Title of the Invention: Adaptive control of internal combustion engine

Abstract Title: An adaptive control of an internal combustion engine including the blending/delaying of filtered propulsion requests

A vehicle has different operating modes, and for each such mode a different characteristic of engine output torque and accelerator pedal position. The rise of engine output torque in response to a propulsion request is more or less delayed according to the instant operating mode. The invention provides for blending of the response to a propulsion request so that the delay is progressively varied between a source and target operating mode.
Adaptive Control of Internal Combustion Engine

FIELD OF THE INVENTION
This invention relates to adaptive control of an internal combustion engine and in particular, but not exclusively, to the response of the engine to an operator command in consequence of a change of engine operating mode. The change of engine operating mode may in turn be related to a change of operating mode of a vehicle in which the engine is installed, for example an operating mode related to the terrain under a vehicle. Aspects of the invention relate to a system, to a method and to a vehicle.

BACKGROUND
Internal combustion engines of vehicles have operating modes which may be selectable by the driver. Thus an economy mode, a normal mode and a sport mode may be provided, each mode having a different engine response to one or more commands of the driver. Typically the engine may respond differently in each mode to a given input of the accelerator pedal, being least responsive in economy mode, and most responsive in sport mode. In this way driveability of the vehicle can be improved by providing a range of accelerator pedal movements which are appropriate to, for example, the desired output torque characteristic of the engine. Such a system necessarily relies upon an electronic input from the vehicle driver, for example an accelerator potentiometer providing an input signal to an electronic control unit having a plurality of accelerator pedal position output torque maps, as will be further described.

Another kind of operating mode relates to the terrain which a vehicle is intended to cross. Thus one or more accelerator pedal position torque maps appropriate to the terrain may be selectable by the driver. For example when driving in rocky terrain, a high torque output may be indicated for a small accelerator movement, thus giving immediate urge to overcome a rock step. In contrast on sand, a lower torque output may be indicated for the same accelerator movement, so as to avoid spinning a vehicle wheel and digging a hole. To some extent the selected torque map is a matter of judgement related to the available grip on the terrain.

Different torque maps are typically selected manually by the vehicle driver.

The response of the vehicle engine to driver demand may be filtered to improve vehicle performance and to assist the driver to deliver smooth acceleration and deceleration. Thus a
propulsion request may give a more or less immediate rise in torque from the vehicle engine on an operating characteristic which is a function of vehicle operating mode.

A negative propulsion request (for example foot-off) may likewise give a more or less immediate reduction in engine output torque. Thus for example, an engine response will be more immediate on a rock surface than on a sand surface. In this specification the term 'propulsion request' indicates a change of accelerator position and includes both the positive (increasing engine speed/torque) and the negative (reducing engine speed/torque).

A propulsion request may comprise a movement of the accelerator pedal from a zero accelerator position (foot-off) or may comprise a further movement from a non-zero position. Typically the position of the accelerator pedal is continually sampled at a suitable frequency, and any change of position may indicate a new propulsion request (positive or negative) to which the vehicle engine is commanded to respond according to the selected map of accelerator pedal position/engine torque.

A pedal progression map relates accelerator pedal position to engine output torque. Fig. 1 illustrates one example of alternative pedal progression maps, in which engine torque (T) is plotted against accelerator pedal position (P) for different vehicle operating conditions. For each vehicle operating mode the map illustrates a target output torque of the engine in response to a percentage advancement of the accelerator pedal from zero (foot-off).

In the alternative, a pedal progression map may relate accelerator pedal position to an analogue of engine output torque, such as one or more of drive torque at the vehicle wheels, power output, another measure of tractive effort, fuel flow, air flow or any measurable indicator that varies according to a accelerator pedal progression and engine output torque. The engine output torque may represent the output of other forms of motive power, such as an electric motor, or an analogue thereof, such as motor current.

Many suitable analogues are known, so that whilst engine output torque is a convenient direct indicator, the use of one of more analogues to define the changing pedal progression characteristic is not excluded.

Furthermore accelerator pedal position is typically converted into an electrical signal for use in a processor which commands an engine output torque according to the selected pedal progression map. The relationship between pedal position and the electrical signal is defined
by a characteristic, which may be linear so that signal changes proportionately to the increasing advancement of an accelerator pedal. The electrical signal is typically a voltage and will be termed the pedal signal map in this specification.

In the example of Fig. 1, it can be seen that at 50% pedal advance, the solid line characteristic (11) shows the engine developing about 100% torque, whereas the chain-dot line (13) shows only about 25% of maximum torque. In the latter case 100% torque is provided only at 100% advancement of the accelerator pedal. The dashed line (12) is an intermediate characteristic. Characteristic (13) is typical for a soft terrain such as sand, whereas characteristic (11) is typical of a hard terrain such as rock.

Techniques are known for blending from one pedal progression map to another over time, so that the vehicle driver is not presented with a step change in engine output torque as the mode changes instantaneously. This avoids for example an immediate increase in engine torque from 25% to 100% of maximum torque at the 50% accelerator position when switching from characteristic (13) to characteristic (11). A blend may take up to 20 seconds to complete.

Fig. 2 illustrates a known filter whereby a driver propulsion request is modified according to terrain conditions, so that an increase in engine torque from zero is more rapid or less rapid in reaching the target output torque of the engine, as indicated by the selected pedal progression map. In practice the response of the engine to generate an output according to a characteristic of Fig. 1 is more delayed or less delayed, but to the intent that target torque is reached within a maximum period, for example about two seconds.

In Fig. 2 accelerator pedal position (P) is plotted against time for a given output torque characteristic. The solid line (21) represents pedal position, and shows a rapid advancement from minimum to maximum (100%) within a short period of time.

The dotted line (22) represents engine output torque for one operating mode of the vehicle, where the propulsion request (21) gives an immediate engine response. This output (22) closely follows the changing accelerator pedal position, and the speed of response of the engine is substantially unmodified. This operating mode is typical for a hard terrain, so that engine output torque reaches the target torque substantially immediately as indicated by the selected pedal progression map.
The dashed line (23) represents a more filtered propulsion request for an operating mode typical for a slippery surface such as grass, gravel or snow. In this case the propulsion request causes engine output torque to rise more slowly so as to avoid spinning of the vehicle wheels. In this case the rate of change of torque is somewhat reduced as compared with characteristic 22.

The dash-dot line (24) represents more extreme filtering appropriate for an operating mode typical of sand, where wheel spinning may cause the vehicle to dig a hole and become stuck. In this case engine torque rises still more slowly in response to a propulsion request.

The characteristics of Fig. 2 are merely examples, and can be modified by a suitably skilled person to obtain an engine response most suitable for the vehicle and the operating condition thereof. In the illustration, target output torque may be achieved within 1-2 seconds for all characteristics.

It should be understood that the same techniques can be applied to a negative propulsion request, so that engine output torque will fall more quickly or less quickly according to the selected pedal progression map.

In practice, all propulsion requests may cause a filter to be applied, and the filter may be negligible (e.g. characteristic 22) or significant (characteristic 24).

Each characteristic is typically retained in a memory device of an engine control unit (ECU) and is automatically implemented upon selection or detection of a new vehicle operating condition.

The example described applies a filter to a pedal progression map relating accelerator pedal position to engine output torque. In the alternative it is also possible to apply a filter to the pedal signal map to achieve the same effect. This detection of a new vehicle operating condition will result in an appropriately filtered pedal signal map, to the intent that engine output torque will rise or fall at a rate appropriate to the newly detected operating condition.

If an alternative operating mode is selected by the vehicle driver, a change in the characteristic of engine response to a propulsion request is generally not a surprise - the change is in fact expected by the driver and is generally desirable. However difficulties may arise if the operating mode is automatically selected in response to a vehicle sensing a
change of operating condition. Thus, for example a vehicle may include a system to detect a change of terrain from rock to sand and command the vehicle engine to adopt a different torque map. The consequent change in engine response may be disconcerting to the driver, especially if such automatic mode changes are repeated frequently.

For example, if driving on a sand terrain, the vehicle driver may become accustomed to a somewhat delayed engine response. The vehicle may automatically detect a temporary change to a hard surface, such as rock, and consequently change the operating mode of the vehicle so that the engine response is immediate.

A mode change may cause an acceleration request to be implemented more or less quickly, as described above, and may also cause a more or less instant drop in engine torque in response to reverse movement of the accelerator pedal. A sudden drop in torque may be obviated for certain terrain conditions.

Thus with reference to Fig. 2 a switch from a sand mode (24) to a rock crawl mode (22) one second after an acceleration request results in an immediate doubling of engine output torque. The opposite effect occurs when the accelerator pedal is released.

This change may be disconcerting, and it would be desirable to indicate to the driver that such a change is in progress; visual or audible indicators are not considered desirable because the driver may be overloaded with information, and not immediately appreciate what the indicator is indicating. Furthermore automatic mode changes may occur frequently, and such indicators may be a distraction.

What is required is an improved means and method of allowing the vehicle driver to become accustomed to a change of engine torque characteristic in response to a propulsion request.

It is against this background that the present invention has been conceived. Aspects and embodiments of the invention may provide a method, a system or a vehicle which address or obviate the above problems. Other aims and advantages of the invention will become apparent from the following description, claims and drawings.

**SUMMARY OF THE INVENTION**

According to one aspect of the invention there is provided a method of blending between different filters of a propulsion request associated with the motor of a vehicle whereby a
propulsion request is more delayed or less delayed according to the operating mode of the vehicle, the method comprising the steps of:

- detecting a current operating mode of the vehicle and applying a source filter appropriate to the current operating mode to a propulsion request,

- detecting a change of operating mode of the vehicle and selecting a target filter appropriate to the changed operating mode for a propulsion request, and

- blending from the source filter to the target filter over time so as to progressively change the delay applied to a propulsion request.

Aspects of the invention thus provide for a progressive change of map over the period for which one of said filters provides a relative delay, so that the driver experiences a progressive change rather than a step change.

One of the source and target filter may define a map which gives a substantially instant response of the vehicle engine to a change in accelerator pedal position. The other of the source and target filter may modify this map to more or less delay the response of the vehicle engine, typically by applying a time constant to the characteristic. The time constant may be close to zero for the substantially instant response. Blending between maps having different time constants, and thus different delay characteristics is within the scope of the invention.

Said filter may be a time constant, and said method may include the step of applying said time constant to a characteristic of accelerator pedal position and engine output torque to define a source map.

Said filter may be a time constant, and said method may include the step of applying said time constant to a characteristic of accelerator pedal position and output torque to define a target map.

Said time constant may be applied to a characteristic relating accelerator pedal position to an electrical output signal, whereby a change of said output signal is representative of the propulsion request.

The method may further include the step of blending progressively from said source map to said target map.

The method may further include the step of blending progressively at a fixed rate.
The method may include the step of blending from the source map to the target map at a percentage per unit time of the difference between said maps.

The method may include the step of detecting a propulsion request of the vehicle and selecting a percentage completion of blending from the source map to the target map according to completion of a blend of engine output torque characteristics associated with different operating modes of the vehicle.

The method may include the step of continually determining a percentage completion of blending of the source map to the target map whilst blending of engine output torque characteristics is in progress.

Said percentage completion of blending may be continually determined at a frequency of 1Hz or greater, optionally 10 Hz or greater.

The method may include the step of detecting a subsequent propulsion request, and selecting a new percentage completion of blending from the source map to the target map according to completion of a blend of engine output torque characteristics associated with different operating modes of the vehicle.

The method may include the step of automatically changing the operating mode of the vehicle according to detection of operating conditions thereof.

The invention is typically implemented in an electronic control unit (ECU) of a vehicle, and the relative delay applied to a propulsion request is obtained for example by reference to a look-up table or an appropriate algorithm. The relative delay, which may be close to zero, may also be selected according to other factors such as transmission ratio or range, or environmental conditions such as rain.

According to another aspect of the present invention there is provided an electronic control system for defining the output of a vehicle engine in relation to the position of an accelerator pedal by reference to a plurality of torque maps held within a memory, said system being adapted to detect a first operating mode of the vehicle and apply a source map, to detect a second operating mode and select a target map, to apply a filter to the source map and
target map so as to more or less delay the effect of a propulsion request and to blend from
the source map to the filtered target map.

The control system may include a processor whereby each said filter comprises a time
constant selected according to the instant operating mode of the vehicle. The processor may
be adapted to progressively vary a source time constant to a target time constant to change
the delay associated with said propulsion request.

According to a further aspect of the present invention, there is provided a vehicle having a
plurality of operating modes, each of which comprises a different characteristic of engine
output torque and accelerator pedal position, and a control system according to the another
aspect of the present invention.

Within the scope of this application it is envisaged that the various aspects, embodiments,
examples, features and alternatives set out in the preceding paragraphs, in the claims and/or
in the following description and drawings may be taken independently or in any combination
thereof. For example, features described in connection with one embodiment are applicable
to all embodiments unless such features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS
Embodiments of the present invention will now be described, by way of example only, with
reference to the accompanying drawings in which:

Fig. 1 is an illustration of engine torque maps of different modes of vehicle operation;

Fig. 2 is an illustration of filtered response to a change of accelerator pedal position;

Fig. 3 illustrates progression of blending between different torque maps;

Fig. 4 illustrates linear progression of a torque blend from one vehicle operating mode to
another;

Fig. 5 corresponds to Fig. 4, and illustrates the effect of blending a filtered propulsion
request, according to an embodiment of the invention; and

Fig. 6 illustrates engine torque maps appropriate to the filtered response of Fig. 5.
DETAILED DESCRIPTION

Fig. 1 illustrates pedal progression maps of different vehicle operating modes, and demonstrates how in some modes a greater accelerator pedal movement is required for a given engine output torque.

Fig. 2 illustrates for different vehicle operating modes, the filtered response of an advancing accelerator pedal position, and demonstrates how a target torque of Fig. 1 may be reached more or less quickly.

With reference to Fig. 3 the characteristics of Fig. 2 are repeated, and show the rise of engine torque (T) plotted against time (t). An unfiltered response is marked (22), a less filtered response is marked (23) and a more filtered response is marked (24).

In the event of a change of vehicle operating mode whereby for example a more filtered characteristic (24) is blended to an unfiltered characteristic (22) blending is in the direction of arrow D, and the progress of the blend is indicated by the intermediate dotted lines.

Thus, according to the invention, the torque response of the engine progressively changes shape as the blend progresses so that, for example, a change of mode will follow the direction of blending until blending is complete. A change of accelerator pedal position whilst blending is in progress causes the engine response to follow the intermediate characteristic, so that the vehicle driver is not presented with a step change of torque output.

Blending is converted into a percentage per unit time value based on the current difference between the source and target characteristics, so as to gradually change the shape of the characteristic throughout the time range associated with the delay in engine response.

With reference to Fig. 4 progression of a torque blend upon mode change of a vehicle is illustrated. From time $t_0$ to $t_1$, a vehicle is in a first operating mode, for example rock crawl. At $t_1$, a mode change is effected, for example to sand, and blending of the pedal progression maps (Fig. 1) commences (in this example at a fixed rate). At $t_2$ blending is complete, and the pedal progression map appropriate to sand is fully implemented.

Fig. 5 shows the effect upon a succession of positive propulsion requests of a vehicle driver over the period of the blend of Fig. 4.
For simplicity each propulsion request is represented by a solid line indicative of both a change of accelerator pedal position and the consequent change of engine output torque that would result if no filtering occurred. Furthermore, the output torque in this illustration is identical for each propulsion request.

Accordingly a first propulsion request before \( t_1 \) is represented by the solid line (31); the vehicle is in rock crawl mode, and accordingly the propulsion request is filtered according to the dotted line (32) to ensure that engine torque rises rapidly to the maximum requested value. The propulsion request ceases before \( t_1 \), whereupon the engine output torque falls rapidly, also according to the filter appropriate to rock crawl mode and unmodified.

A second propulsion request (33) occurs at \( t_3 \), after a mode change has been effected and whilst blending of the pedal progression map is in progress. In this example, at the time of the second propulsion request blending between pedal progression maps is approximately 30% complete.

After \( t_3 \), when blending of the pedal progression maps is complete, a third propulsion request (35) occurs; the vehicle is in sand mode, and accordingly the propulsion request is filtered according to the dotted line (36) to ensure that the rise of engine torque is significantly moderated to avoid any risk of losing traction. The filter is appropriate to sand mode and unmodified; when the propulsion request ceases, engine output torque falls at a much slower rate than for rock crawl mode.

As illustrated in Fig. 5, the second propulsion request (33) is filtered by an intermediate amount, so that the instant rise in engine torque is less fast then characteristic (32), but faster than the characteristic (36).

The modified characteristic (34) thus represents a blend, and may for example be based upon the degree of completion of the blend of pedal progression maps at the time of the propulsion request. Thus in this example the filter may be advanced at a fixed rate of 30% of the difference between the characteristics (32,36), 30% being the degree of completion of the blend at \( t_3 \). The characteristics (32,36) are typically retained in a look-up memory associated with vehicle operating modes, and the intermediate characteristic is generated, in this example, by adding 30% of the instant difference to the initial characteristic (31) over a
sufficient number of small time intervals. The blended characteristic may for example have a frequency of 100Hz.

In the alternative, at each small time interval, a check is made of the degree of completion of the blend of pedal progression maps, so that the filter is progressively modified at a changing rate. Thus at the commencement of the second propulsion request (33), the filter is adjusted by the percentage completion of the blend of Fig. 4, namely about 30%. At about half-way through the rise of filtered torque, point (37), the percentage completion of the blend of pedal progression maps is about 35%, and this value is applied to the difference between characteristics (32) and (36) to generate the instant value of characteristic (34).

Each characteristic associated with a vehicle operating mode may be associated with a time constant, which can be used to modify the unfiltered torque request. To apply a single filter, at each small time interval, the current torque is compared with the requested torque, and the requested torque is modified by the time constant, to produce a filtered response. Once the current torque is within a predetermined amount from the requested torque, the requested torque value is adopted as the current torque and no further filtering is required. On blending between two filters, at each time interval, either the time constant applied may be a result of a blend of the two appropriate time constants, or the filtered torques for each appropriate time constant may be blended. The blend amount may be fixed as in the first embodiment above, according to the percentage of blend between pedal progression maps which has occurred at the start of the propulsion request. Alternatively, as in the alternative embodiment above, at each small time interval, a check is made of the degree of completion of the blend of pedal progression maps, so that the degree of blend of the filters is progressively modified at a changing rate. In this alternative embodiment, at each time interval calculation, the system is required to know only the current torque output, the target or requested torque output, and the degree of completion of the blend of pedal progression maps, in order to calculate the next torque output. No knowledge of the torque output history, such as when a propulsion request began, is required.

Completion of the rise of filtered torque, point (38), is close to about 40% completion of the blend of pedal progression maps, and this value is applied to generate the instant value of characteristic (34).

A faster or slower completion of the blend of pedal progression maps will thus result in a corresponding change in the progression of the filtered response of engine torque to a
propulsion request. Where the blend of pedal progression maps is not linear (in contrast to Fig. 4) the progression of the filtered response will correspond in a non-linear manner.

At \( t_s \), the positive propulsion request ceases (i.e. a negative propulsion request). Accordingly the fall in engine output torque is filtered so that it is less sudden, and is for example adjusted by the completion of the blend of Fig. 4 at \( t_s \), namely 80%.

As illustrated, the fall in torque is not completed until after \( t_s \), so the final portion of the falling characteristic is equal to 100% of the characteristic appropriate to sand mode.

The illustration of Fig. 5 shows an identical target of output engine torque at each propulsion request. This simulates a change of operating mode in which two different pedal progression maps meet at an intermediate advancement of the accelerator pedal - so that the target torque after mode change is completed is the same as that before mode change is initiated. Crossing pedal progression maps are illustrated in Fig. 6 for two different vehicle operating conditions (41,42), and the mode change of Figs. 4 and 5 corresponds to point (43) at \( t_s \).

In most cases the target torque after mode change will be different, and in the example of Fig. 1, the pedal progression maps do not coincide between 0 and 100% movement of the accelerator pedal. In consequence the blend in response to a propulsion request is more complex, but follows the principles outlined above.

The effect of blending between filters applied to a propulsion request is illustrated in Fig. 7. For the purposes of illustration movement of an accelerator pedal (P) is illustrated as a more or less continual on/off cycle 51, so that a vehicle engine is subject to repeating positive and negative propulsion requests.

Vehicle operating mode (M) is represented by line 52, and illustrates a first traction mode (for example rock crawl) up to time \( t_m \), and a second traction mode (for example sand) thereafter.

Torque output \( T \) from the engine in the rock crawl mode changes rapidly between minimum to maximum because each propulsion request is relatively unfiltered. Thus the trace of output torque 53 is very spiky, and this corresponds to driver expectation and need.

Torque output from the engine in sand mode exhibits a more gradual change because each propulsion request is filtered to prevent spikes of engine torque (either increasing or
decreasing). Thus in a steady state condition of the sand mode, the trace of output torque 54 is wave-like with rounded peaks and troughs.

The effect of the invention is to avoid the step change between traces 53 and 54 in response to an automatic change of vehicle operating mode at time $t_c$. In the invention the filter applied to a propulsion request is blended, so as to follow a trace indicated by the chain-dot trace 55, to the intent that blending is completed within a finite period of, for example a few seconds (in the illustrated example, three cycles). Blending of the filter typically may take less than five seconds, and in one embodiment between 1.5 and 2.5 seconds.

It will be understood that even if the target torque (defined by the operating mode of the vehicle) is the same for both modes illustrated in Fig. 7, this torque may not in fact be reached before the engine is required to respond to a negative propulsion request. Thus, as illustrated in Fig. 7, the maximum torque reached after $t_c$ is less than that before $t_c$, and this is due to either insufficient time to reach the target torque, or because target torque in the second mode is less than in the first mode.

Alternate implementation strategies are possible.

In one embodiment, the control signal indicative of accelerator pedal position (typically a voltage from a potentiometer) is subject to a filter associated with the operating mode of the vehicle. The filter may be expressed numerically, and directly modify the output of accelerator position in the manner of a dashpot, so as to more or less reduce the rate of change of the output. The modified output (typically a voltage) provides a control input to an electronic control unit of a vehicle engine, so as to command an engine output torque according to the selected pedal progression map.

In another embodiment, the control signal (typically a voltage) indicative of accelerator pedal position is provided in unmodified form to the engine ECU, and the output signal commanding an engine output torque is filtered to more or less reduce the rate of change thereof.
Claims

1. A method of blending between different filters of a propulsion request associated with
the motor of a vehicle whereby a propulsion request is more delayed or less delayed
according to the operating mode of the vehicle, the method comprising:
   detecting a current operating mode of the vehicle and applying a source filter
   appropriate to the current operating mode to a propulsion request,
   detecting a change of operating mode of the vehicle and selecting a target filter
   appropriate to the changed operating mode for a propulsion request, and
   blending from the source filter to the target filter over time so as to progressively
   change the delay applied to a propulsion request.

2. A method according to claim 1, wherein said source filter is a first time constant, and
said method includes the step of applying said first time constant to a characteristic of
accelerator pedal position and engine output torque to define a source map.

3. A method according to claim 2, wherein said target filter is a second time constant,
and said method includes the step of applying said second time constant to a characteristic
of accelerator pedal position and output torque to define a target map.

4. A method according to claim 2 or claim 3, wherein said first time constant and said
second time constant are applied to a characteristic relating accelerator pedal position to an
electrical output signal, whereby a change of said output signal is representative of the
propulsion request.

5. A method according to claim 3 or claim 4, wherein the step of blending includes the
step of blending over time so as to progressively change from said source map to said target
map.

6. A method according to any of claims 1 to 5, and including the step of blending
progressively at a fixed rate.

7. A method according to any preceding claim, and including the step of blending at a
percentage per unit time of the difference between said maps.
8. A method according to any preceding claim, and including the step of detecting a propulsion request of the vehicle and selecting a percentage completion of blending from one of the source filter to the target filter and the source map to the target map, as appropriate, according to completion of a blend of engine output torque characteristics associated with the change in operating modes of the vehicle.

9. A method according to claim 8, and including the step of continually determining a percentage completion of blending from one of the source filter to the target filter and the source map to the target map, as appropriate, whilst blending of engine output torque characteristics is in progress.

10. A method according to claim 9, wherein said percentage completion of blending is continually determined at a frequency of 10 Hz or greater.

11. A method according to any of claims 8 to 10, and including the step of detecting a subsequent propulsion request, and selecting a new percentage completion of blending from one of the source filter to the target filter and the source map to the target map, as appropriate, according to completion of a blend of engine output torque characteristics associated with different operating modes of the vehicle.

12. A method according to any preceding claim, and including the step of automatically changing the operating mode of the vehicle according to detection of operating conditions thereof.

13. A control system for defining the propulsion applied to a vehicle by controlling blending between different filters of a propulsion request associated with a motor of a vehicle whereby a propulsion request is more delayed or less delayed according to the operating mode of the vehicle, said system being arranged to detect a current operating mode of the vehicle and apply a source filter appropriate to the current operating mode to a propulsion request, to detect a changed operating mode of the vehicle and select a target filter appropriate to the changed operating mode for a propulsion request, and to blend from the source filter to the target filter over time so as to progressively change the delay applied to a propulsion request.
14. A control system according to claim 13, and including a processor whereby each said filter comprises a time constant selected according to the instant operating mode of the vehicle.

15. A control system according to claim 14 wherein said processor is adapted to progressively vary a source time constant to a target time constant to change the delay associated with said propulsion request.

16. A vehicle having a plurality of operating modes, each of which comprises a different characteristic of engine output torque and accelerator pedal position, and a control system as defined in any of claims 13-15.

17. A system, a method or a vehicle constructed and/or arranged substantially as described herein with reference to one or more of the accompanying drawings.
**Application No:** GB1201203.5  
**Examiner:** Mr Kevin Hewitt  
**Claims searched:** 1 to 17  
**Date of search:** 25 May 2012

### Patents Act 1977: Search Report under Section 17

**Documents considered to be relevant:**

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<thead>
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<th>Category</th>
<th>Relevant to claims</th>
<th>Identity of document and passage or figure of particular relevance</th>
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<td>US 2009/0192014 A1 (TIWARI ET AL) See especially the Abstract and Figure 4.</td>
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<td>EP 2055546 A1 (TOYOTA) See especially the Abstract and Figure 3.</td>
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**Field of Search:**

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**International Classification:**

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