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(54) **ENHANCED COLLISION AVOIDANCE**

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G08G 1/16	(2006.01)
B60W 10/20	(2006.01)
B60W 40/10	(2012.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

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See application file for complete search history.

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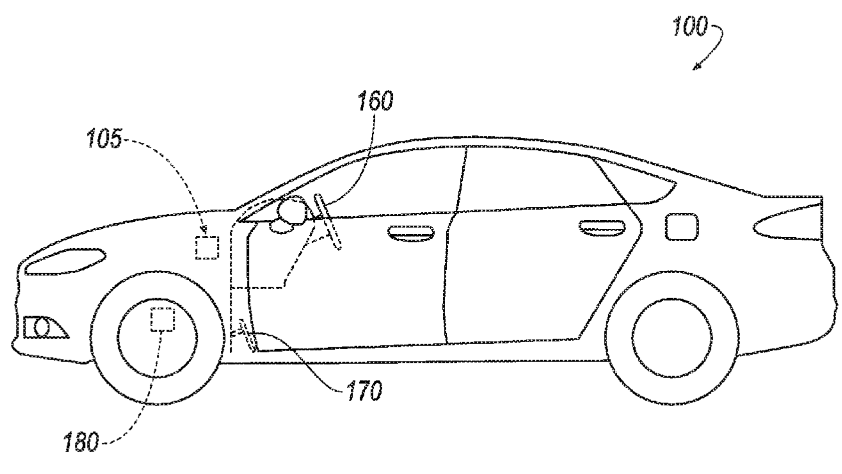
(57) **ABSTRACT**

A driver input representing a steering maneuver associated with non-autonomous operation of a host vehicle is detected. A first target vehicle in an adjacent lane relative to the host vehicle is identified. The steering maneuver is allowed when a second target vehicle is detected in an original lane relative to the host vehicle. The steering maneuver is prevented when no second target vehicle is detected in the original lane of the host vehicle.

18 Claims, 4 Drawing Sheets



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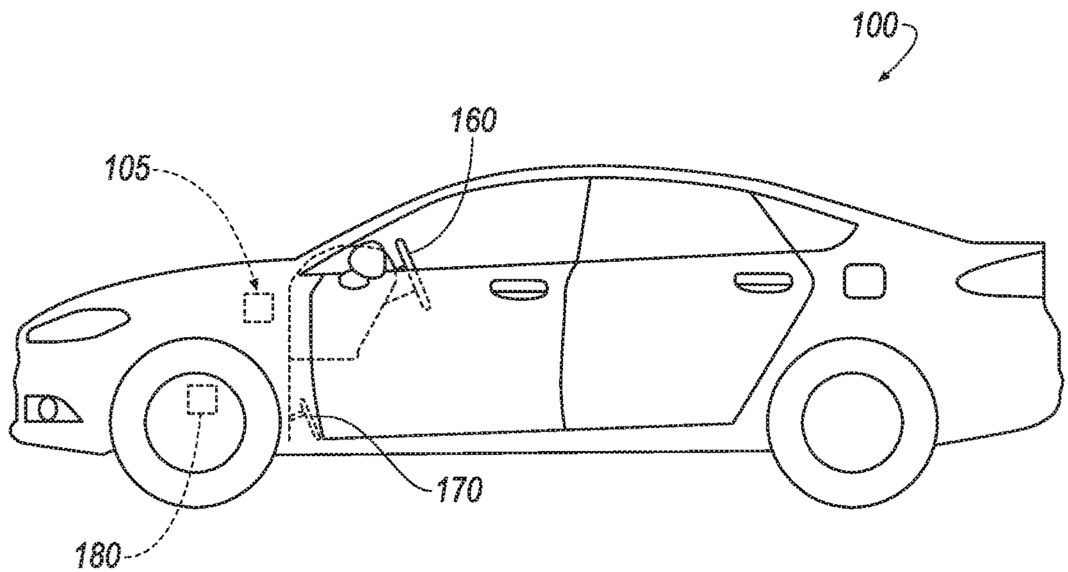

FIG. 1

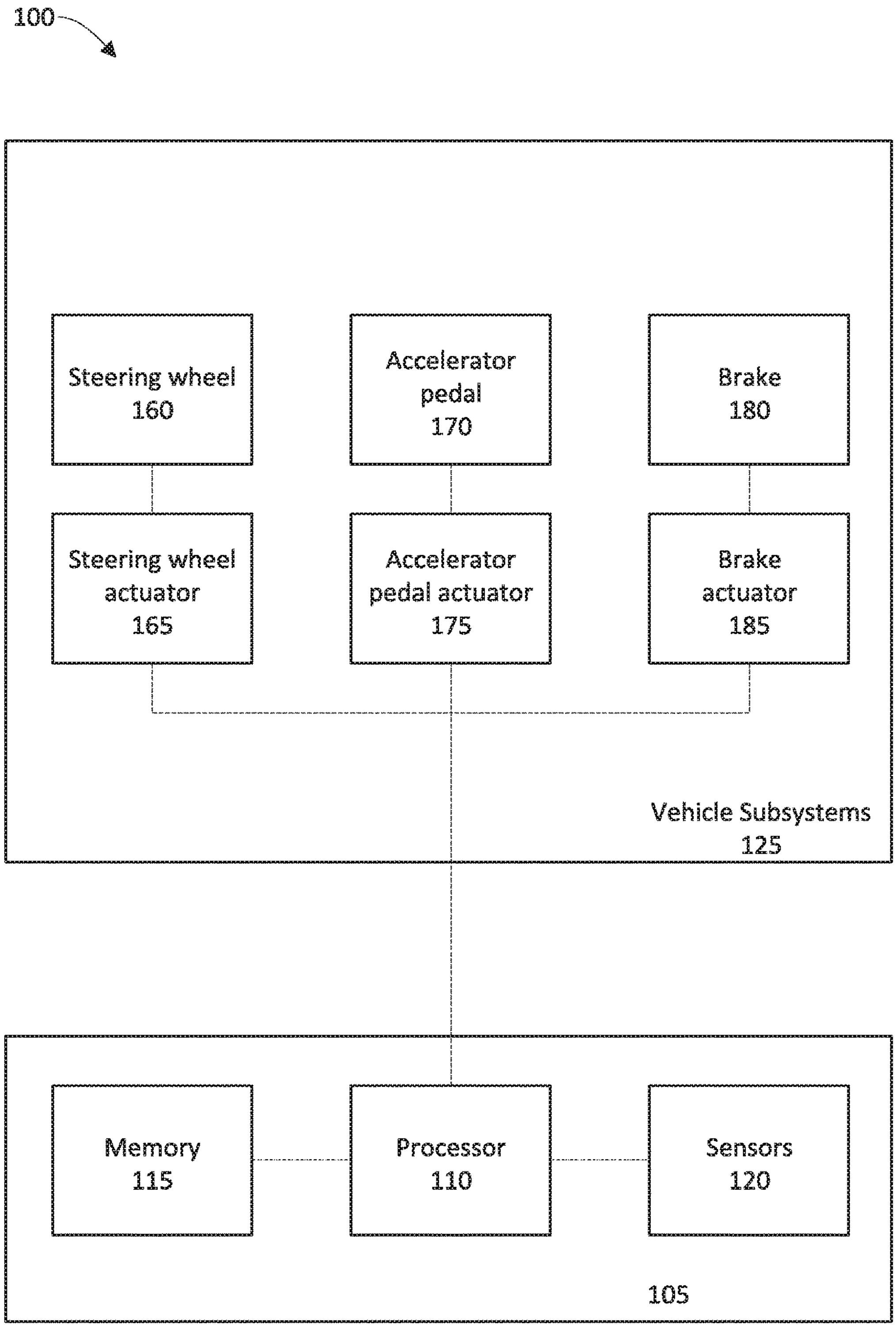
100
Steering wheel
160
Accelerator
pedal
170
Brake
180
Steering wheel
actuator
165
Accelerator
pedal actuator
175
Brake
actuator
185
Vehicle Subsystems
125
Memory
115
Processor
110
Sensors
120
105

FIG. 2

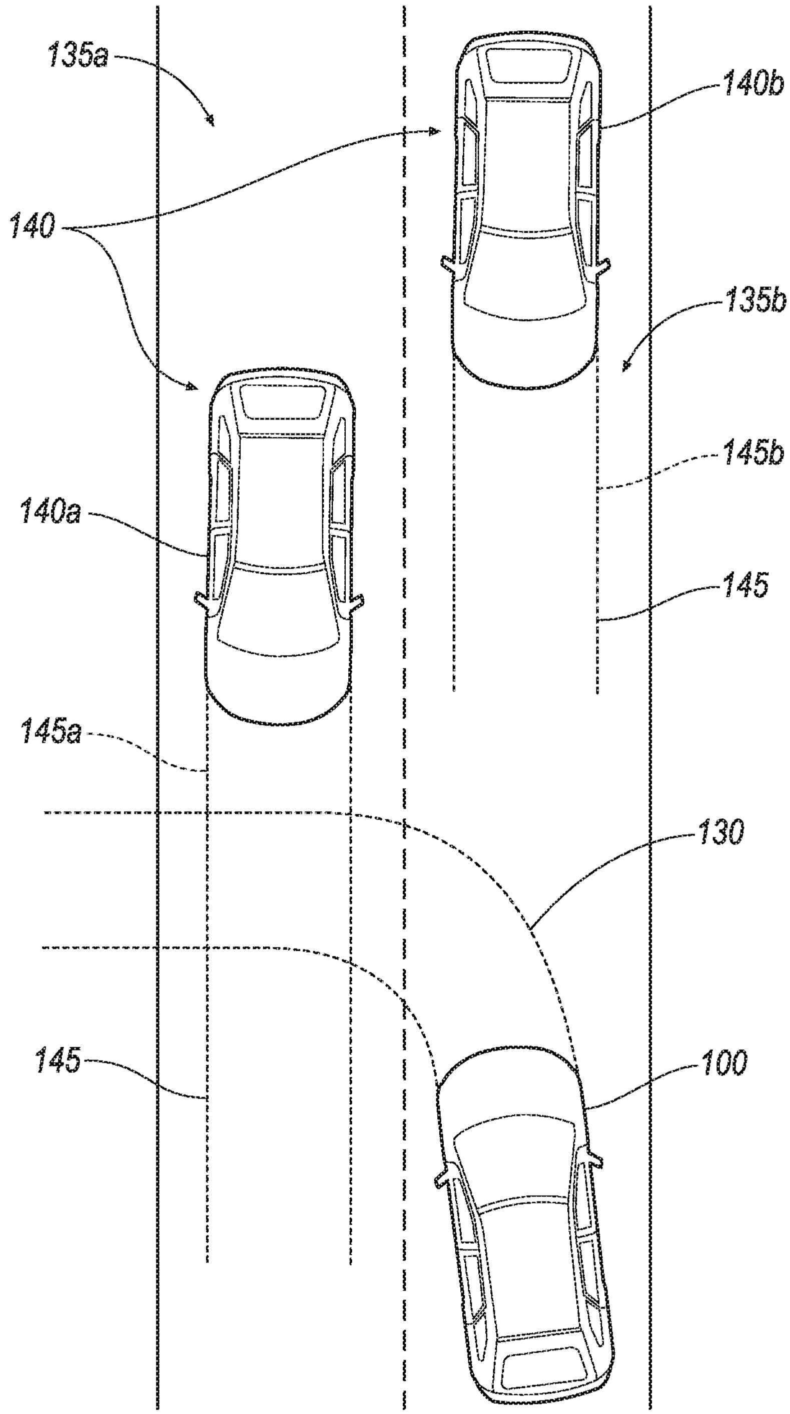

FIG. 3

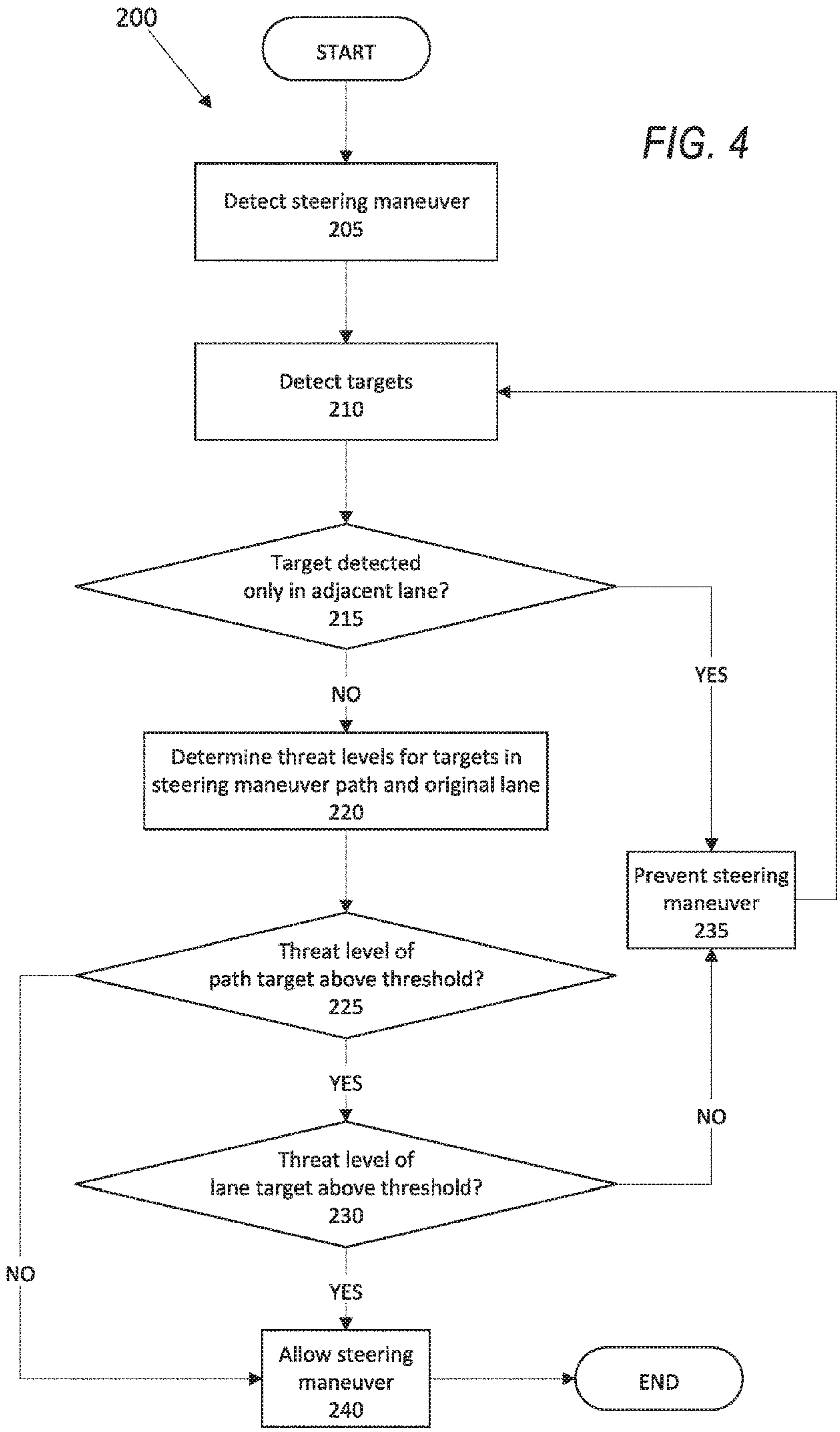
200
START
Detect steering maneuver
205
Detect targets
210
Target detected
only in adjacent lane?
215
YES
NO
Determine threat levels for targets in
steering maneuver path and original lane
220
Prevent steering
maneuver
235
Threat level of
path target above threshold?
225
YES
NO
Threat level of
lane target above threshold?
230
NO
YES
Allow steering
maneuver
240
END

FIG. 4

ENHANCED COLLISION AVOIDANCE

BACKGROUND

Collision avoidance systems use sensors to detect a target vehicle on a collision course with a host vehicle. The systems can detect the target object position and speed to determine a probability of a collision with the host vehicle. Collision avoidance systems apply a brake to prevent the host vehicle from performing a steering maneuver across an adjacent roadway lane with the oncoming target vehicle in the adjacent roadway lane.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an example host vehicle including a collision avoidance system.

FIG. **2** is a block diagram of the host vehicle of FIG. **1** including the collision avoidance system.

FIG. **3** is a view of the example host vehicle of FIG. **1** performing a steering maneuver.

FIG. **4** illustrates a flow chart of an example process for selectively allowing the steering maneuver for the host vehicle.

DETAILED DESCRIPTION

Present collision avoidance systems do not account for more than one target vehicle approaching the host vehicle or when the host vehicle is in the collision path of a target vehicle as a result of trying to avoid an object (e.g., a vehicle traveling in the wrong direction, an object or animal in the roadway, a vehicle stopped in the roadway, etc.) in the lane of the host vehicle. Thus, present current collision avoidance systems may prevent steering maneuvers in these situations even though allowing the steering maneuver may be a better course of action.

One solution includes a collision avoidance system that accounts for multiple vehicles or objects and makes a decision about whether to permit the steering maneuver under various circumstances. Specifically, the system detects a driver input representing a steering maneuver performed during non-autonomous operation of a host vehicle and, when the system identifies a first target vehicle in an adjacent lane relative to the host vehicle, the system will allow the steering maneuver if a second target vehicle is detected in an original lane relative to the host vehicle and prevent the steering maneuver if no second target vehicle is detected in the original lane of the host vehicle.

Accordingly, the system prevents the host vehicle from performing the steering maneuver, e.g., a left-hand turn, when the first target vehicle has a threat level beyond a threat level threshold and the second target vehicle is either not present or has a threat level below the threat level threshold, i.e., only the first target vehicle has a probability of colliding with the host vehicle that the system determines is high enough to warrant preventing the steering maneuver. That is, the system prevents the steering maneuver even though a host vehicle driver intends to move the host vehicle when the first target vehicle could collide with the host vehicle. If the first target vehicle has a threat level below the threat level threshold, or if both target vehicles have threat levels above the threat level threshold, the system allows the driver to perform the steering maneuver.

By accounting for both target vehicles, the collision avoidance system can selectively determine whether to prevent the steering maneuver or to allow the steering maneuver intended by the driver. Using the threat levels, the collision avoidance system determines whether it is better to allow the driver to perform the steering maneuver or to prevent the steering maneuver until one of the target vehicles passes the host vehicle.

FIG. **1** illustrates a host vehicle **100** including a collision avoidance system **105**. The collision avoidance system **105** detects whether the host vehicle **100** is about to perform a steering maneuver from a roadway lane across a second roadway lane (i.e., a roadway lane for oncoming traffic). Based on the steering maneuver, the collision avoidance system **105** determines a probability of a collision with a target vehicle during the steering maneuver. Although shown as a car, the host vehicle **100** may be any vehicle capable of performing the steering maneuver. Thus, the host vehicle **100** may include any passenger or commercial automobile such as a car, a truck, a sport utility vehicle, a crossover vehicle, a van, a minivan, a taxi, a bus, etc. In some possible approaches, as discussed below, the vehicle is an autonomous vehicle that can operate in an autonomous (e.g., driverless) mode, a partially autonomous mode, and/or a non-autonomous mode.

The host vehicle **100** includes a steering wheel **160**, an accelerator pedal **170**, and a brake **180**. The steering wheel **160** operates a powertrain to steer the host vehicle **100**. The driver uses the steering wheel **160** to turn the host vehicle **100**, e.g., in a steering maneuver. The accelerator pedal **170** actuates a propulsion subsystem, e.g., a throttle, an electric motor, etc., to move the host vehicle **100**. The driver uses the accelerator pedal **170** to provide propulsion to the host vehicle **100**. The brake **180** slows and stops the host vehicle **100** by, e.g., providing friction on a vehicle **100** wheel. The driver uses the brake **180** to slow and stop the host vehicle **100**.

FIG. **2** is a block diagram showing example components of the host vehicle **100** including components of the collision avoidance system **105**. The collision avoidance system **105** includes a processor **110**, a memory **115**, and at least one sensor **120**.

Sensors **120**, which are implemented via circuits, chips, or other electronic components, include a variety of devices, e.g., a steering wheel angle sensor, a pedal position sensor, etc. The sensors **120** can output data to the processor **110** via the vehicle **100** network or bus, e.g., data relating to vehicle speed, acceleration, position, system and/or component status, etc. Alternatively, the sensors **120** can output data to a controller. Other sensors **120** could include cameras, motion detectors, etc., i.e., sensors to provide data for evaluating location of the target vehicle, projecting a path of the target vehicle, etc. The processor **110** can instruct the sensors **120** to collect data on specific objects, e.g., the target vehicles.

The processor **110** is implemented via circuits, chips, or other electronic component that can receive the data from the sensors **120** and determine, from the data, whether the host vehicle **100** is performing a steering maneuver. The processor **110** may be programmed to process the sensor **120** data. Processing the data may include processing the video feed or other data stream captured by the sensors **120** to determine where the steering maneuver and the presence of any target vehicles. As described below and shown in FIG. **2**, the processor **110** instructs vehicle components to actuate.

Furthermore, the processor **110** estimates the threat level of the target vehicles and determines whether to allow or to prevent the steering maneuver based on the estimated threat levels. That is, the processor **110** uses data from the sensors **120** to determine the position, speed, and trajectory of the target vehicles to predict a path that each of the target vehicles will follow. Based on the predicted paths of the target vehicles and the path that the steering maneuver will cause the host vehicle to follow, the processor **110** determines the probability of a collision between the host vehicle **100** and each of the target vehicles. Based on the probabilities, the processor **110** estimates the threat level for each target vehicle. Based on the threat levels, the processor **110** determines whether to allow the steering maneuver or to prevent the steering maneuver.

The processor **110** communicates with at least one vehicle subsystem **125**. The vehicle subsystems **125** control components of the host vehicle **100**. The processor **110** instructs the vehicle subsystems **125** to actuate the components to adjust operation of the host vehicle **100**. The vehicle subsystems **125** include, e.g., a steering subsystem, a brake subsystem, a navigation subsystem, a powertrain, etc.

The processor **110** may actuate the subsystems **125** to control the host vehicle **100** components, e.g., to move the host vehicle **100** to a stop, to avoid targets, etc. For example, as shown in FIG. **2**, a steering subsystem includes the steering wheel **160** and a steering wheel actuator **165**. The processor **110** can actuate the steering wheel actuator **165** to move the steering wheel **160** to a steering angle. Thus, the processor **110** can control the steering of the host vehicle **100** with the steering subsystem. For example, the processor **110** may detect a driver input indicating a direction of rotation of a steering wheel **160** toward the adjacent lane and actuate the steering wheel **160** in a direction opposite the direction of rotation of the driver input to keep the host vehicle **100** in the original lane. An accelerator subsystem includes the accelerator pedal **170** and an accelerator pedal actuator **175**. The processor **110** can actuate the accelerator pedal actuator **175** to move the accelerator pedal **170** to an accelerator pedal angle, which actuates the vehicle **100** propulsion. That is, the processor **110** can control the propulsion of the host vehicle **100** with the accelerator subsystem. A brake subsystem includes the brake **180** and a brake actuator **185**. The processor **110** can actuate the brake actuator **185** to actuate the brake **180** to slow or stop the host vehicle **100**. That is, the processor **110** can control the braking of the host vehicle **100** with the brake subsystem. Furthermore, the processor **110** may actuate the brake subsystem according to the time necessary to prevent the steering maneuver. For example, the processor **110** may determine that, to prevent the vehicle **100** from colliding with a target while maintaining the position of the vehicle **100** to complete the steering maneuver, the processor **110** may instruct the brake actuator **185** to abruptly actuate the brake **180**. That is, the processor **110** may instruct the brake actuator **185** to apply the brake **180** to a specific brake angle according to how abruptly the processor **110** determines to prevent the steering maneuver. The processor **110** may output signals to control any number of vehicle subsystems **125**, including the steering subsystem, the accelerator subsystem, and the brake subsystem, to prevent the steering maneuver.

The processor **110** may be programmed to actuate various vehicle subsystems **125** according to the number of target vehicles detected, the locations of the target vehicles relative to the host vehicle, and the threat level of the target vehicles detected. For example, if the processor **110** detects one target vehicle based on the data from the sensor **120**, and the target vehicle is in an adjacent lane to the host vehicle **100**, the processor **110** may be programmed to actuate one or more of the vehicle subsystems **125** to prevent the steering maneuver until the target vehicle passes the host vehicle **100**. When the processor **110** detects two target vehicles, one in the adjacent lane of the host vehicle **100** and one in the original lane of

the host vehicle **100**, the processor **110** may be programmed to selectively prevent the steering maneuver based on the threat levels of the target vehicles. If the processor **110** determines that the threat level for the target vehicle in the adjacent lane is below a threat level threshold or the threat level for the target vehicle in the original lane is above the threat level threshold, the processor **110** may be programmed to allow the driver to execute the steering maneuver. If the processor **110** determines that the threat level of the target vehicle in the adjacent lane is above the threat level threshold and that the threat level of the target in the original lane is below the threat level threshold, then the processor **110** may be programmed to prevent the steering maneuver by outputting various signals to the vehicle subsystems **125** prevent the driver of the host vehicle from executing the steering maneuver.

The processor **110** may be programmed to recognize certain driver inputs as indicating a driver's desire to override the decision by the processor to prevent the steering maneuver and allow the steering maneuver upon recognizing the driver input requesting the override. That is, certain driver inputs indicate to the processor **110** that the driver wishes to proceed with the steering maneuver even though the processor **110** would otherwise prevent the steering maneuver by, e.g., actuating one or more subsystems **125** to prevent the steering maneuver. For example, if an accelerator pedal sensor **120** indicates that the accelerator pedal **170** is depressed by the driver for a predetermined period of time, the processor **110** may be programmed to allow the steering maneuver and accept the driver input to the accelerator subsystem **125**. The processor **110** may be programmed to transition between a non-autonomous mode, a partially autonomous mode, and a fully autonomous mode for the vehicle subsystems **125**. The processor **110** may be programmed to transition between the modes according to a ramp function, e.g., linearly increasing the amount of human operator control when transitioning from a fully autonomous mode to a non-autonomous mode. In the non-autonomous mode, the processor **110** may still provide input to the vehicle subsystems **125**, e.g., with power steering for the steering subsystem, automatic throttle adjustment for the acceleration subsystem, anti-lock braking for the brake subsystem, etc.

FIG. **3** illustrates the host vehicle **100** performing a steering maneuver **130**, shown as a left-hand turn from an original lane **135*b*** of the host vehicle **100** across an adjacent lane **135*a***, while the host vehicle **100** is operating in a non-autonomous mode of operation. As the host vehicle **100** moves along a roadway lane **135** and approaches the location of the turn, the driver starts to perform the steering maneuver by providing a driver input to one or more of the vehicle subsystems **125**, such as the steering wheel **160**, the accelerator pedal **170**, or both, to turn the host vehicle **100** across a lane of traffic. During the steering maneuver, and possibly before the steering maneuver begins, the sensors **120** collect data on the vehicle subsystems **125**, e.g., the steering angle, the transmission state, the throttle angle, etc., and output the collected data to the processor **110**. Based on the vehicle subsystem **125** data, the processor **110** detects that the driver intends to perform the steering maneuver **130**.

The processor **110** can further determine whether target vehicles **140** are present in the lanes **135** during the steering maneuver **130** based on the data collected by the sensors **120**. For instance, the sensors **120** may collect data representing the presence and position of the target vehicles **140**. As used herein, a "position" of the target vehicle **140** and/or the host vehicle **100** may refer to a location specified with reference to coordinates in a coordinate system, e.g., geo-coordinates, a set of coordinates on a predetermined X-Y-Z Cartesian grid, etc. Alternatively, the position of the target vehicles **140** may be defined relative to the position of the host vehicle **100**.

A first target vehicle **140***a* and a second target vehicle **140***b* are shown in FIG. **3**. The sensors **120** detect the target vehicles **140***a*, **140***b* and output signals representing the detected target vehicles **140** to the processor **110**. From the signals output by the sensors **120**, the processor **110** determines the position, direction, and speed of each of the target vehicles **140***a*, **140***b*. In the example shown in FIG. **3**, the first target vehicle **140***a* is traveling in the adjacent roadway lane **135***a* toward the host vehicle **100**. Because the steering maneuver would put the host vehicle in the path of the first target vehicle **140***a*, the first target vehicle **140***a* may be referred to as a "path target" **140** relative to the host vehicle **100**. Because the second target vehicle **140***b* is traveling in the original lane **135***b* of the host vehicle **100**, the second target vehicle **140***b* may be referred to as a "lane target" **140**.

The collision avoidance system **105** predicts a path **145** for each target vehicle **140**. That is, the sensors **120** collect data about the target vehicles **140** and the processor **110** is programmed to predict the path **145** that each target vehicle **140** will follow based on the collected data. The path **145** is a predicted line of travel that the target vehicle **140** will follow based on one or more elements of the target trajectory, e.g., the target vehicle **140** speed, the target vehicle **140** direction of travel, the target vehicle **140** position, etc. For purposes of clarity and simplicity, the path **145** is represented as a strip having two edges separated by a distance that is the width of the target vehicle **140**, e.g., 2 meters, extending in a direction the target vehicle **140** is predicted to travel. In the example of FIG. **3**, the collision avoidance system **105** determines a target path **145** for each target vehicle **140**, i.e., a target path **145***a* for the target vehicle **140***a* and a target path **145***b* for the target vehicle **140***b*. The target paths **145***a*, **145***b* of the target vehicles **140***a*, **140***b* show that the target vehicle **140***b* is in the original lane **135***b* of the host vehicle **100** and that the target vehicle **140***a* is in an adjacent lane **135***a* and is moving into the path of the steering maneuver **130**.

The collision avoidance system **105** determines threat levels for each of the target vehicles **140** based on the paths **145** and the steering maneuver **130**. That is, the processor **110** is programmed to use the data collected by the sensors **120** and the previously determined paths **145** and the steering maneuver **130** to determine a threat level for each target vehicle **140**. The threat level for a target vehicle **140** indicates a probability of a collision between the target vehicle **140** and the host vehicle **100**. The processor **110** may consider a host vehicle **100** position, speed, direction of travel, ability to steer, a target vehicle **140** position, speed, direction of travel, ability to steer, etc., in developing the threat level for each target vehicle **140**. With the threat level, the processor **110** may be programmed to determine how likely it is that the target vehicle **140** and the host vehicle **100** will collide during the steering maneuver, and whether either of the target vehicle **140** and the host vehicle **100** can avoid the collision.

The threat level may be represented as a value between 0 and 1, with numbers closer to 1 indicating a higher probability of a collision. For example, the threat level may be a ratio of a required deceleration to stop the target vehicle **140** prior to reaching the path defined by the steering maneuver **130** (i.e., a "zero-range" deceleration) to a predetermined maximum deceleration of the target **140**. Thus, if the first target vehicle **140***a* has a zero-range deceleration higher than that of the second target vehicle **140***b* the threat level of the first target vehicle **140***a* would be higher than the threat level of the second target vehicle **140***b*. The collision avoidance system **105**, and specifically the processor **110**, would thus determine that the first target vehicle **140***a* has a higher probability of colliding with the host vehicle **100** than the second target vehicle **140***b* would. Alternatively, if the target vehicle **140***b* in the original lane **135***b* is stationary, the processor **110** can determine the threat level based on the host vehicle **100** zero-range deceleration relative to that target vehicle **140***b*. That is, the processor **110** may be programmed to consider data from the sensors **120** of the host vehicle **100** speed to determine the required deceleration to stop the host vehicle **100** prior to reaching the stationary target vehicle **140***b*. The processor **110** uses the zero-range deceleration of the host vehicle **100** to the stationary target vehicle **140***b* to determine the threat level for the target vehicle **140***b*. A similar approach may apply if the target vehicle **140***b* is moving in the same direction as the host vehicle **100**, especially if the target vehicle **140***b* is moving much more slowly than the host vehicle **100**. Accordingly, the collision avoidance system **105** uses the threat levels to determine specific adjustments to vehicle subsystems **125** in the host vehicle **100** to avoid the target vehicles **140** with threat levels above a threat level threshold to avoid collisions.

The collision avoidance system **105**, and specifically the processor **110**, is programmed to actuate the vehicle subsystems **125** to selectively allow or prevent the steering maneuver **130** based on the threat levels of the target vehicles **140**. The first target vehicle **140***a* travels in the lane **135** adjacent to the original lane **135** that the host vehicle **100** travels, i.e., the first target vehicle **140***a* is a path target **140**. The second target vehicle **140***b* travels in the original lane **135** of the host vehicle **100**, i.e., the second target vehicle **140***b* is a lane target **140**. Both target vehicles **140***a*, **140***b* move in a direction toward the host vehicle **100**. If the threat level of the first target vehicle **140***a* is above the threat level threshold, and the second target vehicle **140***b* is either not present or has a threat level below the threat level threshold, the collision avoidance system **105** actuates the vehicle subsystems **125** to prevent the steering maneuver **130** until the first target vehicle **140***a* passes the host vehicle **100**.

To prevent the steering maneuver, the processor **110** may command the brake subsystem to apply a brake **180** until the first target vehicle **140***a* passes the host vehicle **100**, at which point the processor **110** instructs the brake subsystem to release the brake **180**. In addition or in the alternative, the processor **110** can detect the driver input rotating the steering wheel **160** based on the steering angle from the sensor **120** acting as a steering wheel angle sensor indicating that the host vehicle **100** will steer into the adjacent lane **135** and actuate the steering wheel actuator **165** to rotate the steering wheel **160** in a direction opposite the direction of rotation of the steering wheel driver input to keep the host vehicle **100** in the original lane **135**. Preventing the steering maneuver may further or alternatively include the processor **110** commanding the powertrain subsystem to limit the powertrain output, which will slow or stop the host vehicle **100**. If the threat levels for both of the target vehicles **140***a*, **140***b* are above the threat level threshold, the collision avoidance system **105**, and specifically the processor **110**, allows the steering maneuver **130**.

The driver may override the collision avoidance system **105**, as described above. For example, if the driver sees that the target vehicle **140***a* is going to turn away from the host vehicle **100**, something that the collision avoidance system **105** may not be able to detect, the driver may want to perform the steering maneuver **130**. The driver may override the collision avoidance system **105** to perform the steering maneuver **130** by depressing the accelerator pedal **170**. When an accelerator pedal position angle exceeds a pedal position angle threshold for a predetermined period of time, the processor **110** may release the brake **180** by actuating the brake actuator **185**, allowing the driver to perform the steering maneuver **130**.

FIG. **4** illustrates a process **200** for determining whether to allow or prevent the steering maneuver **130** for the host vehicle **100** equipped with the collision avoidance system **105**. The process **200** may be initiated any time the host vehicle **100** is operating and may continue to execute until, e.g., the host vehicle **100** is shut off.

At block **205**, the processor **110** detects the steering maneuver **130** of the host vehicle **100**. The processor **110** instructs the sensors **120** collect data on the vehicle subsystems **125**, e.g., the steering angle, the transmission state, the throttle angle, etc. Based on the vehicle subsystem **125** data, the processor **110** determines that the driver intends to perform the steering maneuver **130**.

At block **210**, the processor **110** instructs the sensors **120** collect data on any nearby target vehicles **140**. For instance, the processor **110** may instruct the sensors **120** to identify target vehicles **140** in the lanes **135**. Based on the data received from the sensors, the processor **110** determines how many targets **140** are present in the lanes **135**, if any, and the locations of the target vehicles **140**. For example, the processor **110** may determine that there are two target vehicles **140**, as in the example of FIG. **3**. In another example, the processor **110** may determine that only one of the path target **140** and the lane target **140** is present, e.g., the path target **140** has passed the host vehicle **100**. As described above, the processor **110** may identify the target vehicle **140** in a lane **135** adjacent to the host vehicle **100** as a path target **140**, and the processor **110** may identify the target **140** in an original lane **135** of the host vehicle **100** as a lane target. In yet another example, the processor **110** may detect no target vehicles **140**.

At decision block **215**, the processor **110** determines whether only one target **140** is detected and whether the detected target vehicle **140** is in an adjacent lane **135** through which the steering maneuver **130** will turn the host vehicle **100**. That is, the processor **110** determines whether the only detected target **140** is a target **140** that could collide with the host vehicle **100** during the steering maneuver. If the processor **110** determines that the target vehicle **140** is only in the adjacent lane **135**, the process **200** proceeds to bock **235**. Otherwise, the process **200** proceeds to block **220**.

At block **220**, the processor **110** determines threat levels for each detected target vehicle **140**, if present. As described above, each respective threat level represents a probability of a collision between the target vehicle **140** and the host vehicle **100**. The threat level may be represented as a value between 0 and 1, with numbers closer to 1 indicating a higher probability of a collision. For example, the threat level may be a ratio of a required deceleration to stop the target vehicle **140** prior to reaching the path defined by the steering maneuver **130** (i.e., a "zero-range" deceleration) to a predetermined maximum deceleration of the target **140**. Alternatively, in some situations, the threat level may be represented as a ratio of the required deceleration to stop the host vehicle **100** prior to reaching one of the target vehicles **140**. If the processor **110** detects no target vehicle **140**, the threat level is 0.

At decision block **225**, the processor **110** determines whether the threat level of the target vehicle **140** in the adjacent lane **135**, i.e., the path target **140**, is above the threat level threshold. As described above, if the processor **110** detects no path targets **140**, the threat level is 0. If the threat level of the path target **140** is above the threat level threshold, the process **200** continues at block **230**. If the threat level of the path target **140** is below the threat level threshold or the processor **110** detects no path target **140**, the process **200** proceeds to block **240**.

At decision block **230**, the processor **110** determines whether the threat level of the target vehicle **140** in the original lane **135** of the host vehicle, i.e., the lane target **140**, is above the threat level threshold. If the processor **110** detects no lane targets **140**, the threat level is 0. If the threat level of the lane target **140** is above the threat level threshold, the process **200** continues at block **235**. If the threat level of the lane target **140** is below the threat level threshold or the processor **110** detects no lane target **140**, the process **200** continues at block **240**.

In the block **235**, the processor **110** instructs the vehicle subsystems **125** to prevent the steering maneuver **130**. Because the threat level for the path target **140** is above the threat level threshold and the threat level of the lane target **140** is below the threat level threshold, the processor **110** determines that the host vehicle **100** should not perform the steering maneuver **130** until the path target **140** passes the host vehicle **100**. The processor **110** actuates vehicle subsystems **125** to prevent the steering maneuver **130**. For example, the processor **110** may detect a driver input indicating a direction of rotation of a steering wheel **160** toward the adjacent lane **135** and actuate the steering wheel **160** in a direction opposite the direction of rotation of the driver input and/or actuate the brake subsystem **125** to stop the host vehicle **100**. The process **200** then returns to block **210** to detect new target vehicles **140** and/or that current target vehicles **140** have passed the host vehicle **100**.

At block **240**, the processor **110** allows the vehicle subsystems **125** to perform the steering maneuver **130**. Allowing the steering maneuver may include the processor **110** not taking any action that would prevent the driver inputs executing the steering maneuver. The process **200** may end after block **240**.

With the process **200**, the driver is permitted to perform steering maneuvers when the threat level for the lane target **140** is above the threat level threshold and/or the threat level for the path target **140** is below the threat level threshold, the processor **110** should allow the driver to perform the steering maneuver **130**. The process **200** further allows the steering maneuver when no path targets **140** were detected. The process **200** prevents the steering maneuver when the threat level for the path target **140** is above the threat level threshold and the threat level of the lane target **140** is below the threat level threshold, at least until the path target **140** passes the host vehicle **100**.

In general, the computing systems and/or devices described may employ any of a number of computer operating systems, including, but by no means limited to, versions and/or varieties of the Ford Sync® operating system, the Microsoft Windows® operating system, the Unix operating system (e.g., the Solaris® operating system distributed by Oracle Corporation of Redwood Shores, Calif.), the AIX UNIX operating system distributed by International Business Machines of Armonk, N.Y., the Linux operating system, the Mac OSX and iOS operating systems distributed by Apple Inc. of Cupertino, Calif., the BlackBerry OS distributed by Blackberry, Ltd. of Waterloo, Canada, and the Android operating system developed by Google, Inc. and the Open Handset Alliance. Examples of computing devices include, without limitation, an on-board vehicle computer, a computer workstation, a server, a desktop, notebook, laptop, or handheld computer, or some other computing system and/or device.

Computing devices generally include computer-executable instructions, where the instructions may be executable by one or more computing devices such as those listed above. Computer-executable instructions may be compiled or interpreted from computer programs created using a variety of programming languages and/or technologies, including, without limitation, and either alone or in combination, Java™, C, C++, Visual Basic, Java Script, Perl, etc. In general, a processor (e.g., a microprocessor) receives instructions, e.g., from a memory, a computer-readable medium, etc., and executes these instructions, thereby performing one or more processes, including one or more of the processes described herein. Such instructions and other data may be stored and transmitted using a variety of computer-readable media.

A computer-readable medium (also referred to as a processor-readable medium) includes any non-transitory (e.g., tangible) medium that participates in providing data (e.g., instructions) that may be read by a computer (e.g., by a processor of a computer). Such a medium may take many forms, including, but not limited to, non-volatile media and volatile media. Non-volatile media may include, for example, optical or magnetic disks and other persistent memory. Volatile media may include, for example, dynamic random access memory (DRAM), which typically constitutes a main memory. Such instructions may be transmitted by one or more transmission media, including coaxial cables, copper wire and fiber optics, including the wires that comprise a system bus coupled to a processor of a computer. Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, any other magnetic medium, a CD-ROM, DVD, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, an EPROM, a FLASH-EEPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

Databases, data repositories or other data stores described herein may include various kinds of mechanisms for storing, accessing, and retrieving various kinds of data, including a hierarchical database, a set of files in a file system, an application database in a proprietary format, a relational database management system (RDBMS), etc. Each such data store is generally included within a computing device employing a computer operating system such as one of those mentioned above, and are accessed via a network in any one or more of a variety of manners. A file system may be accessible from a computer operating system, and may include files stored in various formats. An RDBMS generally employs the Structured Query Language (SQL) in addition to a language for creating, storing, editing, and executing stored procedures, such as the PL/SQL language mentioned above.

In some examples, system elements may be implemented as computer-readable instructions (e.g., software) on one or more computing devices (e.g., servers, personal computers, etc.), stored on computer readable media associated therewith (e.g., disks, memories, etc.). A computer program product may comprise such instructions stored on computer readable media for carrying out the functions described herein.

With regard to the processes, systems, methods, heuristics, etc., described herein, it should be understood that, although the steps of such processes, etc., have been described as occurring according to a certain ordered sequence, such processes could be practiced with the described steps performed in an order other than the order described herein. It further should be understood that certain steps could be performed simultaneously, that other steps could be added, or that certain steps described herein could be omitted. In other words, the descriptions of processes herein are provided for the purpose of illustrating certain embodiments, and should in no way be construed so as to limit the claims.

Accordingly, it is to be understood that the above description is intended to be illustrative and not restrictive. Many embodiments and applications other than the examples provided would be apparent upon reading the above description. The scope should be determined, not with reference to the above description, but should instead be determined with reference to the appended claims. It is intended that future developments will occur in the technologies discussed herein, and that the disclosed systems and methods will be incorporated into such future embodiments. In sum, it should be understood that the application is capable of modification and variation.

The Abstract is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

The invention claimed is:

1. A system, comprising a computer including a processor and a memory storing instructions executable by the processor, the instructions including:

detecting a driver input representing a steering maneuver associated with non-autonomous operation of a host vehicle;

identifying a first target vehicle in an adjacent lane relative to the host vehicle;

determine a threat level associated with the first target vehicle based on a predicted path of the first target vehicle; and

allowing the steering maneuver when a second target vehicle is detected in an original lane relative to the host vehicle and preventing the steering maneuver when no second target vehicle is detected in the original lane of the host vehicle and the threat level exceeds a predetermined threshold.

2. The system of claim **1**, wherein the instructions further include actuating a brake to prevent the steering maneuver.

3. The system of claim **2**, wherein the instructions further include releasing the brake when an accelerator pedal position angle exceeds a pedal position angle threshold for a predetermined period of time.

4. The system of claim **2**, wherein the instructions further include releasing the brake after the first target vehicle passes the host vehicle.

5. The system of claim **1**, wherein detecting the driver input includes detecting a direction of rotation of a steering wheel toward the adjacent lane and wherein preventing the steering maneuver includes actuating the steering wheel in a direction opposite the direction of rotation of the driver input.

6. The system of claim **1**, wherein the instructions further include allowing the steering maneuver after the first target vehicle passes the host vehicle.

7. The system of claim **6**, wherein allowing the steering maneuver includes releasing a brake.

8. The system of claim **1**, wherein detecting the driver input includes detecting a direction of rotation of a steering wheel toward the adjacent lane and wherein preventing the steering maneuver includes actuating the steering wheel in a direction opposite the direction of rotation of the driver input.

9. The system of claim **1**, wherein preventing the steering maneuver includes limiting a powertrain output to prevent the steering maneuver.

10. A method, comprising:

detecting a driver input representing a steering maneuver associated with non-autonomous operation of a host vehicle;

identifying a first target vehicle in an adjacent lane relative to the host vehicle;

determining a threat level associated with the first target vehicle based on a predicted path of the first target vehicle; and

allowing the steering maneuver when a second target vehicle is detected in an original lane relative to the host vehicle and preventing the steering maneuver when no second target vehicle is detected in the original lane of the host vehicle and the threat level exceeds a predetermined threshold.

11. The method of claim **10**, further comprising actuating a brake to prevent the steering maneuver.

12. The method of claim **11**, further comprising releasing the brake when an accelerator pedal position angle exceeds a pedal position angle threshold for a predetermined period of time.

13. The method of claim **11**, further comprising releasing the brake after the first target vehicle passes the host vehicle.

14. The method of claim **10**, wherein detecting the driver input includes detecting a direction of rotation of a steering wheel toward the adjacent lane and wherein preventing the steering maneuver includes actuating the steering wheel in a direction opposite the direction of rotation of the driver input.

15. The method of claim **10**, further comprising allowing the steering maneuver after the first target vehicle passes the host vehicle.

16. The method of claim **15**, wherein allowing the steering maneuver includes releasing a brake.

17. The method of claim **10**, wherein detecting the driver input includes detecting a direction of rotation of a steering wheel toward the adjacent lane and wherein preventing the steering maneuver includes actuating the steering wheel in a direction opposite the direction of rotation of the driver input.

18. The method of claim **10**, wherein preventing the steering maneuver includes limiting a powertrain output to prevent the steering maneuver.

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