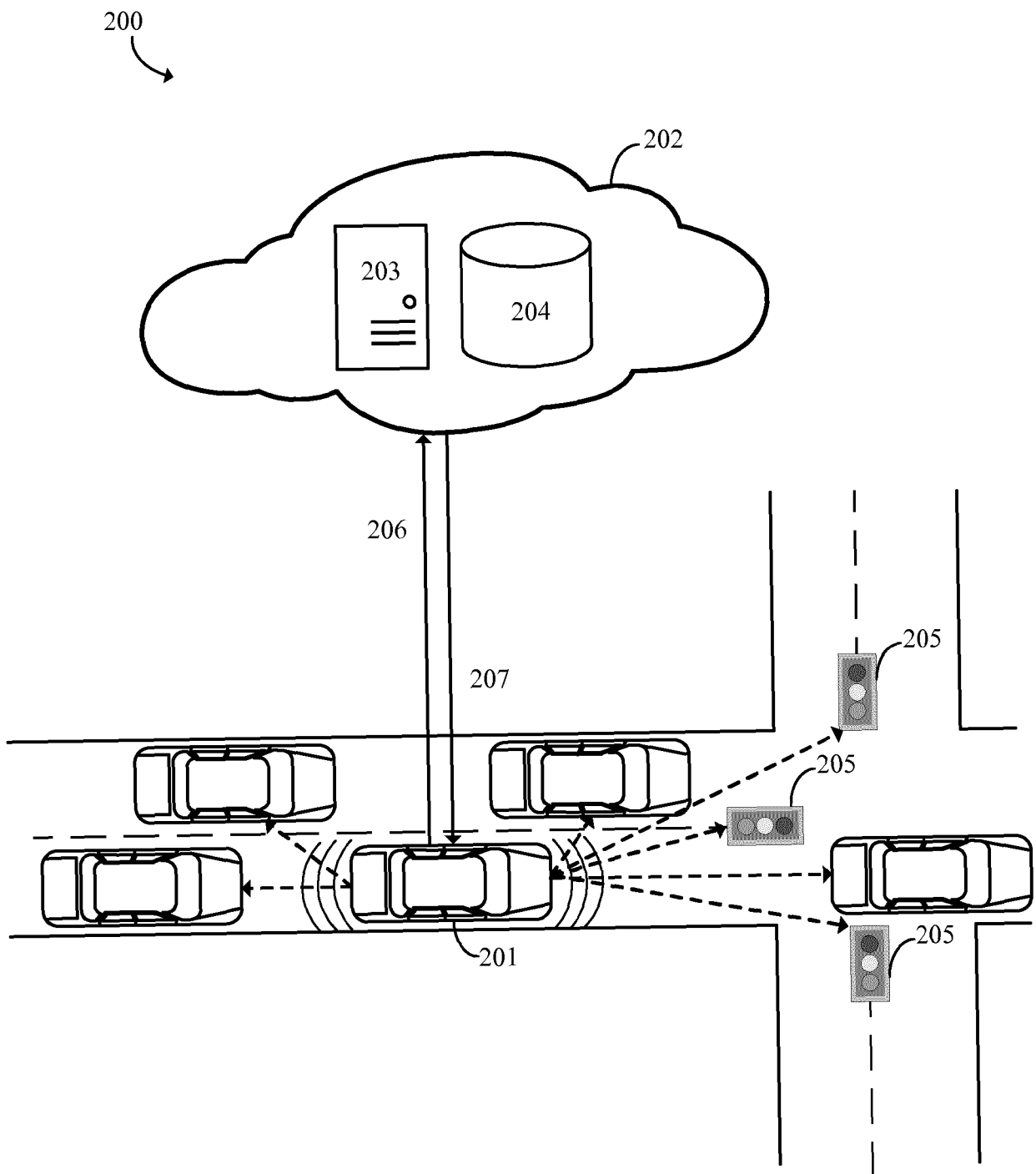


FIG. 2

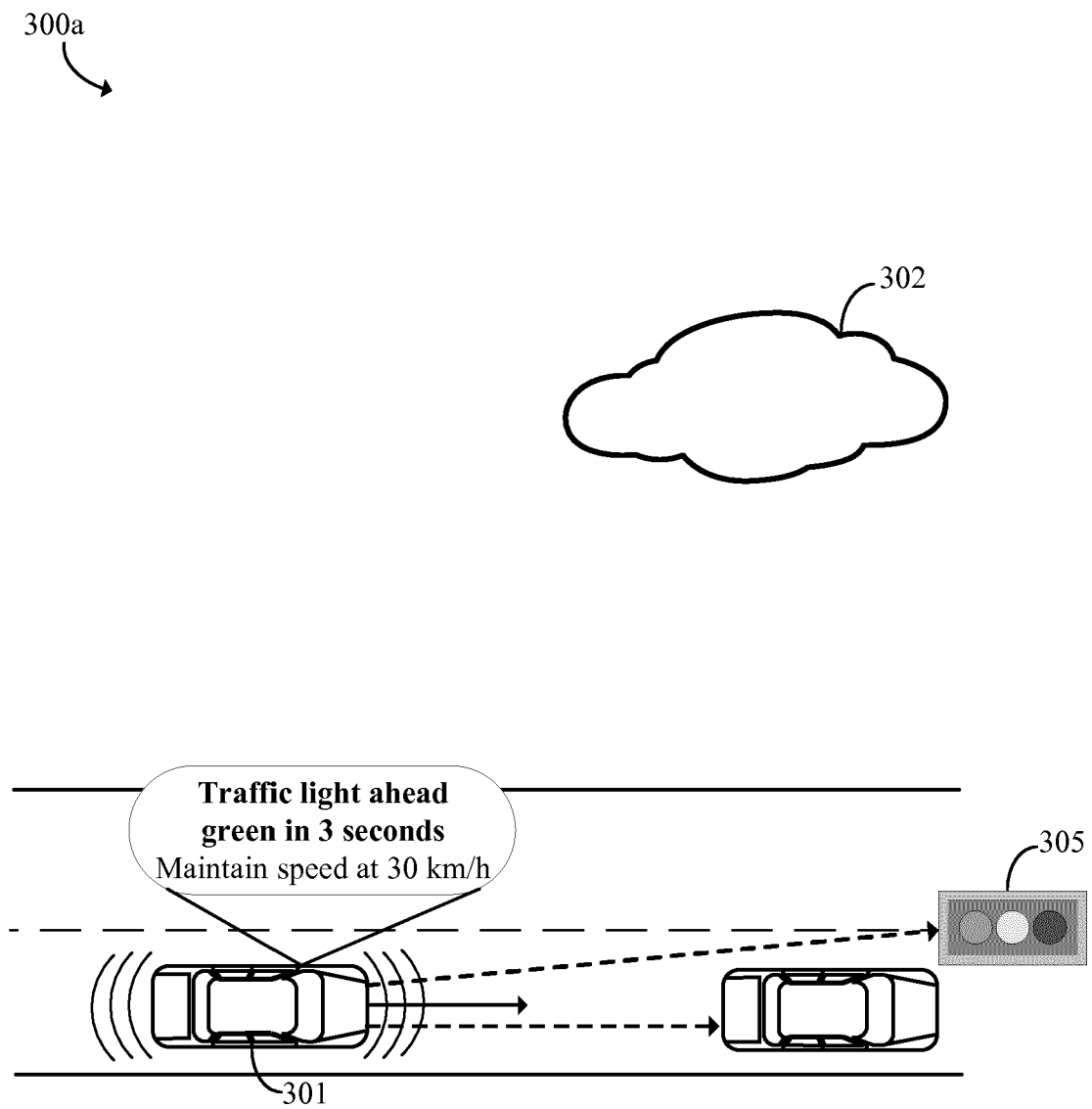


FIG. 3a

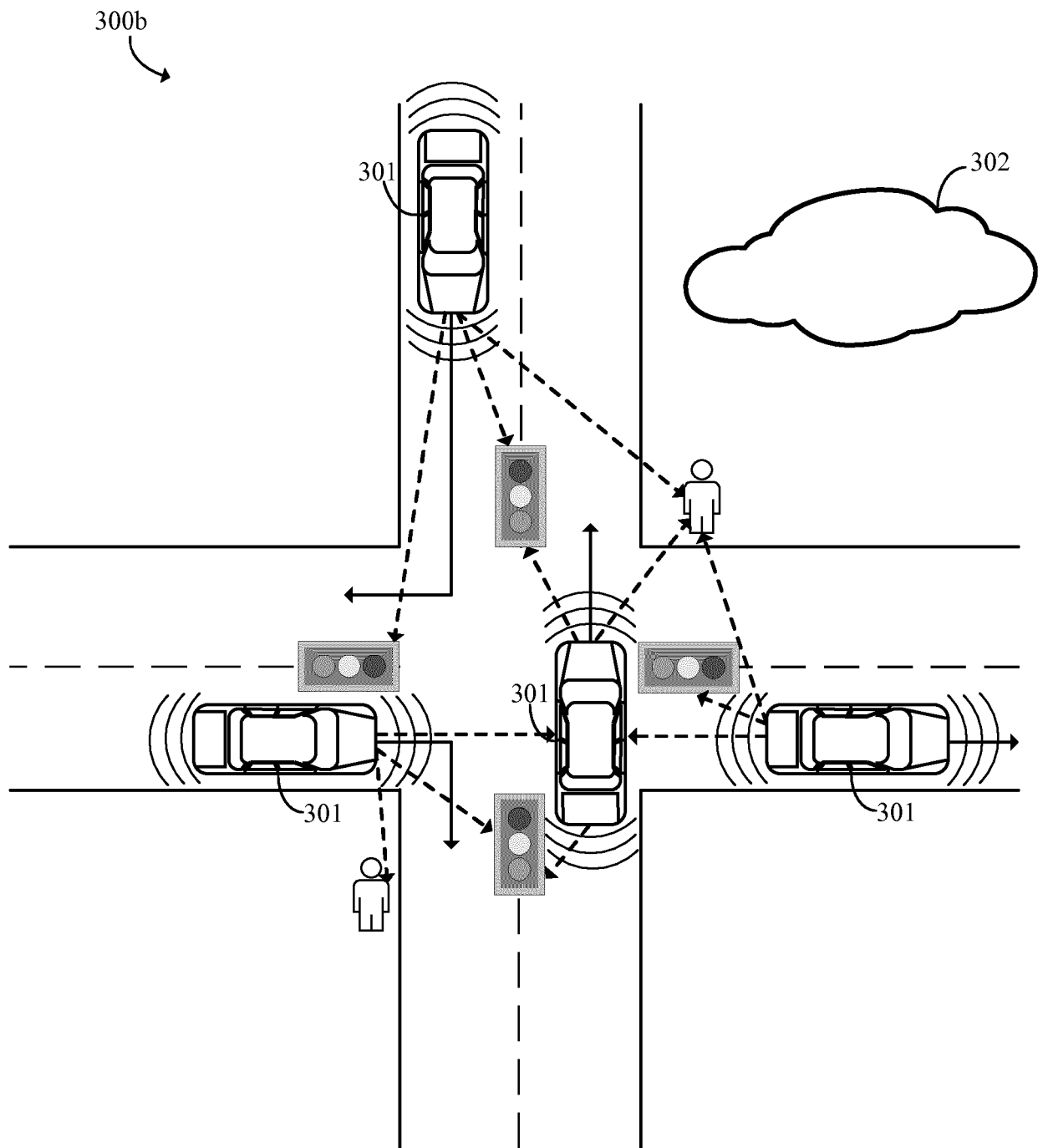


FIG. 3b

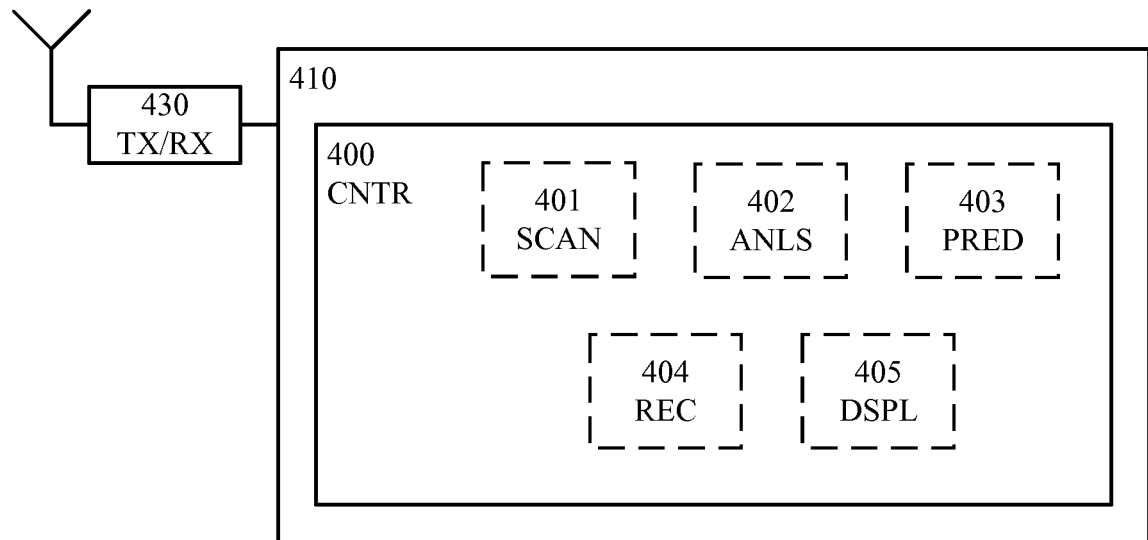


FIG. 4

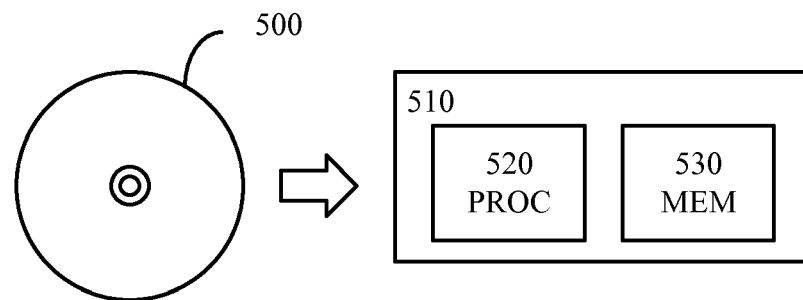


FIG. 5



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Place of search The Hague		Date of completion of the search 12 June 2019	Examiner Thareau-Berthet, N
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