a check symbol and an end of transmission indicator.

In a feature of this invention a vehicle-mounted station includes detecting means for detecting operating conditions of a vehicle, transmitting/receiving means for transmitting data representative of the detected operating conditions to a base station capable of evaluating said data, said transmitting/receiving means being adapted to receive evaluated signals from the base station and to apply signals representative of said evaluated signals to a control means adapted to perform at least one of vary or display said operating conditions in dependence upon said received evaluated signals.

In another feature of this invention there is provided a stationary base station adapted to receive data from a vehicle mounted station, said base station including processing means and storage means for processing the data received from the vehicle mounted station based upon information held in said storage means, the base station being adapted to perform at least one of updating/correcting maps carried by a vehicle located processor, vehicle located sensors and injectors, establish the expected life expectancy of said sensors and injectors and further including transmitting means for transmitting processed data to a vehicle.

Thus, the above mentioned object is principally realized by controlling load sharing between computers. A study of computer control for vehicles indicates that data processing is roughly divided into data requiring high-speed real-time processing and data which may be processed in a comparatively long period. For example, ignition timing control and fuel injection control are control subjects that require processing in synchronism with engine rotation so that high-speed processing is required in response to high speed engine rotation. On the other hand, modification of initial settings because of ageing changes such as those in an engine transmission and suspension, may be computed over a relatively long time cycle. Also, controls which haveto be computed with a high accuracy take time when processed by a vehicle-mounted computer and only increase the load on the computer.

Also, with regard to failure diagnosis or failure prediction processing when status data is obtained, arithmetic processing itself may be separated from the real-time processing without difficulty. Of course, there may be some diagnoses which require emergency processing and a feature of this invention is to discriminate and act upon abnormal conditions that require urgent actions and diagnoses.

In consideration of the increasing complexity of the control system and the necessity for higher speed processing accompanied by the increasing r.p.m. of modern engines, this invention carries out load sharing between a vehicle-mounted computer and a stationary host computer.

More specifically a feature of this invention resides in predetermining the processing sharing conditions when specific operating conditions of the engine or specific conditions of the vehicle-mounted computer are detected, transmitting information to and from the host computer and sharing the processing.

The load sharing between the vehicle-mounted computer and the stationary host computer is achieved through the following operations. When the operating conditions for the engine are detected, the subsequent processing thereon is shifted to the host computer to be shared thereby. Thus, increases in load on the vehicle-mounted computer are prevented.

The above operating conditions are detected, for example, at predetermined distance of travel, when cumulative driving time reaches a predetermined time and/or when a predetermined condition is met such as engine stopped or fuel tank low.

Brief Description of the Drawings

The invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is an overall block diagram of a system according to the present invention,

Figure 2 is a block diagram of the vehicle-mounted computer,

Figure 3 shows occasions when transmission/reception between the computers is performed,

Figures 4(A) and (B) respectively show a data signal and a data transmission/reception sequence,

Figure 5 is a diagram of checking revised items for map matching,

Figure 6 is a diagram of failure diagnosis,

Figure 7 is a diagram of long-term data sampling,

Figure 8 is a flow chart for preparing a revised map,

Figure 9 is a data transmission flow chart when the engine is stopped,

Figure 10 is a flow chart for revised values, and

Figure 11 is a series flow chart of transmissions and receptions.

In the Figures like reference numerals denote like parts.

Description of Preferred Embodiments

In the drawings, Figure 1 shows one embodiment of the overall system where information is transmitted between a vehicle and a host computer located, for example, at a stationary, ground based dealership location through a telecommunications network.

An engine 2 in the vehicle is connected with a vehicle mounted computer 105 including an engine controller 3, a transmission 400 controller 4 and suspension 500 controller 501. In the currently described embodiment only three controllers are shown, but usually a number of these types of controllers are mounted on the vehicle. A transmitter-receiver 5 for transmitting and/or receiving information to and from the host computer 18 is provided within processor 105.

A telecommunication path 10 which may be wired or wireless, e.g. a radio link interconnects the vehicle side located processor 105 with a stationary host computer station 25 including a transmitter-receiver 11 on the host computer station side of the path. There is provided I/O (input/output units) for data analysis 12, I/O for maintenance arithmetic processing 13, I/O for failure analysis computation 14 and I/O for vehicle information 15 over a 2-way bus to the transmitter-receiver 11 and to the host computer 18. The I/O's are also linked to a data base 16 such as a memory store. The host computer side apparatus may be installed at the vehicle dealership or at a vehicle information service center. Although in this exemplary embodiment only 4 I/O's are shown, other I/O's for many other controllers may exist. The host computer 18 may have a capacity of several mega bytes. Also, here a radio communications link connecting the vehicle side and the host side is shown; radio links are preferred as being more practical because the vehicle side is normally moving. Of course, when occasion demands, information can be transmitted or received by wire communication lines from the host computer to a beacon by the roadside for subsequent wireless transmission/reception to the vehicle-mounted computer.

Also, in some cases the engine controller 3 or the transmission controller 4 as shown in Figure 1 has its own built-in processor and carries out respective processings or a vehicle-mounted processor 7 is provided as indicated in broken lines. Hereinafter engine controls are described wherein a processor for engine control is built in.

Figure 2 shows the computer 105 on the vehicle side with the suspension controller 501 omitted. ROM 21, RAM 22 and CPU 7 are connected by a bus line 30 for I/O processing. The bus line consists of a data bus, a control bus, and an address bus.

Other sequences (of which only two are shown) sense the engine operating conditions, inter alia, the engine cooling water temperature (TWS) 32 and the air/fuel ratio (O_2S) 34. Battery voltage and throttle valve opening and rotation speed also correspond to operating condition signals, but here they are omitted. A multiplexer 36 inputs the operating condition signals into an A/D conversion circuit 38. A register 40 sets A/D converted values.

An inlet pipe air flow sensor (AFS) 51 has its value set in a register 54 after conversion in an A/D converter 52. An engine angle sensor (AS) 56 provides reference signals REF and angle position signals POS to an angle signal processing circuit 58. The processed signals are used to control synchronizing signals and timing signals.

Engine operating condition ON/OFF switches (SWI-SWi) 59-61 indicate parameters such as start engine and engine idle. These signals are input into an ON-OFF switch-condition signal-processing circuit 60 and are used independently or in combination with other signals forming logic signals to determine controls or controlling methods known per se.

The CPU 7 carries out computations based on the above mentioned operating condition signals in accordance with multiple programs stored in ROM 21 and outputs its computation results into respective control circuits through the bus lines 30. Here the engine control circuit 3 and the transmission control circuit 4 have been shown, but numerous other control circuits such as an idle speed control circuit and exhaust gas recirculation (EGR) control circuit are possible.

The engine control circuit 3 has a fuel controller for controlling air/fuel ratios and increases or decreases the amount of fuel supplied by controlling an injector 44. 42 is a logic circuit for these controls. The transmission controller 4 carries out a transmission shift 48 in the transmission 400 through a logic circuit 46 based on the computation results of the driving conditions. A control mode register 62 presents timing signals for various control outputs.

Timing circuit 64-70 control transmitting and receiving operations. For example, circuit 64 outputs a trigger signal into the transmitter-receiver whenever a predetermined distance is travelled and transmits a corresponding engine operating condition signal through the transmitter-receiver to the stationary host computer. A display 90 is used to display instructions to the driver.

Circuit 66 is used to detect an engine stopped and to trigger an output signal thereupon. Circuit 68 is used to detect a low fuel tank condition and trigger an output signal thereupon. Circuit 70 is used to check whether predetermined conditions are met and when satisfactory, generate a trigger output signal. Figure 3 shows symbol illustrations of these circuits.

To sum up, circuits 66 to 70 produce signals which decide timing to transmit operating condition data to the stationary host computer. For example, from the circuit 64 which generates a signal whenever a predetermined distance has been travelled, it is possible to diagnose the operating condition per the predetermined travel distance. When only condition signals are transmitted, the host side computer makes a diagnosis based on deviations from the previous values or past condition signal data and conveys instructions based on its results to the vehicle-mounted computer. The vehicle-mounted computer gives driver instructions through a display or alarm in dependence upon the severity or grade of those instructions or modifies processing programs or sets parameter values.

Figure 4(A) shows an example of a data array and Figure 4(B) shows a data transmitting and receiving sequence during data communications between the vehicle-mounted computer and the stationary, e.g. ground, host computer (here a dealer located computer). A subject vehicle is specified by a header and a vehicle number (a number that is unique to the vehicle such as the engine number or the car body number).

Figure 5 shows a processing example when correction items in the map matching are checked (data analysis), the transmitter-receiver 11 at the dealer side being omitted for clarity. When controlling an engine via a microcomputer, control data is computed based on output conditions of each sensor. In addition, a system is used for subsequent engine control by responding to various engine conditions and by storing control data computed as a learning map. Figure 5 shows an example of using other control data values after corrections by analysing such control data stored in the so-called learning map or data to be changed together with other engine controls.

The program processing on the vehicle side is assumed in this example to be to check a map (step 5a). This satisfies conditions by the circuits 64 to 70 as described previously and the checking program of the map starts. Although this is simply called map matching, there is a learning map for ignition timing based on the output of a knock sensor or a learning map for defining an injection pulse width of the fuel injector in the fuel/air (O_2 feedback) from an exhaust to an inlet fuel injector, i.e. an O_2 detector detects if exhaust gas mixture is lean or rich and sends a pulse in dependence thereon to the fuel injector. Map revision is described later in detail with reference to Figure 8. Now, the flow of the transmission processing at the time of map matching is generally explained.

In step 5a, the vehicle-mounted computer checks data in the map by using various methods. For example, when data values contained in the learning map for defining the injection pulse width of the injector using parameters of number of revolutions of the engine N and engine load Qa/N (where Qa is quantity of air) during O_2 feedback are analysed, the corresponding map of the output of the inlet pipe air flow sensor and the air flow quantity is revised by comparing actual data values with previous data values and if the comparison result exceeds a predetermined value then the actual value is used to reset the map, thus effecting a "learning" process. The injector factor is also revised when the injector pulse width of the injector is determined in relation to the engine load Qa/N. Based on checking of the map, engine control data revisions are determined. In step 5b, the vehicle-mounted computer selects necessary data values in the map under check to be used to newly correct engine control data or computes data to be transmitted to the host computer by processing data values stored in the map and stores them in RAM as a map. When data to be transmitted is determined such is rendered as a trigger signal, the map arithmetically processed in the vehicle-mounted computer and contained in RAM is transmitted through the transmitter-receiver 5. The dealer side (host computer), having received this, executes its program based on received signals. In step 5c, data signal reception from the vehicle-mounted computer is started. However, in step 5d, if the dealer-side is already receiving data from another vehicle, a wait instruction is issued in step 5e. When not receiving data from another vehicle, the received data is stored in the memory of the host computer in step 5f. In step 5g, present memory values are compared with past values previously transmitted to the host computer. In step 5h, the amount of deterioration in actuators, such as injectors, and sensors such as inlet air quantity (Qa) sensors, is estimated based on the compared results. Next, in step 5i, the remaining life is estimated from the deterioration amount. In step 5j, data transmitted from the vehicle-mounted computer is computed in accordance with a predetermined program to determine data to be corrected at the vehicle computer. In step 5k, this data is transmitted through the transmitter-receivers 11 and 5. When it receives a transmission signal from the host computer, the vehicle-mounted computer starts the arithmetic processing. When in step 5l receiving the corrected map transmitted from the host computer commences, it is stored in RAM in step 5m. In step 5n, the corrected map is re-written when the engine restarts after stoppage. In step 5p, notification is made to the driver visually, through the display or audibly that the map has been re-written. This is an example of notifying the driver for caution's sake, because correction items of the map may influence whether the vehicle should be driven. However, for cases that do not specifically require this, notification can be omitted. Also, in step 5p, it is possible to display the deterioration amount and remaining life of the injector or sensor. Alternatively, re-writing the map at the time of re-starting the engine for example and/or shifting to the corrected map during travel can be made. However, at this time a method to enable a smooth transition is preferred. For example, methods as follows may be carried out, in that, when the deviation before correction is smaller than a predetermined value, a sequential transition is made and when the deviation is larger than the predetermined value, its intermediate value (in some cases, plural intermediate values) is established and shifted step by step to a corrected map. In addition, re-writing the map may also be carried out in a predetermined period after the power key switch is turned off, i.e. power is supplied for a predetermined period after the power key switch is turned off to enable the map to be re-written or memorised.

Figure 6 shows an example of a failure diagnosis, the transmitter-receiver 11 again being omitted for clarity. The vehicle-mounted computer carries out time-sharing computations of the injection pulse width and ignition timing by the injector in real time. For this, computations for a failure diagnosis are made in the intervals of these computations and only a basic diagnosis are made. This embodiment is based on the concept of having the vehicle-mounted computer make a basic abnormal diagnosis and transmit the data to the host computer. The host computer then makes more advanced, comprehensive and appropriate diagnosis using data indicative of the condition of other control subjects.

In step 6a, the diagnostic mode starts. This is carried out in parallel with the general program and for example, is repetitive at predetermined intervals of about 60 ms. In step 6b, a decision on whether any abnormality exists is made based on the diagnosis results. When no abnormality exists, the process ends. When an abnormality exists, the abnormal code is transmitted to the host computer on the dealer side through the transmitter-receivers 5 and 11. The host computer is triggered by the transmitted signal and executes a more detailed failure diagnosis program. Having received the abnormal code in step 6c, in step 6d, the host computer selects comprehensive control data necessary for failure diagnosis based on the abonormal code and asks the vehicle-mounted computer to transmit data for decision. Upon receipt of the request for transmission, the vehicle-mounted computer transmits the data for decision in step 6e. In step 6f, the host computer diagnoses comprehensively the failure using the data for decision transmitted from the vehicle-mounted computer. In this case, because the host computer is not carrying out the real-time arithmetic processing such as computation of the injector's injection pulse width, if the results of the failure diagnosis in step 6f in which an overall diagnosis is possible based on the data transmitted from the vehicle-mounted computer indicate an emergency, the host computer immediately transmits emergency measures to the vehicle-mounted computer. If an emergency treatment is not specifically diagnosed, the host computer stores the received data in a failure chart in step 6i and subsequently transmits countermeasures to the vehicle-mounted computer in step 6j and completes the diagnostic flow in step 61. In step 6k, the vehicle-mounted computer takes actions based on the countermeasure signals from the host computer and ends the diagnostic mode process at step 6m.

Figure 7 shows an example regarding life prediction or failure prediction in accordance with data collected through sampling over a long period of time in which the transmitter/receiver 11 is again omitted for clarity. In step 7a, the vehicle-mounted computer carries out data sampling at every predetermined interval to detect abnormalities. Detection of abnormalities in this case is a very simple detection of abnormalities and a high-level failure diagnosis is carried out by the host computer. In step 7b, an existence of abnormalities is confirmed and in step 7c, the vehicle-mounted computer transmits the necessary data including sampling values to the host computer through the transmitter-receivers 5, 11 and completes the flow process. If there is no abnormality, the flow process is completed. In addition, in view of the long-term data sampling, high-level failure diagnoses by the host computer may be made at every predetermined distance of travel as shown in Figure 3 or by the circuit 64 in Figure 2. Upon receipt of the data transmission signal from the vehicle-mounted computer, the host computer starts the failure diagnosis program in step 7d. In step 7e, control data accumulated in the memory of the host computer is analyzed to predict lift expectancy. In step 7f, defective parts are specified from data analysis results. In step 7g, the degree of emergency is determined. If there is an emergency, the host computer transmits a signal to that effect to the vehicle-mounted computer through the transmitter-receivers 11, 5 in step 71. The host computer makes life expectancy predictions based on the analysis results and stores the predictions in the failure chart at step 7i. At step 7j, countermeasure signals are transmitted to the vehicle-mounted computer to complete the flow process in step 71.

The vehicle mounted computer, in step 7k, takes action in accordance with the signal transmitted from the host computer and completes the process.

Thus, this invention has shared processing where items are divided into those requiring processing by a vehicle-mounted processor and those requiring long-term or highly accurate computations by a stationary larger computer. Having a vehicle-mounted processor execute all processings, as has been performed in the prior art, only makes a vehicle-mounted processor larger in capacity and physical size.

With regard to checking of the matching map as well as checking of revision items in the map, as performed in steps 5a and 5b of Figure 5, a detailed explanation will now be made by taking map revisions based on the O_2 feedback map as an example. Although there is a prior application (Japanese Patent Application No. 63-283886 (1988)) by the same applicant as this invention regarding O_2 feedback and learning based thereon, its basic methods and concepts are described as follows. The injection time of the injector is determined by the equations (1) and (2) below.

Ti = •Tp•(Ke + Kt-Ks)•(1 + ¯Ki) + Ts (1)

Tp = K const • Qa/N (2)

where

Kconst : injector factor

Tp : basic injection time

: correction factor for air/fuel ratio

Ts : delayed injection time of injector due to mechanical and electrical propogation lag

Ke : steady-state learning factor

Kt : transient learning factor

Ki : a correction factor

Ks : shift factor

Qa : sucked air flow amount

N : number of engine revolutions

That is, a basic fuel injection time Tp is determined through a sucked air flow amount of Qa of the engine and the rotational speed N from equation (2) and the correction factor is changed and corrected so that a stoichiometric air/fuel ratio is obtained based on the output of the air/fuel (O_2) sensor. Here, the correction factor largely deviates from 1.0 because of "ageing" changes in actuators such as the injectors and of sensors. Therefore, supplementary corrections are performed by means of the steady-state learning factor Ke and the transient learning factor Kt to make the correction factor be nearer to 1.0 and determine the fuel injection Time Ti.

Figure 8 shows a flow chart for preparing correction maps. In step 8a, the O_2 feedback learning map is checked to decide whether there are maps requiring corrections. Based on the check results, a decision is made in step 8b whether there are maps requiring re-matching. If not, the process ends. In this embodiment, a Ts map, a Kconst map and a Qs table are illustrated as maps requiring re-matching. Maps requiring re-matching are specified in steps 8c, 8e and 8h and in each of steps 8d, 8f and 8i, control data to be transmitted to the host computer is selected or computed if necessary and is stored in the RAM address of the vehicle-mounted computer to prepare the maps. In step 8j, header data of revision items corresponding to the map to be corrected is prepared, the corrected map is read out from RAM to write in the transmission area in preparation for transmission to the host computer in step 8k and the flow is completed.

Criteria to decide whether a revision is required and specific revision procedures are made in accordance with, for example, prior Japanese Patent Application No. 63-181794 (1988) of the present applicants.

Figure 9 shows an example of data transmission and reception when an engine stops. The engine is controlled by a microcomputer by computing control values to control actuators such as the injector based on outputs of each sensor, including the inlet air flow and crank angle sensors. Each datum may be required for failure diagnosis and matching by the host computer. Necessary data is taken in and stored in the host computer at every ignition key turn OFF.

In step 9a, a decision is made whether the ignition key is turned ON or OFF. When turned ON, the engine is running and the flow terminates. In step 9b, a decision is made whether the engine is rotating or not. When rotating, the flow ends. In steps 9c and 9d, a decision is made whether data transmission to the host computer is required or not. In other words, when the previous revision request is issued in step 9c and when there are revision items of the map to be corrected in step 9d, a decision is made that data transmission is required and operation proceeds to step 9e. Otherwise, operation proceeds to step 9i. In step 9e, a mask setting for transmission/reception is made to prevent interruption, the transmission/reception program is executed in step 9f and the mask is cleared in step 9h. In step 9h, transmission/reception is carried out through the transmitter-receiver 5 if transmission/reception is possible. If transmission/reception is not possible, the flow ends. When transmission/reception is made, the flow proceeds to step 9i, self-shut off and automatically stops the computer after the elapse of a predetermined time.

Next, the execution of data matching in step 5j of Figure 5 by the host computer will be explained by taking Figure 10 as an example.

Figure 10 is an example of obtaining deviations from the previous revision data and for evaluating

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