



(51) International Patent Classification:
H04N 7/18 (2006.01)

(21) International Application Number:
PCT/US2015/042287

(22) International Filing Date:
27 July 2015 (27.07.2015)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
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SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,

[Continued on next page]

(54) Title: BIKE LANE STEERING CONTROL METHODS AND SYSTEMS

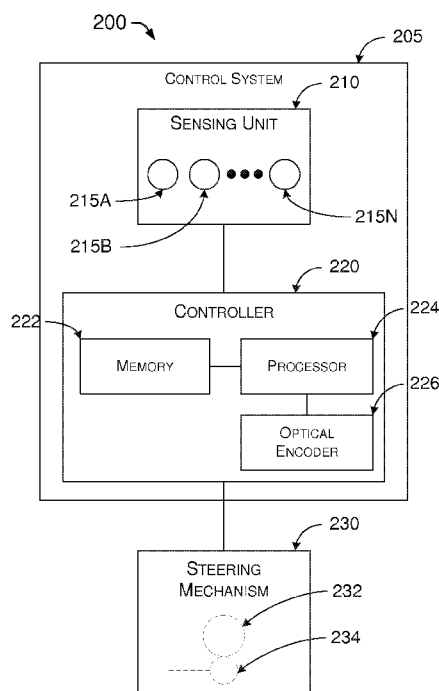


FIG. 2

(57) Abstract: Methods, devices and apparatuses pertaining to steering control of a bicycle traveling in a bike lane. A method may involve a control system installed on a bicycle detecting a deviation of the bicycle with respect to a bike lane when the bicycle is traveling in the bike lane. The method may also involve a steering mechanism, coupled to the control system, steering the bicycle to at least partially offset the deviation in response to the detecting of the deviation.

WO 2017/019022 A1



SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, **Published:**
GW, KM, ML, MR, NE, SN, TD, TG).

— *with international search report (Art. 21(3))*

BIKE LANE STEERING CONTROL METHODS AND SYSTEMS

TECHNICAL FIELD

[0001] The present disclosure generally relates to traffic safety and, more particularly, to methods and systems for steering control of a bicycle traveling in a bike lane.

BACKGROUND

[0002] Presently most bicycles, including electric bicycles, lack intelligent technology such as advanced safety technology that is more prevalent in automobiles. Bike lanes are designed to improve the safety of cyclists and car drivers who share the same roads. If a cyclist were to unknowingly start veering out of a bike lane into car traffic, the result could be catastrophic. This is a potential hazard particularly for inexperienced cyclists who may be new to the area and/or unaware of the bike lanes along major and minor roads.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Non-limiting and non-exhaustive embodiments of the present disclosure are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various figures unless otherwise specified.

[0004] FIG. 1 is a diagram depicting an example environment in which example embodiments of the present disclosure may be implemented.

[0005] FIG. 2 is a block diagram depicting an example apparatus in accordance with an embodiment of the present disclosure.

[0006] FIG. 3 is a diagram depicting an example scenario implementing an embodiment in accordance with the present disclosure.

[0007] FIG. 4 is a flowchart of an example process in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0008] In the following description, reference is made to the accompanying drawings that form a part thereof, and in which is shown by way of illustrating specific exemplary embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the concepts disclosed herein, and it is to be understood that modifications to the various disclosed embodiments may be made, and other embodiments may be utilized, without departing from the scope of the present disclosure. The following detailed description is, therefore, not to be taken in a limiting sense.

[0009] In view of the potential hazard mentioned above, it would be helpful, especially for new cyclists and riding tourists, to have a bike lane-keeping system that detects when the cyclist is deviating with respect to a bike lane and provides a smooth torque input to the handlebar or handlebar shaft of the bicycle to actively guide the bicycle back into the bike lane. Embodiments of the present disclosure may be implemented in bicycles and electric bicycles (also known as e-bikes or booster bikes) as well as in motorcycles, scooters, and other types of vehicles that travel on a road surface. Embodiments of the present disclosure may be embedded or built directly in a bicycle or as an aftermarket solution.

[0010] FIG. 1 illustrates an example environment 100 in which example embodiments of the present disclosure may be implemented. In example environment 100, a road surface 105 may be designed to allow both automobile traffic and bicycle traffic to travel thereon. One or more lines such as a line 110 and a line 120, for example, may be provided on road surface 105

to identify or otherwise designate a bike lane 115 on road surface 105. In some environments, road surface 105 may include a single line (e.g., line 110) to designate bike lane 115. Either or both of lines 110 and 120 may be solid, broken or in another pattern, and may be of any color and any texture. Accordingly, automobile traffic, including an automobile 170, may travel on road surface 105 while bicycle traffic, including a bicycle 130, may travel within bike lane 115 on road surface 105. In example environment 100, bicycle 130 generally travels in a direction 135, e.g., forward, and automobile 170 generally travels in a direction 175, e.g., forward, similar or identical to that of direction 135.

[0011] In example environment 100, bicycle 130 may be equipped with a steering control system which may include, for instance, a control system 145 and a steering mechanism 160. The control system 145 may include one or more sensors 140A – 140D and a controller 150. It is noteworthy that, although a set number of sensors is shown in FIG. 1, i.e., four, the number of sensors may vary in various embodiments of the present disclosure. Each of the one or more sensors 140A – 140D may be configured to sense information related to road surface 105 that has at least one line 110 or 120 identifying the bike lane 115. The one or more sensors 140A – 140D may generate raw or processed data representative of the sensed information. The term “raw data” herein refers to data not processed before being outputted. For example, the information sensed may be outputted as analog signals, e.g., in the form of electrical current and/or voltage, representative of the sensed information. The term “processed data” herein refers to data having been processed before being outputted, e.g., in the digital form. For example, the sensed information may be in the analog form and may be processed and outputted in the digital form. The one or more sensors 140A – 140D may include one or more optical sensors, one or more vision sensors (interchangeably referred to as imaging devices herein), or one or more

optical sensors and one or more imaging devices. At least one of the one or more sensors 140A – 140D may be mounted on the front end of bicycle 130, e.g., handlebars and/or front wheel fork, in order to have clear forward visibility. Optionally, at least one of the one or more sensors 140A – 140D may be mounted on either or both sides of bicycle 130. In embodiments where the one or more sensors 140A – 140D include multiple optical sensors, the multiple optical sensors may be positioned at different angles on the front end of bicycle 130, e.g., handlebars and/or front wheel fork, as well as either or both sides of bicycle 130 for a wider field of view. The one or more sensors 140A – 140D may be directed toward road surface 105. Moreover, the one or more sensors 140A – 140D may be disposed at different locations on bicycle 130 and positioned at different angles with respect to road surface 105.

[0012] Controller 150 may be communicatively connected to the one or more sensors 140A – 140D, e.g., wirelessly or via one or more wires, to receive the raw or processed data from the one or more sensors 140A – 140D. Controller 150 may process the received data using an algorithm to determine the presence of at least one line, e.g., line 110 and/or line 120, which defines or otherwise identifies a bike lane, e.g., bike lane 115, in the vicinity of bicycle 130. That is, when bicycle 130 is traveling in the middle of bike lane 115, a distance between line 110 and sensors 140B and/or 140D may be greater than a threshold distance for detection of line 110. Likewise, when bicycle 130 is traveling in the middle of bike lane 115, a distance between line 120 and sensors 140A and/or 140C may be greater than a threshold distance for detection of line 120. However, when bicycle 130 starts to veer left or right, a distance between bicycle 130 and line 110 or line 120 will decrease to a point where line 110 or line 120 may be sensed, e.g., image captured, by one or more of sensors 140A – 140D (e.g., one or more sensors on the side of bicycle 130 closer to line 110 or line 120).

[0013] In some embodiments, controller 150 may detect the presence of the at least one line in the vicinity of bicycle 130 based on a difference between a color or frequency of the at least one line, e.g., line 110 or line 120, and a color or frequency of road surface 105. In other embodiments, the presence of at least one line is detected based on the intensity of light reflected from the road surface back onto a sensor. Controller 150 may detect, using the information sensed by the one or more sensors 140A – 140D, a deviation of bicycle 130 with respect to bike lane 115 when bicycle 130 is traveling on road surface 105. In response to detecting the deviation, controller 150 may generate a command signal.

[0014] Steering mechanism 160 may be communicatively connected to controller 150, e.g., wirelessly or via one or more wires, to receive the command signal. In response to receiving the command signal, steering mechanism 160 may apply a torque to a handlebar or a handlebar shaft of bicycle 130 to at least partially offset the deviation in response to the detecting of the deviation.

[0015] Accordingly, embodiments of the present disclosure may detect a deviation of a bicycle with respect to a bike lane, e.g., bike lane 115, and steer the bicycle back on track to stay in the bike lane, e.g., by applying a torque to the handlebar or handlebar shaft of the bicycle. Thus, embodiments of the present disclosure would assist a cyclist to prevent the cyclist from veering the bicycle out of the bike lane and into car traffic. Advantageously this would tremendously improve the safety of the cyclist.

[0016] FIG. 2 illustrates an example apparatus 200 in accordance with an embodiment of the present disclosure. Example apparatus 200 may be implemented in example environment 100. Example apparatus 200 may include a control system 205 and a steering mechanism 230. Control system 205 may include a sensing unit 210 and a controller 220. Sensing unit 210 may

include a number of sensors 215A – 215N, where N is a positive integer greater than 1. Example apparatus 200 may be one of various implementations of example environment 100, and may be installed on a bicycle such as bicycle 130. That is, sensors 215A – 215N may be an implementation of sensors 140A – 140D, controller 220 may be an implementation of controller 150, and steering mechanism 230 may be an implementation of steering mechanism 160. Control system 205 may be installed on a bicycle, e.g., bicycle 130, and configured to detect a deviation of the bicycle with respect to a bike lane when the bicycle is traveling in the bike lane. Steering mechanism 230 may be configured to steer the bicycle to at least partially offset the deviation in response to the detecting of the deviation.

[0017] To detect a deviation of the bicycle with respect to the bike lane, control system 205 may be configured to monitor, e.g., using sensing unit 210, a path of the bicycle when the bicycle is traveling in the bike lane and determine, e.g., using controller 220, whether the bicycle is deviating with respect to the bike lane based on the monitoring. Each of the sensors 215A – 215N of sensing unit 210 may be configured to sense information related to a road surface that has at least one line identifying a bike lane. For instance, at least one of the sensors 215A – 215N may be configured to capture an image of the road surface. Additionally or alternatively, at least one of the sensors 215A – 215N may be configured to sense wavelengths of lights from the surrounding area, including wavelengths of lights reflected from the road surface. Sensors 215A – 215N of sensing unit 210 may generate raw or processed data representative of the sensed information. Sensors 215A – 215N of sensing unit 210 may include one or more optical sensors, one or more imaging devices, or one or more optical sensors and one or more imaging devices. At least one of the sensors 215A – 215N of sensing unit 210 may be mounted on the front end of a bicycle, e.g., handlebars and/or front wheel fork, in order to have clear forward

visibility. Optionally, at least one of the sensors 215A – 215N of sensing unit 210 may be mounted on either or both sides of the bicycle. In embodiments where sensors 215A – 215N of sensing unit 210 include multiple optical sensors, the multiple optical sensors may be positioned at different angles on the front end of the bicycle, e.g., handlebars and/or front wheel fork, as well as either or both sides of the bicycle for a wider field of view. Sensors 215A – 215N of sensing unit 210 may be directed toward the road surface on which the bicycle travels. Moreover, sensors 215A – 215N of sensing unit 210 may be disposed at different locations on the bicycle and positioned at different angles with respect to the road surface.

[0018] Controller 220 may be communicatively connected to sensing unit 210, e.g., wirelessly or via one or more wires, to receive the raw or processed data from sensors 215A – 215N. Controller 220 may include a memory 222 and a processor 224 coupled to memory 222. Memory 222 may be configured to store data, e.g., the raw or processed data received from sensing unit 210, as well as one or more sets of processor-executable instructions. At least one of the one or more sets of instructions may define an algorithm executable by processor 224 to detect at least one line identifying a bike lane on a road surface and to detect a deviation of the bicycle. For instance, processor 224 may process the received data using the algorithm to determine the presence of at least one line, e.g., line 110 and/or line 120, which defines or otherwise identifies a bike lane, e.g., bike lane 115, in the vicinity of the bicycle. In some embodiments, processor 224 may detect the presence of the at least one line in the vicinity of the bicycle based on a difference between a color or frequency of the at least one line and a color or frequency of the road surface. For instance, given that the lines used to identify a bike lane are typically painted in white and the color of the road surface is typically grey or dark grey, there is a difference in color as well as frequency (or wavelength) of the light reflected by the bike lane-

identifying line(s) and by the road surface. Processor 224 may detect, using the information sensed by sensors 215A – 215N, a deviation of the bicycle with respect to the bike lane when the bicycle is traveling on the road surface. In response to detecting the deviation, processor 224 may generate a command signal. In some embodiments, the presence of a line is detected using a combination of vision sensors (for image processing based on color) and optical sensors (for measuring frequency and intensity), which allows the system to distinguish between white lines and yellow lines, as well as to distinguish between reflective, retro-reflective, and non-reflective paint used, for example, to apply lines on the road surface.

[0019] Steering mechanism 230 may be communicatively connected to controller 220, e.g., wirelessly or via one or more wires, to receive the command signal. Steering mechanism 230 may include an electric motor 232 and a gear assembly 234. Electric motor 232 may be a battery-powered linear electric motor with internal bearings and a full pass-through shaft to provide the torque input to the handlebar or handlebar shaft of the bicycle. Gear assembly 234 may be mechanically engaged with the electric motor 232 and act as the physical link between electric motor 232 and a shaft that turns the handlebar. In response to receiving the command signal, electric motor 232 of steering mechanism 230 may apply a torque to the handlebar or handlebar shaft of the bicycle to at least partially offset the deviation. This helps steer the bicycle back on course to stay within the bike lane.

[0020] In some embodiments, controller 220 may control the steering mechanism 230 by controlling either or both of a rotational speed or a rotational angle associated with the torque applied by electric motor 232, based at least in part on an amount of the deviation.

[0021] In some embodiments, controller 220 may additionally include an optical encoder 226 communicatively coupled to processor 224. Optical encoder 226 may be configured to

monitor a rotational position of electric motor 232 and provide data from the monitoring to controller processor 224.

[0022] In one example scenario, processor 224 may determine an amount of initial torque to apply to at least partially offset the deviation, and steering mechanism 230 may apply the initial torque to a handlebar of the bicycle or a handlebar shaft of the bicycle to steer the bicycle. For instance, electric motor 232 of steering mechanism 230 may apply the initial torque by turning gear assembly 234 of steering mechanism 230 which is engaged to the handlebar of the bicycle or the handlebar shaft of the bicycle. When the initial torque is applied, control system 205 may monitor a rotational position of an electric motor of the steering mechanism, e.g., using optical encoder 226, and control either or both of a rotational speed and a rotational angle associated with the initial torque applied by the electric motor, based at least in part on an amount of the deviation. In steering the bicycle, control system 205 may also monitor a result of the steering of the bicycle and determine whether additional torqueing is required to offset the deviation. In response to a determination that additional torqueing is required, control system 205 may cause steering mechanism 230 to apply an additional torque or a counter torque to the handlebar of the bicycle or the handlebar shaft of the bicycle to steer the bicycle.

[0023] FIG. 3 is a diagram depicting an example scenario 300 implementing an embodiment in accordance with the present disclosure. Example scenario 300 may be one of various implementation scenarios based on example environment 100, and is provided solely for illustrative purpose so that those skilled in the art may better appreciate benefits and advantages provided by the present disclosure. Therefore, the scope of the present disclosure is not limited by example scenario 300.

[0024] In example scenario 300, a cyclist 370 rides a bicycle 360 which is equipped with a stability control device. Stability control device may be a built-in solution or an aftermarket solution. In the former case the combination of bicycle 360 and the stability control device may be considered as an apparatus. Stability control device may include a control system, e.g., control system 205, and a steering mechanism, e.g., steering mechanism 230. The control system of the stability control device may be configured to detect a deviation of bicycle 360 from a bike lane when bicycle 360 is traveling in the bike lane. The steering mechanism of the stability control device may be controlled by the control system, and may be configured to receive a command signal from the control system, in response to the control system detecting the deviation, to apply a torque to at least partially offset the deviation.

[0025] In example scenario 300, the control system may include a plurality of sensors, e.g., sensors 310A and 310B as shown in FIG. 3, and a controller 320. The plurality of sensors may be configured to sense information related to a road surface that has at least one line identifying the bike lane. Controller 320 may be communicatively coupled to receive the sensed information from the plurality of sensors, e.g., sensors 310A and 310B, to detect a presence of the at least one line in a vicinity of bicycle 360. The plurality of sensors may include one or more optical sensors, one or more imaging devices, or one or more optical sensors and one or more imaging devices, which are disposed at different locations on bicycle 360 and directed toward the road surface at different angles with respect to the road surface. Controller 320 may be configured to detect the presence of the at least one line based on a difference between a color or frequency of the at least one line and a color or frequency of the road surface.

[0026] The steering mechanism may include an electric motor 330 and a gear assembly 340. Electric motor 330 may be configured to apply the torque to help steer bicycle 360. Gear

assembly 340 may be coupled to electric motor 330 and configured to engage a handlebar of bicycle 360 or a handlebar shaft of bicycle 360. Gear assembly 340 may turn the handlebar or the handlebar shaft of bicycle 360 in response to electric motor 330 applying the torque.

[0027] In some embodiments, controller 320 of the control system may be configured to control the steering mechanism by controlling either or both of a rotational speed or a rotational angle associated with the torque applied by electric motor 330, based at least in part on an amount of the deviation.

[0028] In some embodiments, the control system may also include an optical encoder 350 communicatively coupled to controller 320. Optical encoder 350 may be configured to monitor a rotational position of electric motor 330 of the steering mechanism and provide a result of the monitoring to controller 320. Accordingly, data as a result of the monitoring provided back to controller 320 may be treated as feedback for adjusting the amount of torque provided by electric motor 330.

[0029] FIG. 4 illustrates an example process 400 in accordance with an embodiment of the present disclosure. Example process 400 may include one or more operations, actions, or functions shown as blocks such as 402 and 404 which may encompass sub-blocks 410, 420, 430, 440, 450, 460 and 470. Although illustrated as discrete blocks, various blocks may be divided into additional blocks, combined into fewer blocks, or eliminated, depending on the desired implementation. Example process 400 may be implemented in example environment 100, example apparatus 200 and/or example scenario 300. For simplicity of description and not limiting the scope thereof, example process 400 is described below in the context of example apparatus 200. Example process 400 may begin with block 402.

[0030] At 402, example process 400 may involve control system 205 detecting a deviation of a bicycle, e.g., bicycle 130, with respect to a bike lane, e.g., bike lane 115, when the bicycle is traveling in the bike lane. Block 402 may be followed by block 404.

[0031] At 404, example process 400 may involve steering mechanism 230 steering the bicycle to at least partially offset the deviation in response to the detecting of the deviation.

[0032] In detecting the deviation of the bicycle with respect to the bike lane, example process 400 may involve a number of operations including 410 and 420.

[0033] At 410, example process 400 may involve control system 205 monitoring a path of the bicycle when the bicycle is traveling in the bike lane. In some embodiments, in monitoring the path of the bicycle, example process 400 may involve one or more of sensors 215A – 215N of sensing unit 210 of control system 205 sensing information related to a road surface that has at least one line identifying the bike lane, and further involve controller 220 of control system 205 detecting a presence of the at least one line in a vicinity of the bicycle. In some embodiments, the one or more sensors 215A – 215N may include one or more optical sensors or one or more imaging devices of the control system that are disposed at different locations on the bicycle and directed toward the road surface at different angles with respect to the road surface. In some embodiments, controller 220 may detect the presence of the at least one line based on a difference between a color or frequency of the at least one line and a color or frequency of the road surface. Sub-block 410 may be followed by sub-block 420.

[0034] At 420, example process 400 may involve control system 205 determining whether the bicycle is deviating with respect to the bike lane based on the monitoring. For instance, controller 220 may determine that the bicycle is deviating with respect to the bike lane based on the detection of a presence of the at least one line identifying the bike lane, e.g., based

on a difference between a color or frequency of the at least one line and a color or frequency of the road surface.

[0035] In steering the bicycle, example process 400 may involve a number of operations including 430, 440, 450, 460 and 470.

[0036] At 430, upon a determination that the bicycle is deviating with respect to the bike lane, example process 400 may involve control system 205 determining an amount of initial torque to apply to at least partially offset the deviation. For instance, based on an amount of the deviation and a speed of the bicycle, controller 220 of control system 205 may determine how much amount of torquing to be applied to steer the bicycle to offset the deviation. Sub-block 430 may be followed by sub-block 440.

[0037] At 440, example process 400 may involve steering mechanism 230 applying the initial torque to a handlebar of the bicycle or a handlebar shaft of the bicycle to steer the bicycle. In some embodiments, in applying the initial torque, electric motor 232 of steering mechanism 230 may apply the initial torque by turning gear assembly 234 of steering mechanism 230 which is engaged to the handlebar of the bicycle or the handlebar shaft of the bicycle. In some embodiments, in applying the initial torque, control system 205 may monitor, e.g., using optical encoder 226, a rotational position of electric motor 232 of steering mechanism 230, and control system 205 may control either or both of a rotational speed and a rotational angle associated with the initial torque applied by electric motor 232 based at least in part on an amount of the deviation. Sub-block 440 may be followed by sub-block 450.

[0038] At 450, example process 400 may involve control system 205 monitoring a result of the steering of the bicycle. For instance, controller 220 may utilize information received from

one or more sensors 215A – 215N of sensing unit 210 to continuously monitor the result of the steering. Sub-block 450 may be followed by sub-bloc 460.

[0039] At 460, example process 400 may involve control system 205 determining whether additional torqueing is required to offset the deviation. For instance, after applying the initial torque, controller 220 of control system 205 may determine whether the initial torque was insufficient or excessive in terms of offsetting the detected deviation. On one hand, if it is determined that the initial torque was insufficient, controller 220 may determine that an additional torque is required to supplement the initial torque in offsetting the deviation. On the other hand, if it is determined that the initial torque was excessive, controller 220 may determine that a counter torque is required to compensate for the initial torque. Sub-bloc, 460 may be followed by sub-block 470.

[0040] At 470, in response to a determination that additional torqueing is required, example process 400 may involve steering mechanism 230 applying an additional torque or a counter torque to the handlebar of the bicycle or the handlebar shaft of the bicycle to steer the bicycle.

[0041] After applying the additional torqueing, whether an additional torque or a counter torque, control system 205 may continue to monitor a result of the steering of the bicycle. For instance, after 470 example process 400 may continue at 450 to repeat at least a part of the process. In an event that it is determined that additional torqueing is not required, example process 400 may continue to detect any further deviation of the bicycle by monitoring the path of the bicycle with respect to the bike lane as the bicycle continues to travel in the bike lane. For instance, in an event that it is determined that additional torqueing is not required at 460,

example process 400 may resume at 410 to monitor the path of the bicycle as the bicycle travels in the bike lane.

[0042] The articles “a” and “an” are used herein to refer to one or to more than one (i.e., to at least one) of the grammatical object of the article. By way of example, “a user” means one user or more than one users. Reference throughout this specification to “one embodiment,” “an embodiment,” “one example,” or “an example” means that a particular feature, structure, or characteristic described in connection with the embodiment or example is included in at least one embodiment of the present disclosure. Thus, appearances of the phrases “in one embodiment,” “in an embodiment,” “one example,” or “an example” in various places throughout this specification are not necessarily all referring to the same embodiment or example. Furthermore, the particular features, structures, databases, or characteristics may be combined in any suitable combinations and/or sub-combinations in one or more embodiments or examples. In addition, it should be appreciated that the figures provided herewith are for explanation purposes to persons ordinarily skilled in the art and that the drawings are not necessarily drawn to scale.

[0043] Embodiments in accordance with the present disclosure may be embodied as an apparatus, method, or computer program product. Accordingly, the present disclosure may take the form of an entirely hardware-comprised embodiment, an entirely software-comprised embodiment (including firmware, resident software, micro-code or the like), or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module,” or “system.” Furthermore, embodiments of the present disclosure may take the form of a computer program product embodied in any tangible medium of expression having computer-usable program code embodied in the medium.

[0044] The flow diagrams and block diagrams in the attached figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present disclosure. In this regard, each block in the flow diagrams or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It will also be noted that each block of the block diagrams and/or flow diagrams, and combinations of blocks in the block diagrams and/or flow diagrams, may be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions. These computer program instructions may also be stored in a computer-readable medium that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable medium produce an article of manufacture including instruction means which implement the function/act specified in the flow diagram and/or block diagram block or blocks.

[0045] Although the present disclosure is described in terms of certain embodiments, other embodiments will be apparent to those of ordinary skill in the art, given the benefit of this disclosure, including embodiments that do not provide all of the benefits and features set forth herein, which are also within the scope of this disclosure. It is to be understood that other embodiments may be utilized, without departing from the scope of the present disclosure.

CLAIMS

1. A method, comprising:

detecting, by a control system installed on a bicycle, a deviation of the bicycle with respect to a bike lane when the bicycle is traveling in the bike lane; and

steering, by a steering mechanism coupled to the control system, the bicycle to at least partially offset the deviation in response to the detecting of the deviation.

2. The method of claim 1, wherein the detecting of the deviation comprises:

monitoring a path of the bicycle when the bicycle is traveling in the bike lane; and

determining whether the bicycle is deviating with respect to the bike lane based on the monitoring.

3. The method of claim 2, wherein the monitoring of the path of the bicycle comprises:

sensing information related to a road surface that has at least one line identifying the bike lane; and

detecting a presence of the at least one line in a vicinity of the bicycle,

wherein the sensing comprises sensing by one or more optical sensors or one or more imaging devices of the control system that are disposed at different locations on the bicycle and directed toward the road surface at different angles with respect to the road surface, and

wherein the detecting of the presence of the at least one line comprises detecting the presence of the at least one line based on a difference between a color or frequency of the at least one line and a color or frequency of the road surface.

4. The method of claim 3, wherein detecting a presence of the at least one line in a vicinity of the bicycle includes detecting an intensity of light reflected from the road surface back onto a sensor.

5. The method of claim 1, wherein the steering of the bicycle comprises:
determining an amount of initial torque to apply to at least partially offset the deviation;
and
applying the initial torque to a handlebar of the bicycle or a handlebar shaft of the bicycle to steer the bicycle.

6. The method of claim 5, wherein the applying of the initial torque comprises applying the initial torque by an electric motor of the steering mechanism turning a gear assembly of the steering mechanism that is engaged to the handlebar of the bicycle or the handlebar shaft of the bicycle.

7. The method of claim 5, wherein the applying of the initial torque comprises:
monitoring, by the control system, a rotational position of an electric motor of the steering mechanism; and
controlling, by the control system, either or both of a rotational speed and a rotational angle associated with the initial torque applied by the electric motor based at least in part on an amount of the deviation.

8. The method of claim 5, wherein the steering of the bicycle further comprises:
monitoring, by the control system, a result of the steering of the bicycle;
determining whether additional torquing is required to offset the deviation; and
in response to a determination that additional torquing is required, applying an additional torque or a counter torque to the handlebar of the bicycle or the handlebar shaft of the bicycle to steer the bicycle.

9. An apparatus, comprising:
a control system associated with a bicycle and configured to detect a deviation of the bicycle with respect to a bike lane when the bicycle is traveling in the bike lane; and
a steering mechanism controlled by the control system, the steering mechanism configured to receive a command signal from the control system, in response to the control system detecting the deviation, to apply a torque to at least partially offset the deviation.

10. The apparatus of claim 9, wherein the control system comprises:
a plurality of sensors configured to sense information related to a road surface that has at least one line identifying the bike lane; and
a controller communicatively coupled to receive the sensed information from the sensors to detect a presence of the at least one line in a vicinity of the bicycle.

11. The apparatus of claim 10, wherein the plurality of sensors comprise one or more optical sensors or one or more imaging devices that are disposed at different locations on the bicycle and directed toward the road surface at different angles with respect to the road surface.

12. The apparatus of claim 10, wherein the controller is configured to detect the presence of the at least one line based on a difference between a color or frequency of the at least one line and a color or frequency of the road surface.

13. The apparatus of claim 10, wherein the control system further comprises:
an optical encoder communicatively coupled to the controller, the optical encoder configured to monitor a rotational position of an electric motor of the steering mechanism and provide a result of the monitoring to the controller.

14. The apparatus of claim 9, wherein the steering mechanism comprises:
an electric motor configured to apply the torque; and
a gear assembly coupled to the electric motor and configured to engage a handlebar of the bicycle or a handlebar shaft of the bicycle,
wherein the gear assembly turns the handlebar or the handlebar shaft of the bicycle in response to the electric motor applying the torque.

15. An apparatus, comprising:
a bicycle;
a control system associated with the bicycle and configured to detect a deviation of the bicycle with respect to a bike lane when the bicycle is traveling in the bike lane; and

a steering mechanism controlled by the control system, the steering mechanism configured to receive a command signal from the control system, in response to the control system detecting the deviation, to apply a torque to at least partially offset the deviation.

16. The apparatus of claim 15, wherein the control system comprises:

a plurality of sensors configured to sense information related to a road surface that has at least one line identifying the bike lane; and

a controller communicatively coupled to receive the sensed information from the sensors to detect a presence of the at least one line in a vicinity of the bicycle,

wherein the plurality of sensors comprise one or more optical sensors or one or more imaging devices that are disposed at different locations on the bicycle and directed toward the road surface at different angles with respect to the road surface.

17. The apparatus of claim 16, wherein the controller is configured to detect the presence of the at least one line based on a difference between a color or frequency of the at least one line and a color or frequency of the road surface.

18. The apparatus of claim 16, wherein the control system further comprises:

an optical encoder communicatively coupled to the controller, the optical encoder configured to monitor a rotational position of an electric motor of the steering mechanism and provide a result of the monitoring to the controller.

19. The apparatus of claim 15, wherein the steering mechanism comprises:
an electric motor configured to apply the torque; and
a gear assembly coupled to the electric motor and configured to engage a handlebar of the bicycle or a handlebar shaft of the bicycle,
wherein the gear assembly turns the handlebar or the handlebar shaft of the bicycle in response to the electric motor applying the torque.

20. The apparatus of claim 15, wherein the control system is further configured to control the steering mechanism by controlling either or both of a rotational speed or a rotational angle associated with the torque based at least in part on an amount of the deviation.

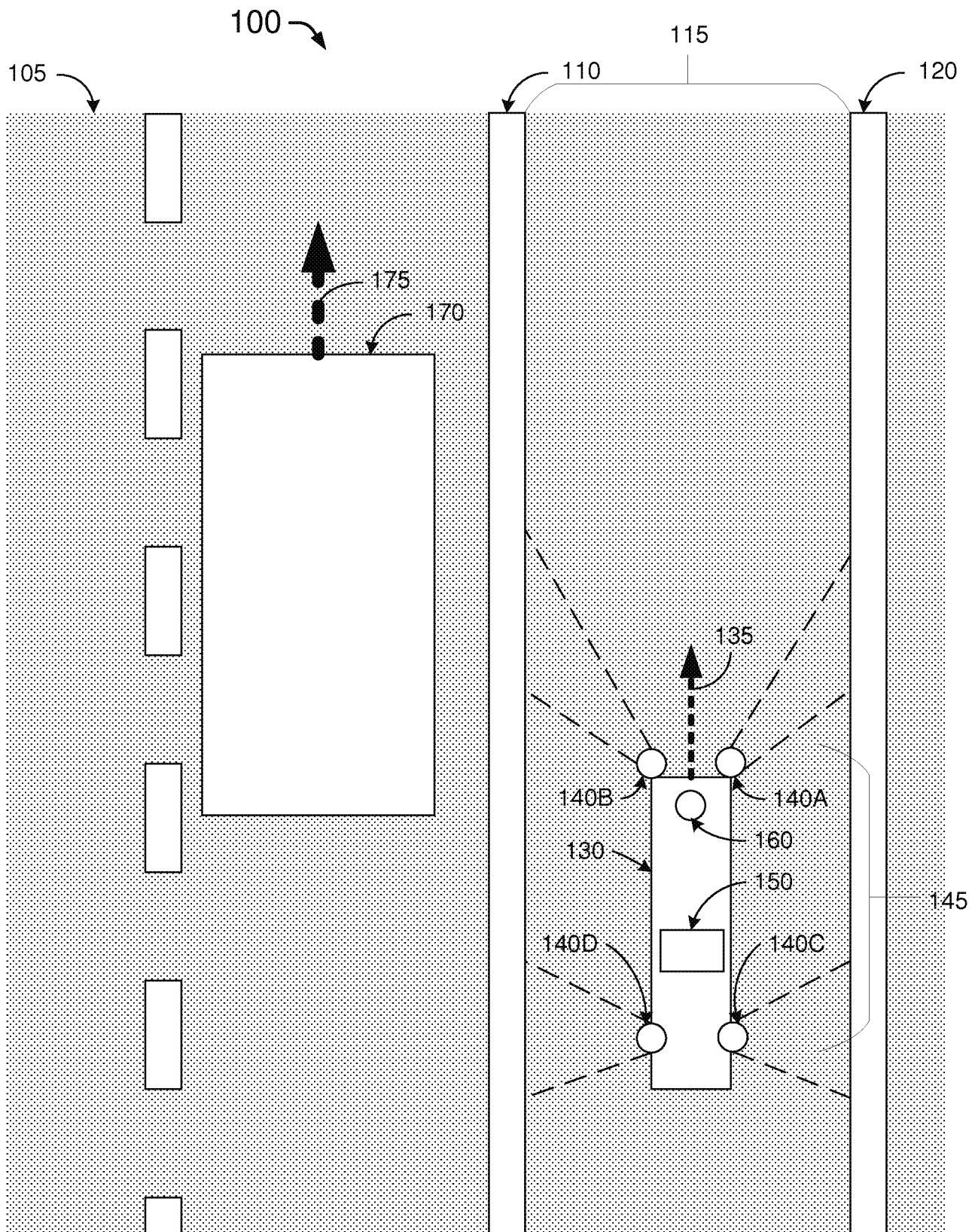


FIG. 1

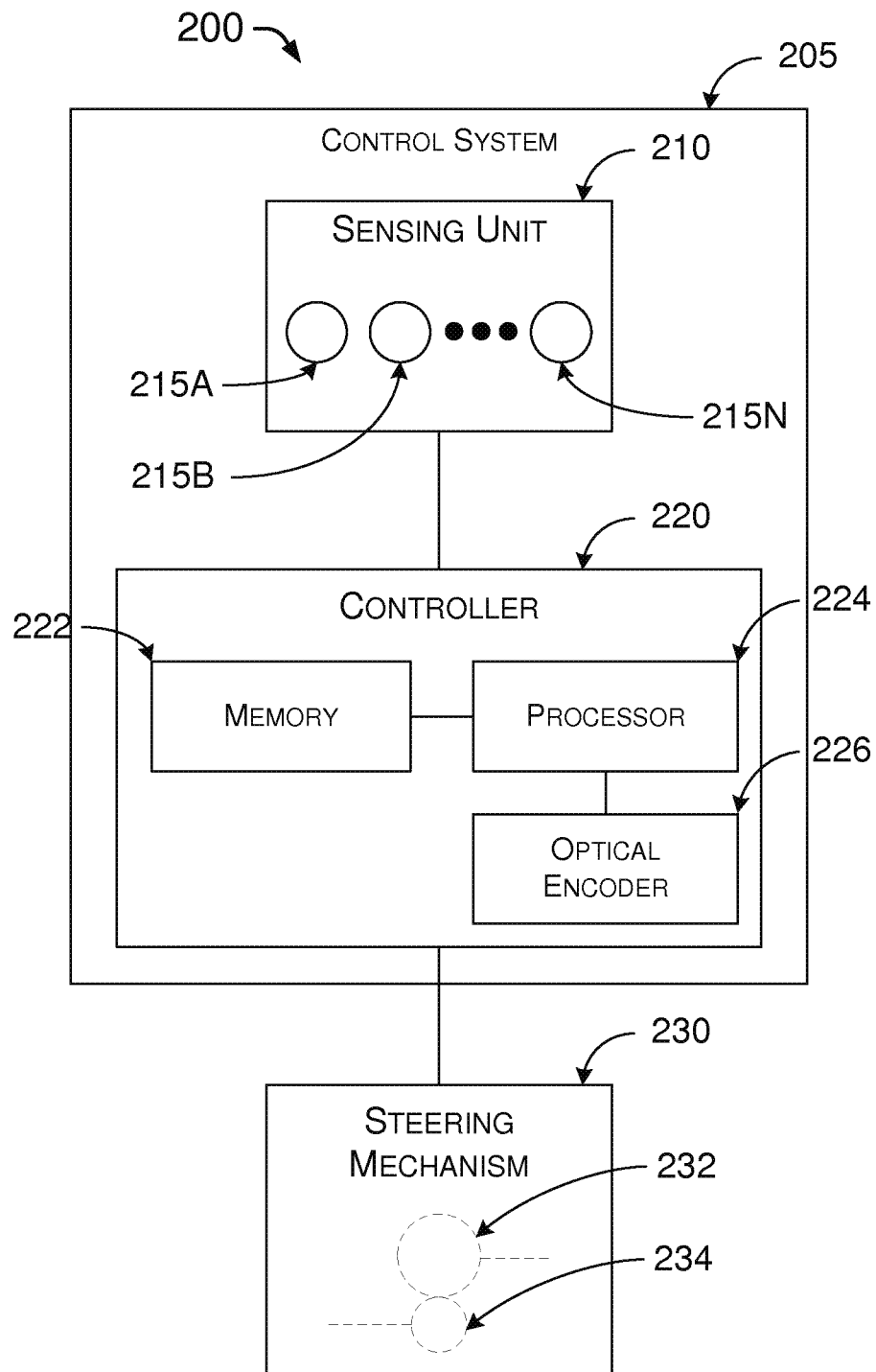


FIG. 2

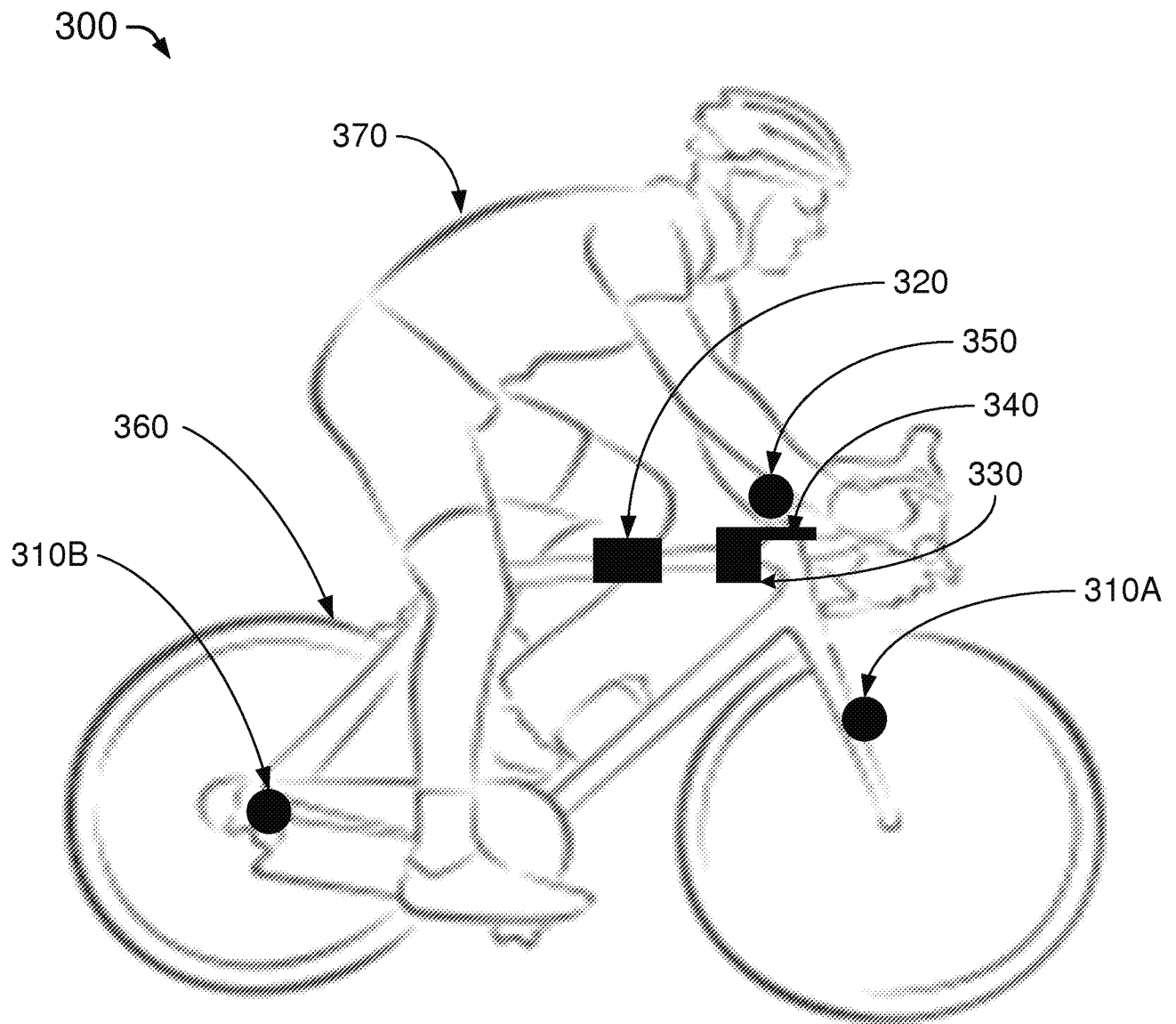


FIG. 3

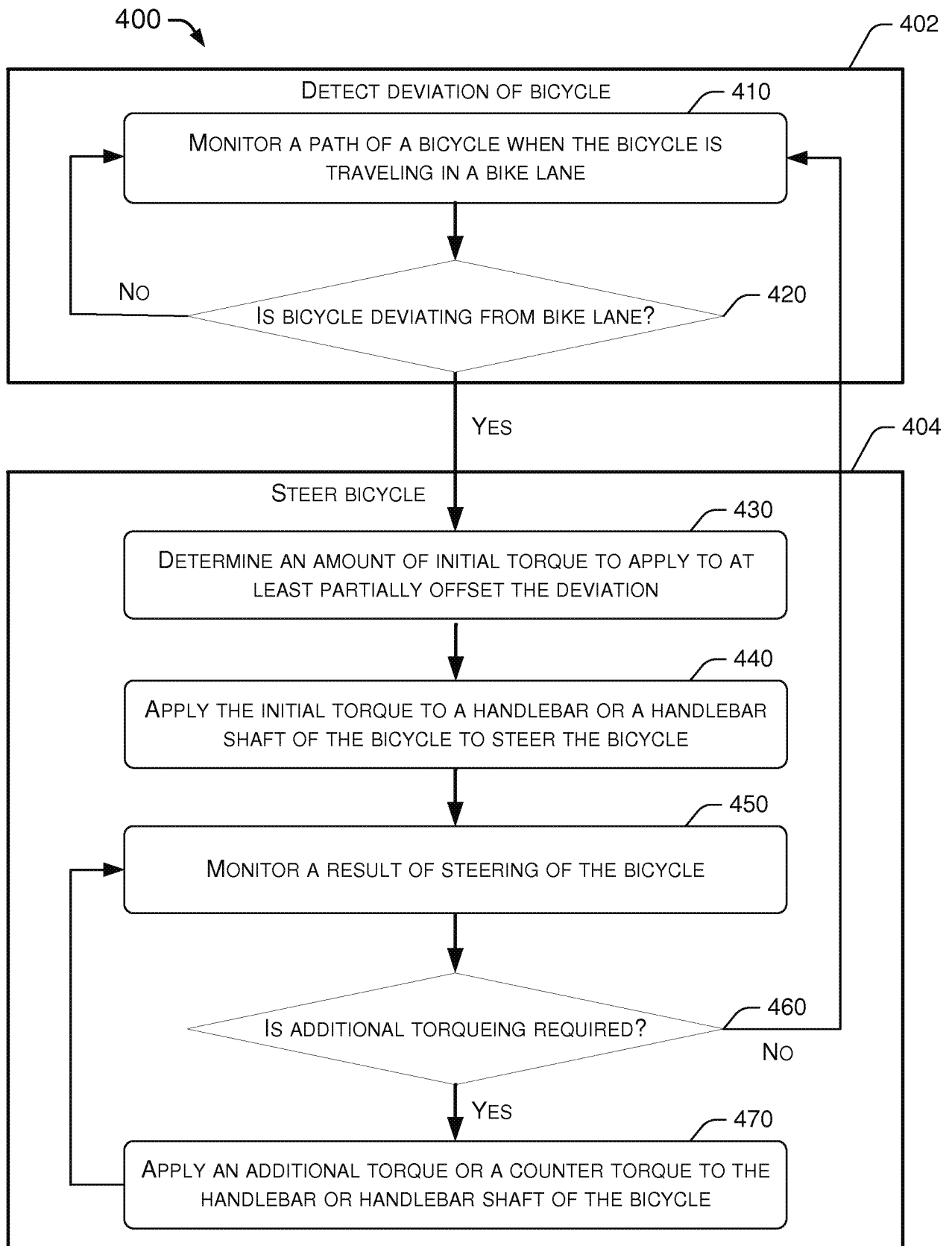


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/042287

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H04N 7/18 (2015.01)

CPC - B60W 30/08 (2015.04)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - B60W 20/00; B62D 6/10; B62J 11/00; B62M 3/08; G01L 3/10; G06K 9/00; G06Q 20/32, 50/28; H04N 7/18 (2015.01)

USPC - 180/220; 348/46, 149; 477/3; 705/44

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

CPC - B60W 20/10, 30/08, 10, 12, 40/06; G05D 1/0011; G06K 9/00798, 00805; G06Q 20/3224, 50/28 (2015.04) (keyword delimited)

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

Orbit, Google Patents, Google Scholar.

Search terms used: control system, bicycle, bike lane, steering mechanism, deviation detection, path monitoring, road surface, line detection, lane detection, optical sensor, imaging device, torque, light intensity

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/0136414 A1 (ABHYANKER) 15 May 2014 (15.05.2014) entire document	1-4
Y		5-20
Y	US 2013/0133969 A1 (HONDA MOTOR CO LTD.) 30 May 2013 (30.05.2013) entire document	5-20
A	US 2013/0157804 A1 (PETRON) 20 June 2013 (20.06.2013) entire document	1-20
A	US 2013/0314503-A1 (MAGNA ELECTRONICS INC.) 28 November 2013 (28.11.2013) entire document	1-20
A	US 2012/0062747 A1 (ZENG) 15 March 2012 (15.03.2012) entire document	1-20
A	WO 2014/124126 A1 (NORTHEASTERN UNIVERSITY) 14 August 2014 (14.08.2014) entire document	1-20
A	WO 2014/204525 A2 (NORTHEASTERN UNIVERSITY) 24 December 2014 (24.12.2014) entire document	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

26 September 2015

Date of mailing of the international search report

19 OCT 2015

Name and mailing address of the ISA/

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