(12) UK Patent Application (19) GB (11) 2570473 (13) A

(43) Date of A Publication 31.07.2019

(21) Application No: 1801294.8

(22) Date of Filing: 26.01.2018

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(51) INT CL:
F16H 61/02 (2006.01) ***F16H 59/44*** (2006.01)
F16H 59/46 (2006.01) ***F16H 59/60*** (2006.01)
F16H 59/66 (2006.01)

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US 20140315686 A1 **US 20140142822 A1**
US 20070032341 A1

(58) Field of Search:
INT CL **F16H**
Other: **ONLINE: EPODOC, WPI**

(54) Title of the Invention: **Vehicle control method and apparatus**
Abstract Title: **Transmission controller and control method**

(57) A controller 7, for controlling selection of a drive ratio in an automatic or semi-automatic transmission 6 of a host vehicle 2, comprises a processor 8 configured to determine a current/reference speed and an expected speed of the host vehicle 2. A processor 8 controls operation of the transmission 6 in dependence on a comparison of the expected speed and the current speed. The expected speed may be determined in dependence on one or more map data relating to a road on which the host vehicle travelling, traffic data and a legislative speed limit. The control system 1 is configured to identify operating parameters indicative of a potential overtaking event when the host vehicle 2 has slowed as a result of a target vehicle 3. The control system 1 could be configured to inhibit control of one or more vehicle systems if the host vehicle reference speed is less than a minimum speed threshold, e.g. less than 10km/h. Reference is also made to a method of controlling selection of a drive ratio and a vehicle having the controller 7.

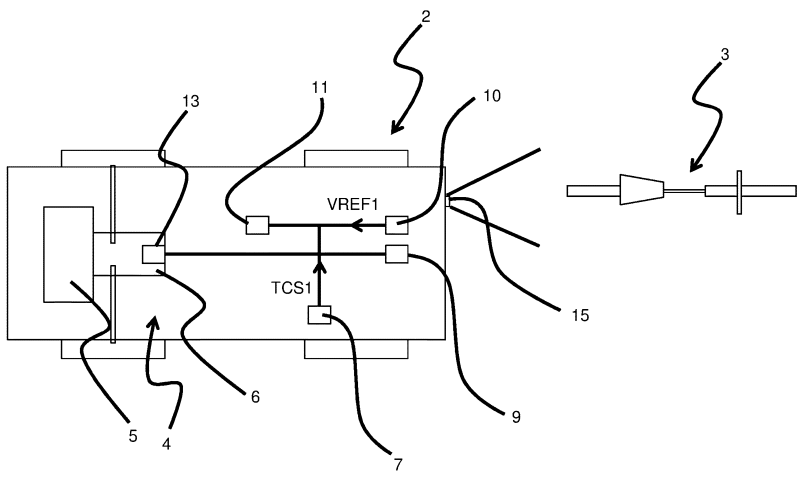


FIG. 2

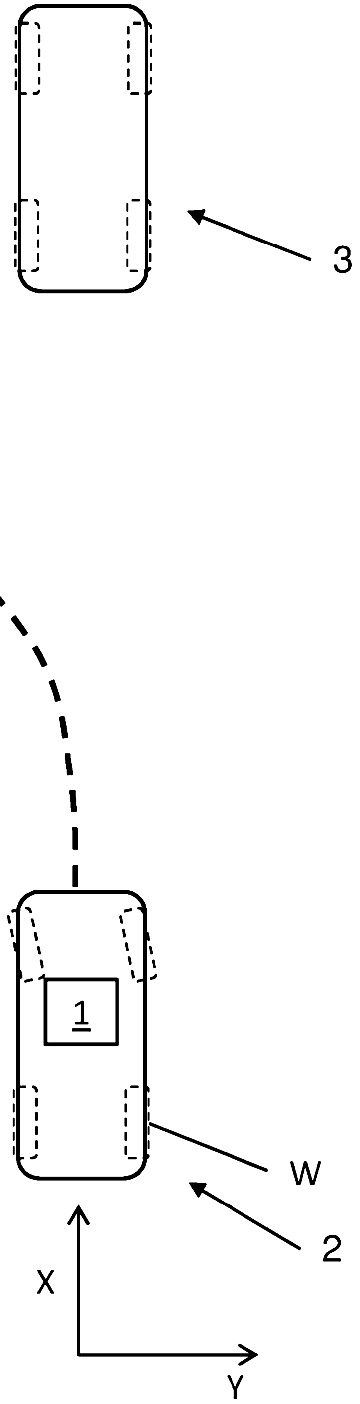


FIG. 1

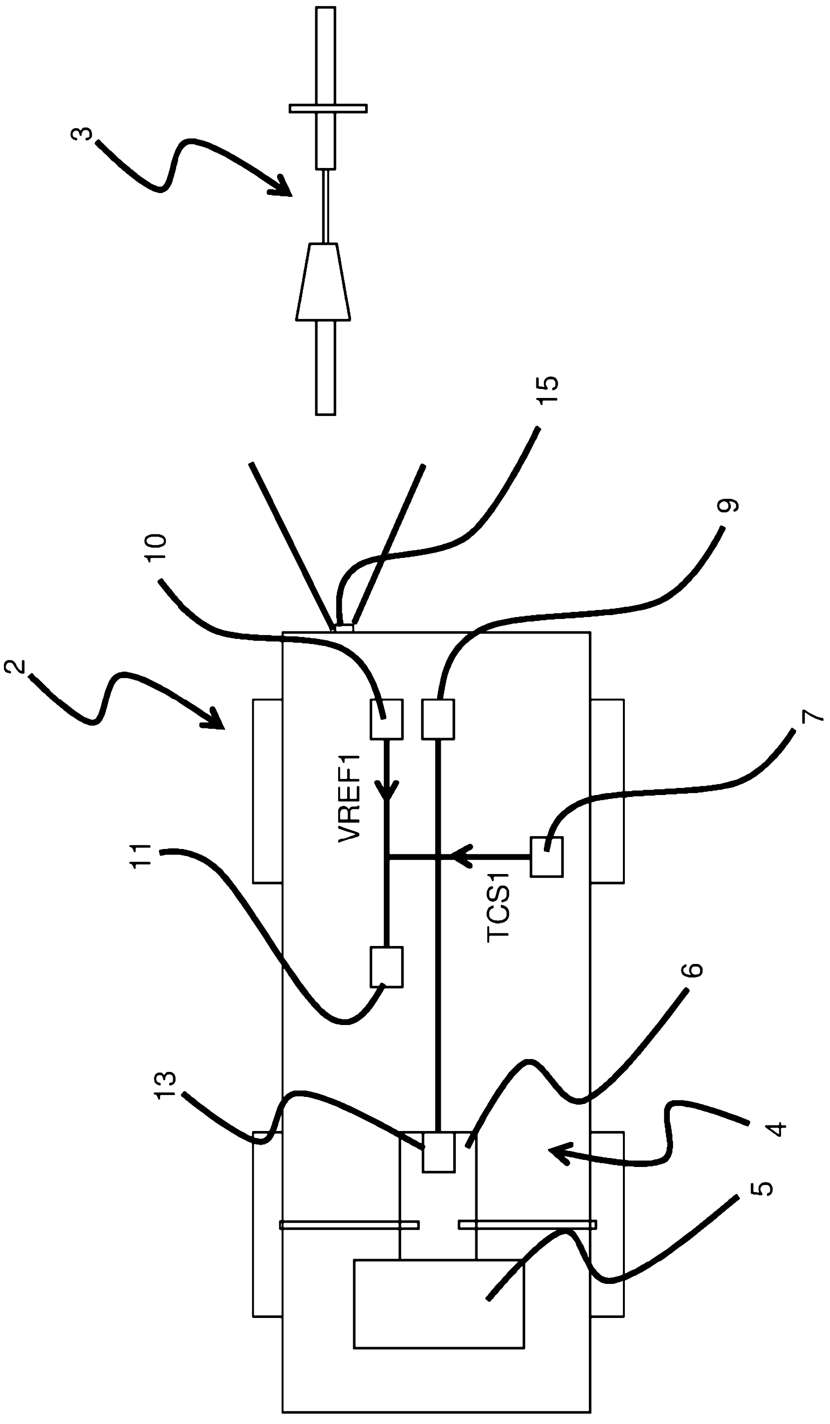


FIG. 2

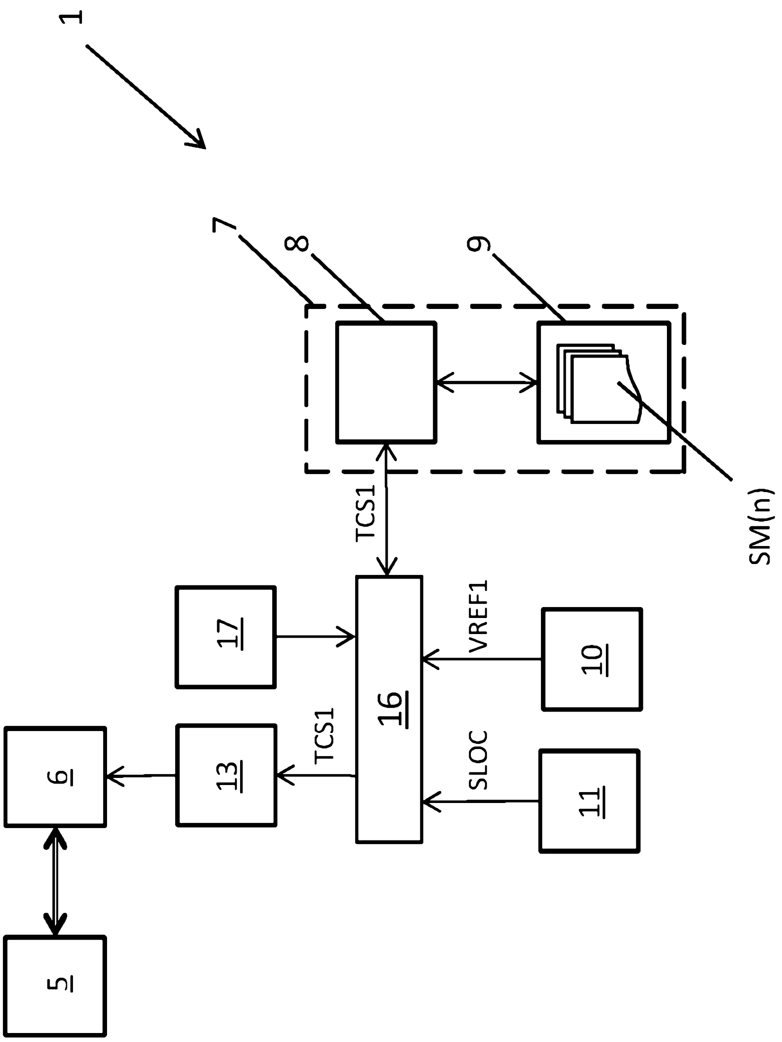


FIG. 3

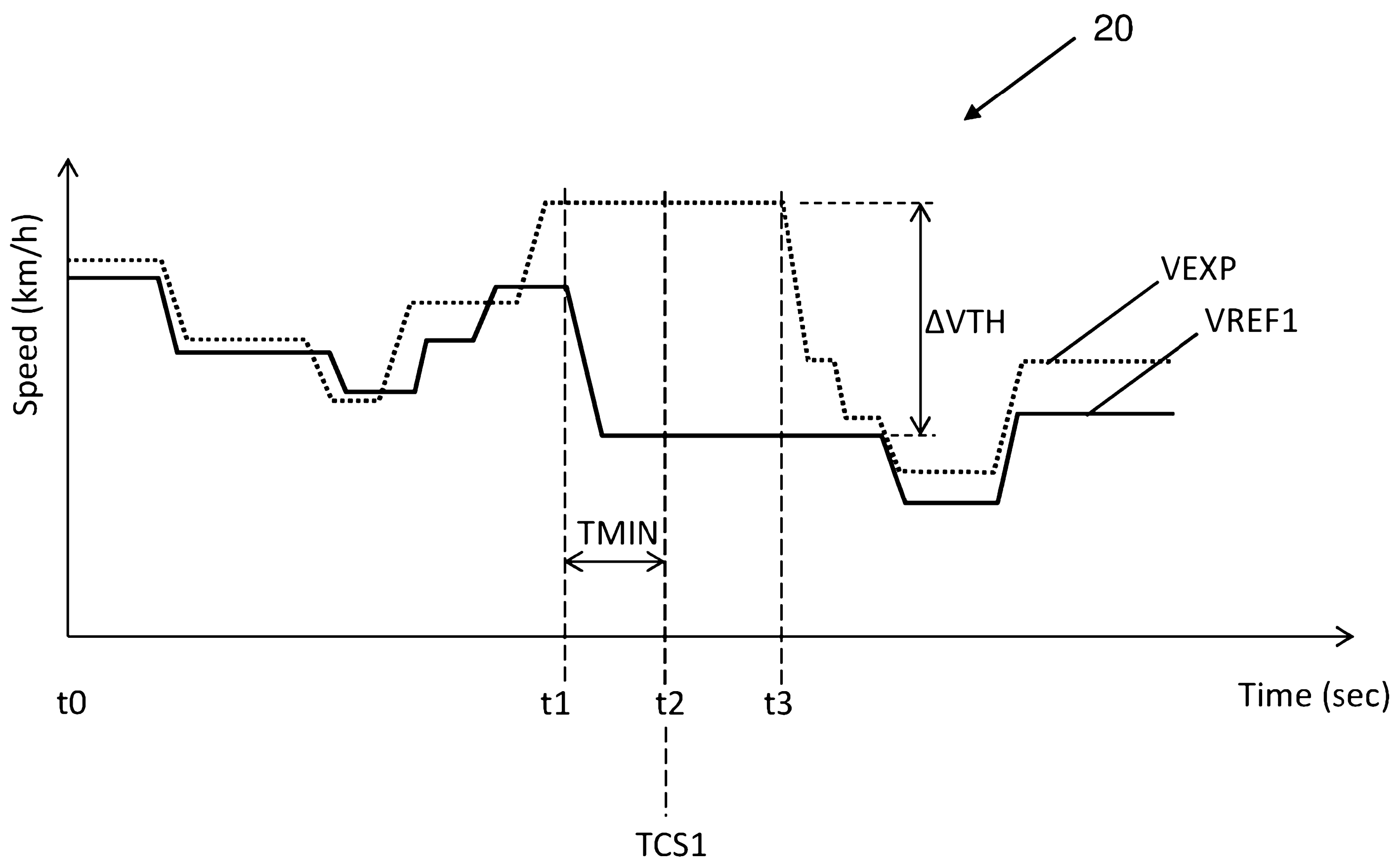


FIG. 4

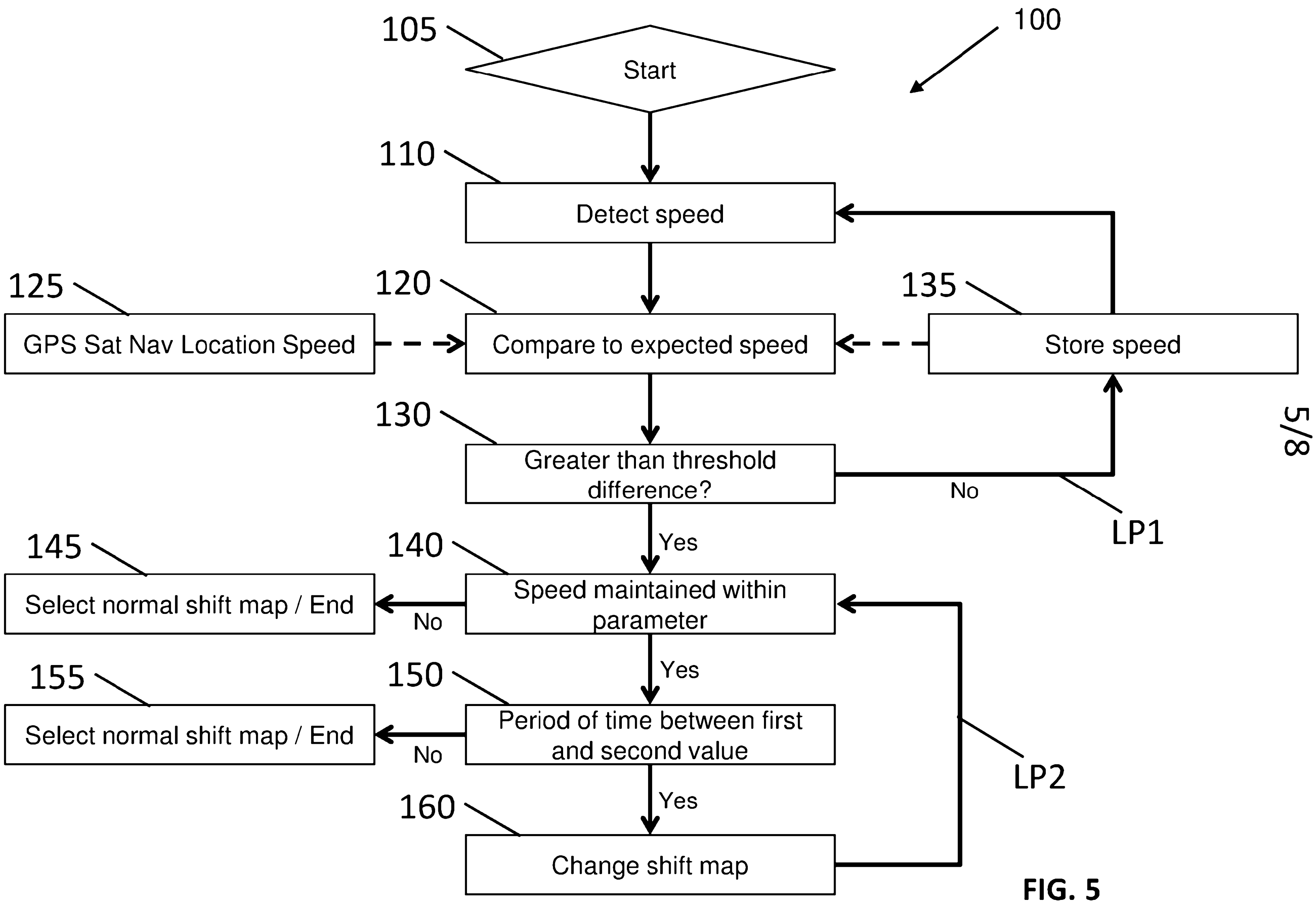

100
105
Start
110
Detect speed
125
GPS Sat Nav Location Speed
120
Compare to expected speed
135
Store speed
130
Greater than threshold difference?
No
LP1
Yes
145
Select normal shift map / End
140
Speed maintained within parameter
No
Yes
155
Select normal shift map / End
150
Period of time between first and second value
No
Yes
160
Change shift map
LP2

FIG. 5

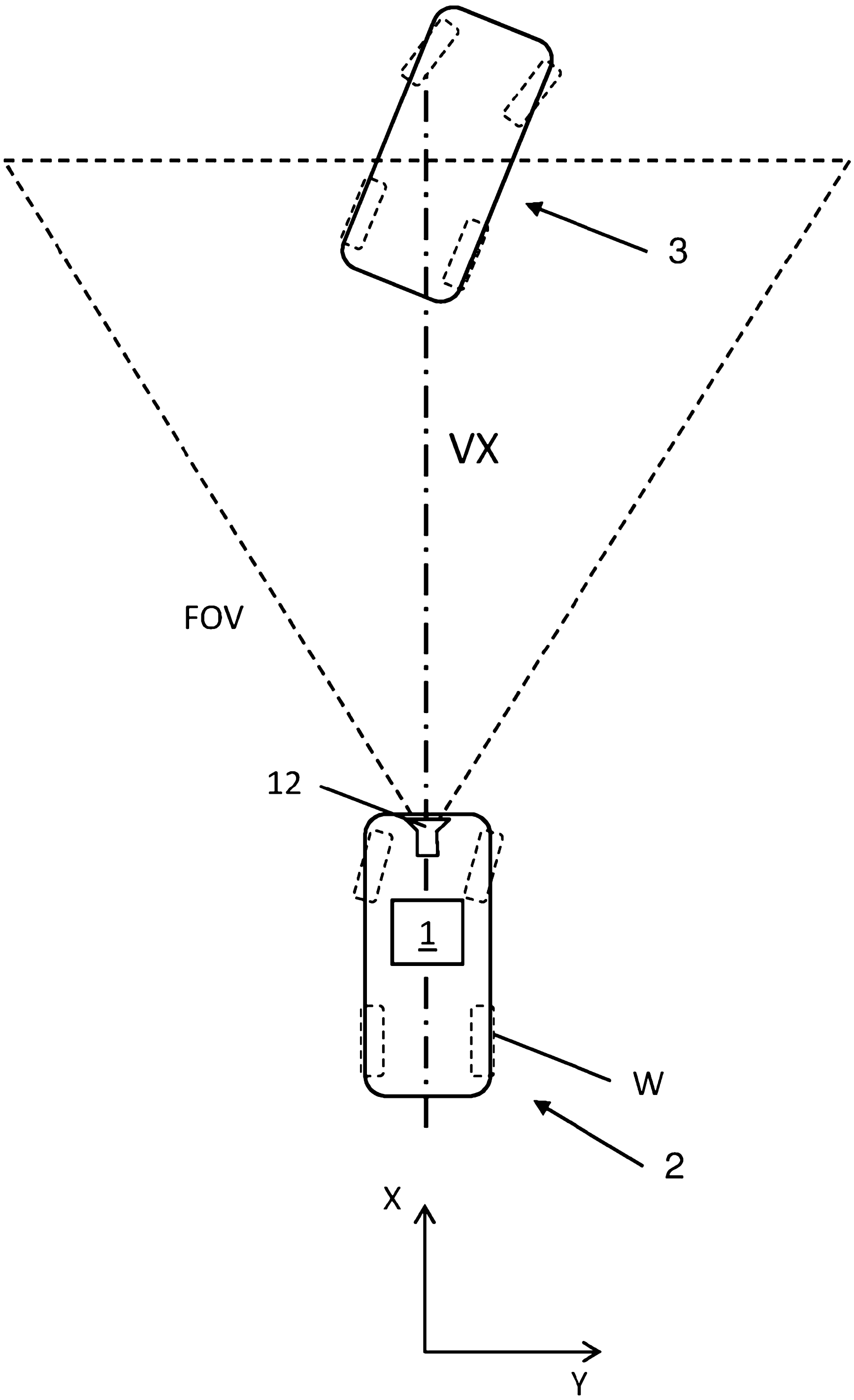


FIG. 6

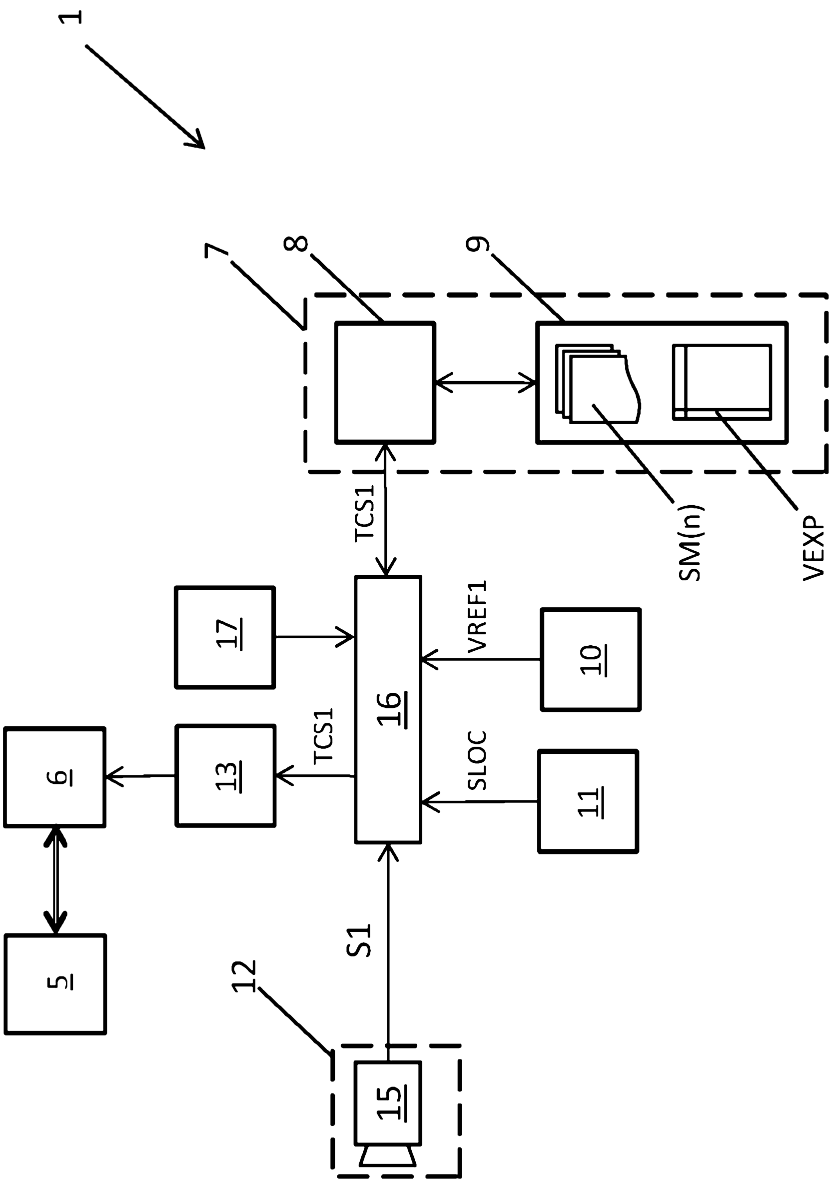
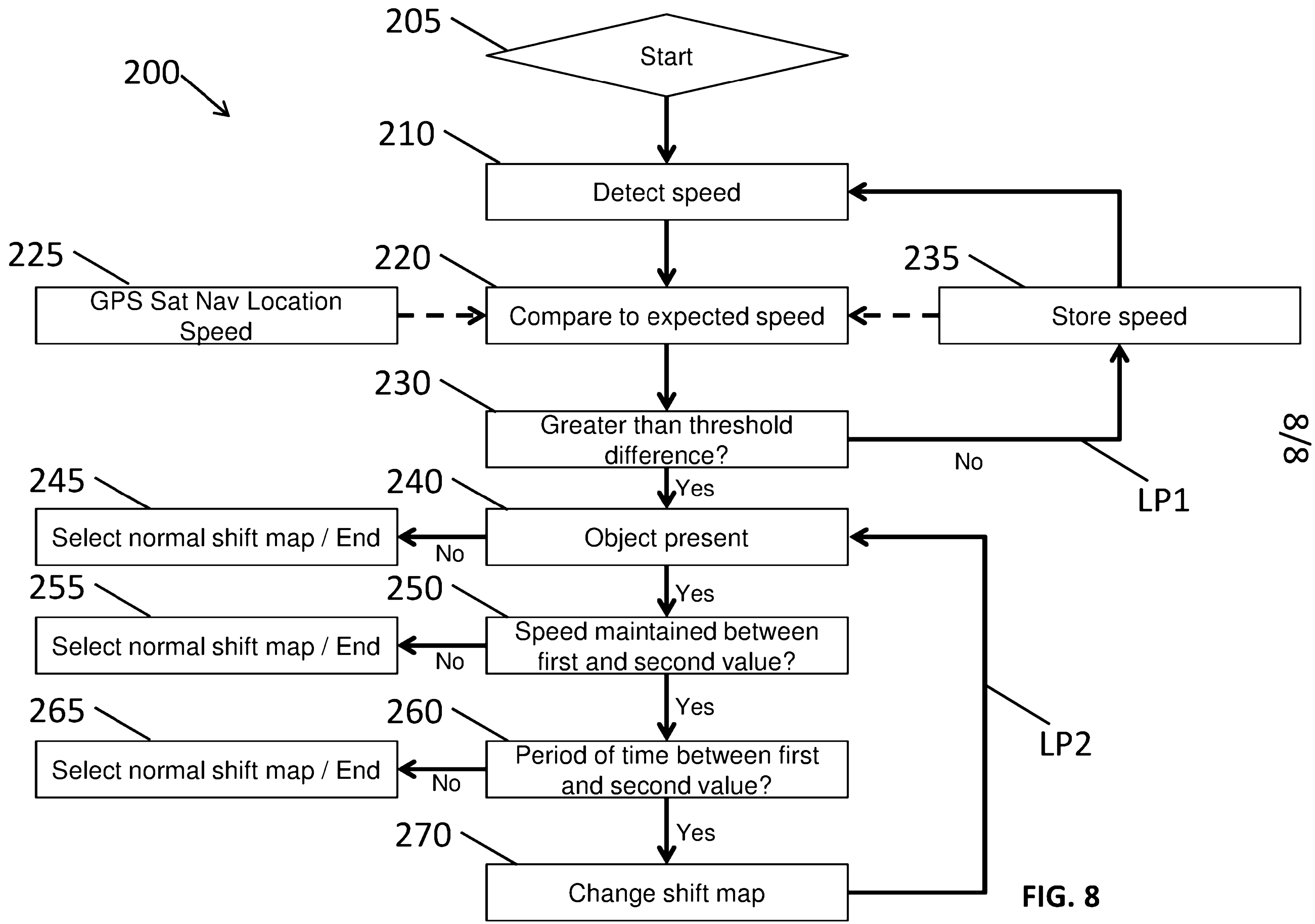


FIG. 7



200
205
Start
210
Detect speed
225
GPS Sat Nav Location Speed
220
Compare to expected speed
235
Store speed
230
Greater than threshold difference?
No
LP1
Yes
245
Select normal shift map / End
240
Object present
No
Yes
255
Select normal shift map / End
250
Speed maintained between first and second value?
No
Yes
265
Select normal shift map / End
260
Period of time between first and second value?
No
Yes
270
Change shift map
LP2

FIG. 8

VEHICLE CONTROL METHOD AND APPARATUS

TECHNICAL FIELD

The present disclosure relates to a vehicle control method and apparatus. In particular, but not exclusively, the present disclosure relates to a method and apparatus for controlling a vehicle to assist in the performance of an overtaking manoeuvre. The method and apparatus may be used to control operation of a transmission in a host vehicle.

BACKGROUND

A vehicle approaching a slow-moving vehicle from behind will often slow to reduce the closing velocity. The resulting reduction in the speed of the vehicle often prompts an automatic transmission to shift to a gear adapted for efficient speed to power ratio. Acceleration from that gear to overtake the slow-moving vehicle may however require a down shift resulting in a delay before acceleration can be realised. A driver of a semi-automatic car can compensate for the required downshift by manually downshifting before overtaking. However this requires manual intervention from the driver.

At least in certain embodiments, the present invention seeks to provide an improved control system and method.

SUMMARY OF THE INVENTION

Aspects of the present invention relate to a controller, a vehicle, a method of controlling a transmission and a non-transitory computer-readable medium as claimed in the appended claims.

According to a further aspect of the present invention there is provided a controller for controlling selection of a drive ratio in an automatic or semi-automatic transmission of a host vehicle; the controller comprising a processor configured to:

determine a current speed of the host vehicle;

determine an expected speed of the host vehicle; and

control operation of the transmission in dependence on a comparison of the expected speed and the current speed. The transmission comprises a plurality of drive ratios which are selectable automatically or semi-automatically. The controller in accordance with an aspect of the present invention is configured to control operation of the transmission. By comparing the expected speed and the current speed, the controller in accordance with the present invention may pre-emptively configure the transmission for an anticipated event, such as an overtaking manoeuvre. In particular, the controller may control the transmission to select or hold a drive ratio suitable for accelerating the host vehicle to perform a passing or overtaking manoeuvre.

The processor may be configured to output a control signal for controlling operation of the transmission. The control signal may be generated, at least in part, in dependence on the comparison of the expected speed and the current speed. The control signal may control operation of the transmission in accordance with the control strategy described herein.

Using existing vehicle systems, the current vehicle speed can be compared to an expected speed for a particular location. The expected speed may, for example, be determined based on a combination of an average speed the vehicle has been moving and the speed limit for the road on which the vehicle is moving. A speed drop (rapidly or otherwise) below the average speed maintained for a time above a first threshold and below a second threshold may suggest that the vehicle has encountered a slow moving vehicle. An optional check can be made using object detection, for example within a camera image. If the processor determines that the host vehicle is behind a target vehicle which is travelling at a lower speed, the processor may control the transmission to select a lower than usual drive ratio in preparation for acceleration. The selected drive ratio may be held while the vehicle remains at the slower speed and until a time period has elapsed, after which the normal operating drive ratio may be selected.

The expected speed may be determined for a current geospatial location of the host vehicle. The expected speed of the host vehicle may be determined in dependence on at least one circumstantial condition and/or historic data.

The comparison may comprise determining when the current speed of the host vehicle is less than the expected speed. The processor may be configured to control operation of the transmission when the determined difference between the current reference speed and the expected speed is greater than a predetermined threshold.

The expected speed may be predefined or may be determined dynamically. The expected speed may be determined in dependence on vehicle speed data relating to the host vehicle. The vehicle speed data may relate to a current geographic location of the host vehicle. The vehicle speed data may comprise an average speed of the host vehicle. The average speed may be calculated over a predefined time period, for example a predefined time period prior to a detected braking event.

The vehicle speed data may comprise or consist of data generated in dependence on current operation of the host vehicle. The current operation of the host vehicle may refer to operation of the host vehicle within a prescribed time interval, for example the last 30 seconds, 1 minute, 3 minutes or 5 minutes of operation. The vehicle speed data may comprise an average speed of the host vehicle during the prescribed time interval. Alternatively, the current operation of the host vehicle may refer to operation of the host vehicle since initiating the current journey. The vehicle speed data may comprise an average speed of the host vehicle since the journey began.

Alternatively, or in addition, the vehicle speed data comprises or consists of historic data generated in dependence on historic operation of the host vehicle. The at least one reference speed may be historical data for the particular host vehicle, for example generated during one or more previous journeys along the same road. The historical vehicle speed data may be collated at a similar time of day as the current journey.

Alternatively, or in addition, the vehicle speed data may comprise vehicle speed data of one or more other vehicles. The vehicle speed data may comprise an average speed of one or more other vehicles. For example, an average speed of a plurality of host vehicles on a particular section of the road, for example comprising historic vehicle speed data or current speed data. Alternatively, or in addition, the reference speed could be generated in dependence on an average speed of a plurality of host vehicles currently travelling on the same road.

The expected speed may be determined in dependence on one or more of the following set:

map data relating to a road on which the host vehicle is currently travelling;

traffic data relating to a current traffic density on a road on which the host vehicle is currently travelling; and

a posted or local speed limit applicable on a road on which the host vehicle is currently travelling.

The map data may be stored in a storage device, for example based on historical data and/or a predetermined data file. The expected speed may be computed at least substantially in real time, for example by analysing stored map data. By way of example, the analysis may comprise determining a radius of curvature based on stored map data and/or an elevation change based on stored map data. The traffic data may be generated by the host vehicle, for example using one or more on-board sensors. Alternatively, the traffic data may be determined from an external source, for example via vehicle-to-vehicle communication or vehicle-to-infrastructure communication.

The expected speed may be determined in dependence on a detected position and/or a detected speed of one or more other vehicles proximal to the host vehicle. For example, the expected speed could be determined in dependence on the speed of a vehicle in front of the host vehicle.

The processor may be configured to control operation of the transmission in dependence on detection of a target vehicle in front of the host vehicle.

The transmission may be controlled, at least in part, in dependence on the comparison of the expected speed and the current speed to implement one or more of the following:

changing to a lower drive ratio; and

delaying a change to a higher drive ratio.

The controller may control operation of the transmission in dependence on one or more of the following: a current selected drive ratio; a desired (requested) drive ratio; and a measurement of the length of time that a current drive ratio has been selected.

Alternatively, or in addition, the controller may modify shift time of the transmission in dependence on the outcome of said comparison. Related changes could, for example, include changing accelerator pedal response.

The processor may be configured to control operation of the transmission by delaying a change of a selected drive ratio, for example until a predetermined time period has elapsed. For example, the processor may control the transmission to delay changing the selected drive ratio until the difference between the expected speed and the current speed exceeds a predetermined threshold for a minimum period of time. The minimum period of time may correspond to a minimum time threshold. The implementation of a time threshold may suppress relatively short-period changes in the current speed of the host vehicle, for example if the host vehicle brakes temporarily for a corner.

The processor may be configured to control operation of the transmission, at least in part, in dependence on the comparison of the expected speed and the current speed only while the current speed of the host vehicle is maintained within a prescribed operating speed range. The processor may be configured to end (i.e. conclude) control of the transmission in dependence on the comparison of the expected speed and the current speed when the current speed of the host vehicle is outside the prescribed operating speed range. The prescribed operating speed range could be predefined, for example defining a minimum speed of the host vehicle. Alternatively, the prescribed operating speed range may be determined in dependence on the speed of the host vehicle when the determined difference between the current reference speed and the expected speed exceeded the predetermined threshold. The prescribed operating speed range may be the host vehicle reference speed plus or minus a prescribed value (for example ±5km/h or ±10km/h); or the host vehicle reference speed plus or minus a prescribed percentage (for example ±5% or ±10%).

The processor may be configured to control operation of the transmission in dependence on the comparison of the expected speed and the current speed for a predefined time period.

The processor may be configured to control operation of the transmission by selecting a transmission shift map in dependence on the comparison of the expected speed and the current speed. The processor may be configured to select one of a plurality of transmission shift maps in dependence on the comparison. The transmission shift maps may be predefined and specify which drive ratio should be selected based on the current (prevailing) operating conditions, for example the operating speed and/or power of the internal combustion engine 5. When the current speed of the host vehicle is less than the expected speed, the processor may be configured to select a transmission shift map for prioritising acceleration of the host vehicle (as opposed to other factors, such as fuel economy) to facilitate overtaking. By way of example, a first transmission shift map be selected to prioritise acceleration instead of a second transmission shift map which provides an efficient speed to power ratio to improve fuel economy. The first transmission shift map may correspond to the transmission shift map which is currently active and the processor may be configured to hold the first transmission shift map rather than change to the second transmission shift map.

According to a further aspect of the present invention there is provided a vehicle comprising a controller as described herein. The controller may be incorporated into a transmission control module, or may be a separate controller configured to output a transmission control signal.

According to a further aspect of the present invention there is provided a method of controlling selection of a drive ratio in an automatic or semi-automatic transmission of a host vehicle; the method comprising:

determining a current speed of the host vehicle;

determining an expected speed of the host vehicle; and

controlling operation of the transmission in dependence on a comparison of the expected speed and the current speed.

The comparison may comprise determining when the current speed of the host vehicle is less than the expected speed.

The method may comprise controlling operation of the transmission when the determined difference between the current reference speed and the expected speed is greater than a predetermined threshold.

The expected speed may be determined in dependence on vehicle speed data relating to the host vehicle.

The vehicle speed data may comprise an average speed of the host vehicle.

The vehicle speed data may comprise or consist of data generated in dependence on current operation of the host vehicle.

The vehicle speed data may comprise or consists of historic data generated in dependence on historic operation of the host vehicle.

The method may comprise determining the expected speed in dependence on one or more of the following set:

map data relating to a road on which the host vehicle is currently travelling;

traffic data relating to a current traffic density on a road on which the host vehicle is currently travelling; and

a posted or local speed limit applicable on a road on which the host vehicle is currently travelling.

The method may comprise determining the expected speed in dependence on a detected position and/or a detected speed of one or more other vehicles proximal to the host vehicle.

The method may comprise controlling operation of the transmission in dependence on detection of a target vehicle in front of the host vehicle.

The control of the transmission in dependence on the comparison of the expected speed and the current speed may comprise one or more of the following set:

changing to a lower drive ratio; and

delaying a change to a higher drive ratio.

The control of the transmission in dependence on the comparison of the expected speed and the current speed may comprise delaying a change of a selected drive ratio until a predetermined time period has elapsed

The method may comprise controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed only while the current speed of the host vehicle is maintained within a prescribed operating speed range. The method may comprise ending (i.e. concluding) control of the transmission in dependence on the comparison of the expected speed and the current speed when the current speed of the host vehicle is outside the prescribed operating speed range. The prescribed operating speed range could be predefined, for example defining a minimum speed of the host vehicle. Alternatively, the prescribed operating speed range may be determined in dependence on the speed of the host vehicle when the determined difference between the current reference speed and the expected speed exceeded the predetermined threshold. The prescribed operating speed range may be the host vehicle reference speed plus or minus a prescribed value (for example ±5km/h or ±10km/h); or the host vehicle reference speed plus or minus a prescribed percentage (for example ±5% or ±10%).

The method may comprise controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed for a predefined time period.

According to a further aspect of the present invention there is provided a non-transitory computer-readable medium having a set of instructions stored therein which, when executed, cause a processor to perform the method described herein.

Any control unit or controller described herein may suitably comprise a computational device having one or more electronic processors. The system may comprise a single control unit or electronic controller or alternatively different functions of the controller may be embodied in, or hosted in, different control units or controllers. As used herein the term “controller” or “control unit” will be understood to include both a single control unit or controller and a plurality of control units or controllers collectively operating to provide any stated control functionality. To configure a controller or control unit, a suitable set of instructions may be provided which, when executed, cause said control unit or computational device to implement the control techniques specified herein. The set of instructions may suitably be embedded in said one or more electronic processors. Alternatively, the set of instructions may be provided as software saved on one or more memory associated with said controller to be executed on said computational device. The control unit or controller may be implemented in software run on one or more processors. One or more other control unit or controller may be implemented in software run on one or more processors, optionally the same one or more processors as the first controller. Other suitable arrangements may also be used.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the present invention will now be described, by way of example only, with reference to the accompanying Figures, in which:

Figure 1 shows a schematic representation of a host vehicle incorporating a control system in accordance with an embodiment of the present invention;

Figure 2 shows a schematic representation of the components of the host vehicle shown in Figure 1;

Figure 3 shows a schematic representation of the components of the control system shown in Figures 1 and 2;

Figure 4 shows an exemplary chart representing the operation of the control system to compare the host vehicle reference speed with a host vehicle expected speed;

Figure 5 shows a block diagram illustrating operation of the control system in accordance with the embodiment shown in Figures 1 to 4;

Figure 6 shows a schematic representation of a host vehicle incorporating a control system in accordance with a further embodiment of the present invention;

Figure 7 shows a schematic representation of the components of the control system shown in Figure 6; and

Figure 8 shows a block diagram illustrating operation of the control system in accordance with the embodiment shown in Figures 6 and 7.

DETAILED DESCRIPTION

A control system 1 for controlling operation of a host vehicle 2 in accordance with an embodiment of the present invention will now be described with reference to the accompanying Figures. The control system 1 is configured to control one or more vehicle systems to facilitate overtaking of another vehicle (referred to herein as a target vehicle 3). The control system 1 may be referred to as an overtake assist control device.

As shown in Figures 1 and 2, the control system 1 is operable to identify a target vehicle 3 in front of the host vehicle 2. The target vehicle 3 may be moving or may be stationary. The host vehicle 2 is a wheeled vehicle having four wheels W. The host vehicle 2 in the present embodiment is an automobile, but it will be understood that the control system 1 may be installed in other types of vehicle. The host vehicle 2 may have fewer or more wheels W than the host vehicle 2 shown in Figures 1 and 2. The target vehicle 3 may be an automobile or other road vehicle, such as a motorcycle, a truck, a coach or a bicycle (cyclist).

The host vehicle 2 comprises a vehicle powertrain (denoted generally by the reference numeral 4). As shown schematically in Figure 2, the vehicle powertrain 4 comprises a prime mover 5 arranged to provide the motive force with which to propel the vehicle in use. In this example, the prime mover comprises an internal combustion engine 5 and a transmission 6. It will be appreciated that the prime mover may additionally or alternatively comprise an electric traction motor. The transmission 6 in the present embodiment is a semi-automatic transmission operable to select one of a plurality of drive ratios. In use, torque generated by the prime mover 5 is transmitted to two or more of the wheels W to apply a tractive force to propel the host vehicle 2. The host vehicle 2 in the present embodiment is rear-wheel drive and torque is transmitted to the rear wheels W3, W4. It will be understood that the control system 1 could also be installed in a host vehicle 2 having front-wheel drive or four-wheel drive. At least some of the torque transmitted to the wheels W could be generated by one or more electric traction machine. The one or more electric traction machine could be used instead of, or in addition to the internal combustion engine 5.

A schematic representation of the control system 1 installed in the host vehicle 2 is shown in Figure 3. The control system 1 comprises a controller 7 having at least one electronic processor 8 and a memory 9. The controller 7 is maintained in communication with the transmission 6. The controller 7 is operative to maintain at least substantially continuous (i.e.

uninterrupted) control of the transmission 6 whilst the host vehicle 2 is in use. As described herein, the controller 7 is operative to implement a modified control strategy in dependence on a comparison of a host vehicle reference speed VREF1 with an expected host vehicle speed VEXP. The description herein focuses on the modified control strategy implemented in dependence on this comparison. However, it will be understood that the controller 7 remains in communication with the transmission 6. Data and signals relating to the conventional operation of the transmission 6 continue to be transmitted between the transmission 6 and the controller 7.

The processor 8 is configured to receive the host vehicle reference speed VREF1 for indicating a current speed of the host vehicle 2. The host vehicle reference speed VREF1 may, for example, be generated by one or more wheel speed sensors 10 associated with one or more respective wheels W of the host vehicle 2. The processor 8 is also connected to a positioning system 11, such as a Global Navigation Satellite System (GNSS), for example, Global Positioning System (GPS), to receive a location signal SLOC indicating a current (i.e. real time) geospatial location of the host vehicle 2. Other techniques may be used to determine the geospatial location of the host vehicle 2, for example by wireless communication with one or more nodes of a cellular communication network (either directly from a wireless transceiver disposed in the host vehicle 2, or via a cellular telephone paired to the host vehicle 2). The processor 8 is operable to output a transmission control signal TCS1 to a transmission control module 13 to control operation of the transmission 6. As described herein, the transmission control module 13 is operable to control the transmission 6 to engage (or to retain/hold onto) one of a plurality of transmission shift maps SM(n) in dependence on the received transmission control signal TCS1. The transmission shift maps SM(n) are predefined and specify which drive ratio should be selected based on the current (prevailing) operating conditions, for example the operating speed and/or power of the internal combustion engine 5. The processor 8 in the present embodiment is configured to generate the transmission control signal TCS1 to select a first transmission shift map SM(1) for prioritising acceleration of the host vehicle 2 to facilitate overtaking the target vehicle 3. The first transmission shift map SM(1) may, for example, be selected instead of a second transmission shift map SM(2) which provides an efficient speed to power ratio to improve fuel economy. The first transmission shift map SM(1) may correspond to the transmission shift map SM(n) which is currently active and in this case the transmission control signal TCS1 may prompt the transmission control module 13 to hold said first transmission shift map SM(1) rather than change to the second transmission shift map SM(2).

As outlined above, the controller 7 is configured to determine the geospatial location of the host vehicle 2 by referencing the positioning system 11. The controller 7 may cross-reference the determined geospatial location with map data, for example to identify a road or highway along which the host vehicle 2 is travelling. The map data in the present embodiment is stored in the memory 9, but could be stored in any suitable machine-readable storage device. The storage device may be provided in the host vehicle 2 or may be remote from the host vehicle 2, for example accessible over a cellular communication network. In accordance with an aspect of the present invention, the map data also comprises vehicle speed data defining the expected host vehicle speed VEXP. The expected host vehicle speed VEXP defines an expected reference velocity of the host vehicle 2 at a given location. The expected host vehicle speed VEXP may be determined in dependence on one or more of the following set: historic data; road type or classification; ambient weather conditions; road traffic information; time of day; time of year; driving style; and driver identity. The historic data may, for example, comprise historic speed data recorded while the host vehicle 2 travelled along the same road or a section thereof on one or more previous occasions. Alternatively, or in addition, the historic data may provide an indication of driver familiarity with the road or a section thereof, for example based on the number of times or frequency with which the host vehicle 2 travels along that road. The road type or classification may, for example, differentiate between one or more of the following: a multi-lane divided expressway (for example a motorway or a dual carriageway), a multi-lane undivided expressway, a principal highway (for example a primary “A” road), a secondary highway (for example a secondary “B” road) and a local road. Other roads types and classifications include a federal interstate, a federal highway, a state/provincial highway, a county primary, a principal local road and other roads/trails. It will be understood that the road type or classification may be derived directly from map data. The ambient weather conditions may be derived from local weather data, for example accessed over a communications network. Alternatively, the ambient weather conditions may be derived from one or more sensors 17 provided on the host vehicle 2, for example by on-board rain sensors. The road traffic information may be accessed from any suitable traffic monitoring service. The driving style may be assessed in dependence on vehicle acceleration and/or vehicle braking and/or vehicle maximum speed and/or vehicle average speed during the current journey and/or a previous journey (or previous journeys). The expected host vehicle speed VEXP may also take account of the relevant highway legislation, for example relevant posted or local speed limits. Such speed limits may be set national or local authorities for public roads, or may be set by land owners for private roads. The speed limits may vary in dependence on the time of day, for example around schools, or in dependence on prevailing conditions, for example when it is snowing or raining or if there is traffic congestion in the area.

The expected traffic host vehicle speed VEXP may also be determined in dependence on host vehicle operating parameters. The host vehicle 2 may comprise a traction control system (not shown) which provides an estimation of the available traction, for example based on detected wheel slip. The expected host vehicle speed VEXP may be modified in dependence on the available traction. The host vehicle 2 may comprise an inertial measurement unit (IMU) (not shown) which measures inertial movements of the host vehicle 2, for example longitudinal and or lateral movement of the host vehicle 2. The expected host vehicle speed VEXP may be modified in dependence on the IMU measurements.

The control system 1 is configured to identify operating parameters indicative of a potential overtaking event when the host vehicle 2 has slowed as a result of the target vehicle 3 and the driver may wish to overtake the target vehicle 3. If a potential overtaking event is identified, the control system 1 controls one or more vehicle systems to configure the host vehicle 2 to facilitate overtaking, for example to prioritise vehicle acceleration. In the present embodiment, the control system 1 is configured to identify when the host vehicle 2 is travelling slower than expected on a given stretch of road and to configure one or more vehicle systems to prioritise acceleration of the host vehicle 2, for example to facilitate overtaking the target vehicle 3.

The control system 1 is configured to identify when the host vehicle reference speed VREF1 decreases to less than the expected host vehicle speed VEXP for the current location of the host vehicle 2. The processor 8 determines a theoretical speed difference ΔVTH between the host vehicle reference speed VREF1 and the expected host vehicle speed VEXP. When the theoretical speed difference ΔVTH is greater than a predefined speed threshold, the processor 8 identifies a potential overtaking event. The predefined speed threshold may, for example, be 10km/h, 20km/h, 30km/h, 40km/h or 50km/h. The predefined speed threshold may be predefined or may be calculated dynamically. The predefined speed threshold may be determined with reference to the expected host vehicle speed VEXP, for example as a percentage of the expected host vehicle speed VEXP. The percentage could, for example, be defined as 50%, 60%, 70% or 80% of the expected host vehicle speed VEXP. If the theoretical speed difference ΔVTH is greater than the predefined speed threshold for at least a predefined minimum time period, the processor 8 generates a transmission control signal TCS1 to request that the transmission control module 13 activate an alternative transmission shift map SM(n) to prioritise acceleration of the host vehicle 2 to facilitate completion of an overtaking manoeuvre. The control system 1 could be configured to inhibit control of the one or more vehicle systems if the host vehicle reference speed VREF1 is less than a minimum speed threshold, for example if the host vehicle reference speed VREF1 is less than 10km/h, 20km/h or 30km/h. The control system 1 could be configured to inhibit control of the one or more vehicle systems if the host vehicle 2 comes to a halt (i.e. the host vehicle reference speed VREF1 is at least substantially equal to zero (0).

The alternative transmission shift map SM(n) may, for example, specify that the transmission 6 remains in, or selects a lower drive ratio than would be selected when a normal transmission shift map SM(n) is activated. If the theoretical speed difference ΔVTH is less than the predefined speed threshold for at least a predefined minimum time period TMIN, the processor 8 generates a transmission control signal TCS1 to request that the transmission control module 13 activate a normal transmission shift map SM(n), for example to prioritise an efficient speed to power ratio for the internal combustion engine 5. The predefined minimum time period TMIN may, for example, be 5 seconds, 10 seconds, 15 seconds, 20 seconds or 30 seconds. The predefined minimum time period could be calculated dynamically, for example the predefined minimum time period may be proportional to a measured rate of deceleration of the host vehicle 2.

A typical use case for the control system 1 is illustrated in an exemplary chart 20 shown in Figure 4. The chart 20 shows the host vehicle reference speed VREF1 and the expected host vehicle speed VEXP for a sample journey. There is a close correlation between the host vehicle reference speed VREF1 and the expected host vehicle speed VEXP for an initial part of the journey from an initial time t0 to a first time t1. However, following the first time t1, the host vehicle reference speed VREF1 diverges from the expected host vehicle speed VEXP. The processor 8 calculates the theoretical speed difference ΔVTH and determines that it exceeds the predefined speed threshold of, for example, 50% of the expected host vehicle speed VEXP. Upon determining that the theoretical speed difference ΔVTH is greater than the predefined speed threshold for the predefined minimum time period TMIN, the processor 8 generates a transmission control signal TCS1 to request that the transmission control module 13 activate the alternate transmission shift map SM(n) to prioritise acceleration of the host vehicle 2.

The operation of the control system 1 in accordance with the present embodiment will now be described with reference to a first block diagram 100 shown in Figure 5. The control system 1 is activated (BLOCK 105). The controller 7 detects the host vehicle reference speed VREF1 (BLOCK 110). The controller 7 communicates with the positioning system 11 in order to determine the geospatial location of the host vehicle 2. The controller 7 determines an expected host vehicle speed VEXP (BLOCK 120). The controller 7 may, for example, determine the expected host vehicle speed VEXP as a product of the recent speed of the host vehicle 2, for example an average speed over a predetermined time period, or the average speed previously driven by the host vehicle 2. Alternatively or in addition, the expected host vehicle speed VEXP may be accessed from map data, for example in dependence on the current geospatial location of the host vehicle 2 determined from the positioning system 11 (BLOCK 125). In such an example the expected speed may be a product of one or more of a posted or local speed limit; the speed previously driven; road type or classification; ambient weather conditions and road traffic information.

The controller 7 compares the host vehicle reference speed VREF1 to the expected host vehicle speed VEXP to determine a theoretical speed difference ΔVTH (BLOCK 125). A check is performed to determine if the difference in the host vehicle reference speed VREF1 and the expected host vehicle speed VEXP is greater than a predefined speed threshold (BLOCK 130). If the theoretical speed difference ΔVTH is less than the predefined speed threshold (LP1), the map data is updated by storing the host vehicle reference speed VREF1 for the current geospatial location of the host vehicle 2 (BLOCK 135), thereby updating the expected host vehicle speed VEXP for future comparisons (represented by a dashed line in Figure 5). The controller 7 then restarts the process by detecting the host vehicle reference speed VREF1 (BLOCK 110). If the theoretical speed difference ΔVTH is greater than the predefined speed threshold, the control system 1 identifies the host vehicle 2 as travelling outside a normal operating speed range (i.e. outside an expected speed range).

The controller 7 then checks whether the host vehicle reference speed VREF1 is maintained within an operating speed range (BLOCK 140). The operating speed range may, for example, be defined as a range determined in dependence on the host vehicle reference speed VREF1. For example, the operating speed range may be the host vehicle reference speed VREF1 plus or minus a prescribed value (for example ±5km/h or ±10km/h); or the host vehicle reference speed VREF1 plus or minus a prescribed percentage (for example ±5% or ±10%). The operating speed range is applied to suppress output of the transmission control signal TCS1 in the event that the host vehicle 2 is braking to stop. If the host vehicle reference speed VREF1 is not maintained within the operating speed range, the controller 7 outputs a transmission control signal TCS1 to the transmission control module 13 to select a normal transmission shift map SM(n) (i.e. a standard transmission shift map based on the current operating speed of the host vehicle 2 and the internal combustion engine) and the process ends (BLOCK 145). If the host vehicle reference speed VREF1 is maintained within the operating range, the controller 7 performs an additional check to determine if the theoretical speed difference ΔVTH is greater than the predefined time threshold for a period of time greater than a first predefined time value and less than a second predefined time value (BLOCK 150). If this condition is not satisfied, the controller 7 outputs a transmission control signal TCS1 to the transmission control module 13 to select a normal transmission shift map (i.e. a standard transmission shift map based on the current operating speed of the host vehicle 2 and the internal combustion engine) and the process ends (BLOCK 155). If this condition is satisfied (i.e. the theoretical speed difference ΔVTH remains greater than the predefined time threshold for a period of time within the specified range), the controller 7 outputs a transmission control signal TCS1 to the transmission control module 13 to select an alternative transmission shift map (BLOCK 160). The alternative transmission shift map is defined to prioritise acceleration of the host vehicle 2 to facilitate completion of an overtaking manoeuvre. The alternative transmission shift map may, for example, specify that the transmission 6 operates in a lower drive ratio than would be selected in the normal transmission shift map.

Following output of the transmission control signal TCS1, the controller 7 enters a procedural loop (LP2) to continue to check that the theoretical speed difference ΔVTH remains within the operating speed range (BLOCK 140). The procedural loop (LP2) continues until the period of time elapsed is greater than the second predefined time value (BLOCK 150), prompting the output of a transmission control signal TCS1 to select a normal shift range and end the procedure (BLOCK 155).

A further embodiment of the present invention will now be described with reference to Figures 6, 7 and 8. This embodiment is a development of the embodiment described with reference to Figures 1 to 5. Like reference numerals are used for like components.

As shown in Figures 6 and 7, the controller 7 according to the present embodiment is connected to a sensing means 12 suitable for detecting the target vehicle 3. The sensing means 12 outputs a data signal S1 to the processor 8 of the controller 7. The processor 8 is operable to process the data signal S1 to detect the target vehicle 3. As shown in Figure 6, the sensing means 12 is mounted in a forward-facing orientation to establish a detection region in front of the host vehicle 2. The sensing means 12 in the present embodiment comprises at least one optical sensor 15 mounted to the host vehicle 2. The sensing means 12 may comprise a single camera or more than one camera. The sensing means 12 may, for example, comprise a stereoscopic camera. The at least one optical sensor 15 may be mounted at the front of the vehicle, for example incorporated into a front bumper or engine bay grille; or may be mounted within the vehicle cabin, for example in front of a rear-view mirror. The at least one optical sensor 15 has a field of view FOV having a central optical axis VX extending substantially parallel to the longitudinal axis X of the host vehicle 2. The field of view FOV is generally conical in shape and extends in horizontal and vertical directions. The at least one optical sensor 15 comprises a digital imaging sensor for capturing image data. The at least one optical sensor 15 captures image data substantially in real-time, for example at 30 frames per second. The at least one optical sensor 15 in the present embodiment is operable to detect light in the visible light spectrum. The sensing means 12 comprises optics (not shown) for directing the incident light onto an imaging sensor, such as a charge-coupled device (CCD), operable to generate image data for transmission in the data signal S1. Alternatively, or in addition, the sensing means 12 may be operable to detect light outside of the visible light spectrum, for example in the infra-red range to generate a thermographic image. Alternatively, or in addition, the sensing means 12 may comprise a radar sensor. Alternatively, or in addition, the sensing means 12 may comprise a Lidar sensor for projecting a laser light in front of the host vehicle 2. Other types of sensor are also contemplated.

The sensing means 12 publishes the data signal S1 to a communication bus 16 provided in the host vehicle 2. The data signal S1 is read from the communication bus 16 by the controller 7. In the present embodiment, the connection between the sensing means 12 and the communication bus 16 comprises a wired connection. In alternative embodiments, the connection between the sensing means 12 and the controller 7 may comprise a wireless connection, for example to enable remote positioning of the sensing means 12. The processor 8 is operable to parse the data signal S1 and extract image data. The processor 8 implements an image processing algorithm to identify the target vehicle 3 within the extracted image data. The image processing algorithm may recognise a shape or profile of the target vehicle 3, for example using pattern matching techniques. By applying the image processing algorithm to successive frames of the image data, the processor 8 tracks the movement of the target vehicle 3 relative to the host vehicle 2. The processor 8 may also calculate a distance (range) to the target vehicle 3 from the host vehicle 2. It will be understood that the processor 8 may access data from one or more other sensors to track the target vehicle 3. Alternatively, or in addition, the distance between the host vehicle 2 and the target vehicle 3 may be determined by a radar sensor or a Lidar sensor provided on the host vehicle 2. Alternatively, or in addition, the closing velocity of the host vehicle 2 relative to the target vehicle 3 may be determined by a radar sensor or a Lidar sensor provided on the host vehicle 2.

The controller 7 uses the detection of the target vehicle 3 as a further check when generating the transmission control signal TCS1. In particular, the controller 7 checks for the presence of the target vehicle 3 before outputting the transmission control signal TCS1 to request activation of the alternative transmission shift map SM(n).

The operation of the control system 1 in accordance with the present embodiment will now be described with reference to a second block diagram 200 shown in Figure 8. The control system 1 is activated (BLOCK 205). The controller 7 detects the host vehicle reference speed VREF1 (BLOCK 210). The controller 7 communicates with the positioning system 11 in order to determine the geospatial location of the host vehicle 2. The controller 7 determines an expected host vehicle speed VEXP. The controller 7 may, for example, determine the expected host vehicle speed VEXP as a product of the recent speed of the host vehicle 2, for example an average speed over a predetermined time period, or the average speed previously driven by the host vehicle 2. Alternatively or in addition, the expected host vehicle speed VEXP may be accessed from map data, for example in dependence on the current geospatial location of the host vehicle 2 determined from the GPS 11 (BLOCK 225). In such an example the expected speed may be a product of one or more of the posted or local speed limit; the speed previously driven; road type or classification; ambient weather conditions and road traffic information.

The controller 7 compares the host vehicle reference speed VREF1 to the expected host vehicle speed VEXP to determine a theoretical speed difference ΔVTH (BLOCK 220). A check is performed to determine if the difference between the host vehicle reference speed VREF1 and the expected host vehicle speed VEXP is greater than a predefined speed threshold (BLOCK 230). If the theoretical speed difference ΔVTH is less than the predefined speed threshold (LP1), the map data is updated by storing the host vehicle reference speed VREF1 for the current geospatial location of the host vehicle 2 (BLOCK 235), thereby updating the expected host vehicle speed VEXP for future comparisons (represented by a dashed line in Figure 7). The controller 7 then restarts the process by detecting the host vehicle reference speed VREF1 (BLOCK 210). If the theoretical speed difference ΔVTH is greater than the predefined speed threshold, the control system 1 identifies the host vehicle 2 as travelling outside a normal operating speed range (i.e. outside an expected speed range). The controller 7 then checks whether the sensing means 12 detected the target vehicle 3 (BLOCK 240). If the target vehicle 3 was not detected, the controller 7 outputs a transmission control signal TCS1 to the transmission control module 13 to select a normal transmission shift map SM(n) (i.e. a standard transmission shift map based on the current operating speed of the host vehicle 2 and the prime mover) and the process ends (BLOCK

245). If the target vehicle 3 is detected, the controller 7 performs an additional check to determine if the host vehicle reference speed VREF1 is within a predefined operating speed range comprising first and second values (BLOCK 250). The operating speed range may, for example, be defined as a range determined in dependence on the host vehicle reference speed VREF1. For example, the operating speed range may be the host vehicle reference speed VREF1 plus or minus a prescribed value (for example ±5km/h or ±10km/h); or the host vehicle reference speed VREF1 plus or minus a prescribed percentage (for example ±5% or ±10%). The operating speed range is applied to suppress output of the transmission control signal TCS1 in the event that the host vehicle 2 is braking to a halt. If the host vehicle reference speed VREF1 is not within the predefined speed range, the controller 7 outputs a transmission control signal TCS1 to the transmission control module 13 to select a normal transmission shift map (i.e. a standard transmission shift map based on the current operating speed of the host vehicle 2 and the internal combustion engine) and the process ends (BLOCK 255). If the host vehicle reference speed VREF1 is within the predefined speed range, the controller 7 performs an additional check to determine if the theoretical speed difference ΔVTH is greater than the predefined time threshold for a period of time greater than a first predefined time value and less than a second predefined time value (BLOCK 260). If this condition is not satisfied, the controller 7 outputs a transmission control signal TCS1 to the transmission control module 13 to select a normal transmission shift map SM(n) (i.e. a standard transmission shift map SM(n) based on the current operating speed of the host vehicle 2 and the internal combustion engine) and the process ends (BLOCK 265). If this condition is satisfied (i.e. the theoretical speed difference ΔVTH remains greater than the predefined time threshold for a period of time within the specified range), the controller 7 outputs a transmission control signal TCS1 to the transmission control module 13 to select an alternative transmission shift map (BLOCK 270).

The alternative transmission shift map is defined to prioritise acceleration of the host vehicle 2 to facilitate completion of an overtaking manoeuvre. The alternative transmission shift map SM(n) may, for example, specify that the transmission 6 operates in a lower drive ratio than would be selected in the normal transmission shift map. Following output of the transmission control signal TCS1, the controller 7 enters a procedural loop (LP2) to continue to check that the target vehicle 3 is detected (BLOCK 240). The procedural loop (LP2) continues until the period of time elapsed is greater than the second predefined time value (BLOCK 260), prompting the output have a transmission control signal TCS1 to select a normal shift range and end the procedure (BLOCK 265).

In a variant, the processor 8 may be operable to process the data signal S1 to estimate a target vehicle reference speed VREF2. The processor 8 in this arrangement may determine a closing velocity between the host vehicle 2 and the target vehicle 3 (corresponding to the difference between the host vehicle reference speed VREF1 and the target vehicle reference speed VREF2). The processor 8 may be configured to control operation of the host vehicle 2 in dependence on the relative speeds of the host vehicle 2 and the target vehicle 3.

It will be appreciated that various modifications may be made to the embodiment(s) described herein without departing from the scope of the appended claims.

The control system 1 has been described herein as controlling operation of the transmission 6 to prioritise acceleration of the host vehicle 2 in response to a driver request. Alternatively, or in addition, the control system 1 could be configured to control a throttle map in dependence on the comparison of the host vehicle reference speed VREF1 and the host vehicle expected speed VEXP. For example, the throttle map could be modified to increase throttle response to prioritise acceleration of the host vehicle 2 in response to a driver request. Alternatively, or in addition, the control system 1 may modify operation of one or more torque generating machines in the host vehicle 2 to assist with an overtaking manoeuvre. For example, the control system 1 may increase a torque output, for example from an electric machine, to assist in overtaking the target vehicle 3.

CLAIMS:

1. A controller for controlling selection of a drive ratio in an automatic or semi-automatic transmission of a host vehicle; the controller comprising a processor configured to:

determine a current speed of the host vehicle;

determine an expected speed of the host vehicle; and

control operation of the transmission in dependence on a comparison of the expected speed and the current speed.

2. A controller as claimed in claim 1, wherein the comparison comprises determining when the current speed of the host vehicle is less than the expected speed.

3. A controller as claimed in claim 2, wherein the processor is configured to control operation of the transmission when the determined difference between the current reference speed and the expected speed is greater than a predetermined threshold.

4. A controller as claimed in any one of claims 1, 2 or 3, wherein the expected speed is determined in dependence on vehicle speed data relating to the host vehicle.

5. A controller as claimed in claim 4, wherein the vehicle speed data comprises an average speed of the host vehicle.

6. A controller as claimed in claim 4 or claim 5, wherein the vehicle speed data comprises or consists of data generated in dependence on current operation of the host vehicle.

7. A controller as claimed in any one of claims 4, 5 or 6, wherein the vehicle speed data comprises or consists of historic data generated in dependence on historic operation of the host vehicle.

8. A controller as claimed in any one of the preceding claims, wherein the expected speed is determined in dependence on one or more of the following set:

map data relating to a road on which the host vehicle is currently travelling;

traffic data relating to a current traffic density on a road on which the host vehicle is currently travelling; and

a legislative speed limit applicable on a road on which the host vehicle is currently travelling.

9. A controller as claimed in any one of the preceding claims, wherein the expected speed is determined in dependence on a detected position and/or a detected speed of one or more other vehicles proximal to the host vehicle.

10. A controller as claimed in any one of the preceding claims, wherein the processor is configured to control operation of the transmission in dependence on detection of a target vehicle in front of the host vehicle.

11. A controller as claimed in any one of the preceding claims, wherein controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed comprises one or more of the following:

changing to a lower drive ratio; and

delaying a change to a higher drive ratio.

12. A controller as claimed in any one of the preceding claims, wherein controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed comprises delaying a change of a selected drive ratio until a predetermined time period has elapsed.

13. A controller as claimed in any one of the preceding claims, wherein the processor is configured to control operation of the transmission in dependence on the comparison of the expected speed and the current speed only while the current speed of the host vehicle is maintained within a prescribed operating speed range.

14. A controller as claimed in any one of the preceding claims, wherein the processor is configured to control operation of the transmission in dependence on the comparison of the expected speed and the current speed for a predefined time period.

15. A vehicle comprising a controller as claimed in any one of the preceding claims.

16. A method of controlling selection of a drive ratio in an automatic or semi-automatic transmission of a host vehicle; the method comprising:

determining a current speed of the host vehicle;

determining an expected speed of the host vehicle; and

controlling operation of the transmission in dependence on a comparison of the expected speed and the current speed.

17. A method as claimed in claim 16, wherein the comparison comprises determining when the current speed of the host vehicle is less than the expected speed.

18. A method as claimed in claim 17, wherein the method comprises controlling operation of the transmission when the determined difference between the current reference speed and the expected speed is greater than a predetermined threshold.

19. A method as claimed in any one of claims 16, 17 or 18, wherein the expected speed (VEXP) is determined in dependence on vehicle speed data relating to the host vehicle.

20. A method as claimed in claim 19, wherein the vehicle speed data comprises an average speed of the host vehicle.

21. A method as claimed in claim 19 or claim 20, wherein the vehicle speed data comprises or consists of data generated in dependence on current operation of the host vehicle.

22. A method as claimed in any one of claims 19, 20 or 21, wherein the vehicle speed data comprises or consists of historic data generated in dependence on historic operation of the host vehicle.

23. A method as claimed in any one of claims 16 to 22 comprising determining the expected speed in dependence on one or more of the following set:

map data relating to a road on which the host vehicle is currently travelling;

traffic data relating to a current traffic density on a road on which the host vehicle is currently travelling; and

a posted or local speed limit applicable on a road on which the host vehicle is currently travelling.

24. A method as claimed in any one of claims 16 to 23 comprising determining the expected speed in dependence on a detected position and/or a detected speed of one or more other vehicles proximal to the host vehicle.

25. A method as claimed in any one of claims 16 to 24 comprising controlling operation of the transmission in dependence on detection of a target vehicle in front of the host vehicle.

26. A method as claimed in any one of claims 16 to 25, wherein controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed comprises one or more of the following set:

changing to a lower drive ratio; and

delaying a change to a higher drive ratio.

27. A method as claimed in any one of claims 16 to 26, wherein controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed comprises delaying a change of a selected drive ratio until a predetermined time period has elapsed.

28. A method as claimed in any one of claims 16 to 27, wherein the method comprises controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed only while the current speed of the host vehicle is maintained within a prescribed operating speed range.

29. A method as claimed in any one of claims 16 to 28, comprising controlling operation of the transmission in dependence on the comparison of the expected speed and the current speed for a predefined time period.

30. A non-transitory computer-readable medium having a set of instructions stored therein which, when executed, cause a processor to perform the method claimed in any one of claims 16 to 29.

Intellectual Property Office

Application No:	GB1801294.8	**Examiner:**	Mike McKinney
Claims searched:	1 to 30	**Date of search:**	12 July 2018

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 to 30	US 2007/032341 A1 (SHIIBA et al) see figures and, for example, paragraphs [0038] to [0055].
X	1 to 30	US 2014/142822 A1 (LI) see figures and, in particular, paragraphs [0024] to [0038].
X	1 to 30	EP 3255316 A1 (SCANIA CV AB) see figures and, especially, paragraph [0041].
X	1 to 30	US 2014/315686 A1 (MATSUO et al) see figures and, for example, paragraph [0042].
X	1 to 7, 11, 15 to 22 and 30	GB 2511831 A1 (JAGUAR LAND ROVER LTD) see figures and, in particular, paragraphs [0035] and [0052].

Categories:

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

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

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

F16H

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

EPODOC, WPI

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
F16H	0061/02	01/01/2006
F16H	0059/44	01/01/2006
F16H	0059/46	01/01/2006
F16H	0059/60	01/01/2006
F16H	0059/66	01/01/2006