(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 169 634 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
31.03.2010 Bulletin 2010/13

(51) Int Cl.:
G07C 5/08 (2006.01) *G06F 17/50* (2006.01)

(21) Application number: **08425613.0**

(22) Date of filing: **19.09.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(71) Applicant: **C.R.F. Società Consortile per Azioni
10043 Orbassano (Torino) (IT)**

(72) Inventors:
- **Sanseverino, Maria Luisa
10043 Orbassano (IT)**
- **Zanzola, Marco
10043 Orbassano (IT)**

(74) Representative: **Bergadano, Mirko et al
Studio Torta S.r.l.
Via Viotti, 9
10121 Torino (IT)**

(54) **Automotive system fault diagnosis**

(57) A method of constructing a model-based functional-logic graph to diagnose a fault in an automotive system (2), the method including the steps of acquiring the components of the system (2); acquiring the topological structure of the system; acquiring failure and operating modes of the system components; determining the connections between the components of the system (2); acquiring predetermined operating and failure modes for the connections; establishing connecting branches between objects in the graph as a function of the logic dependency and/or functional dependency between the signals; and constructing the functional-logic graph as a function of the objects and the relative connecting branches.

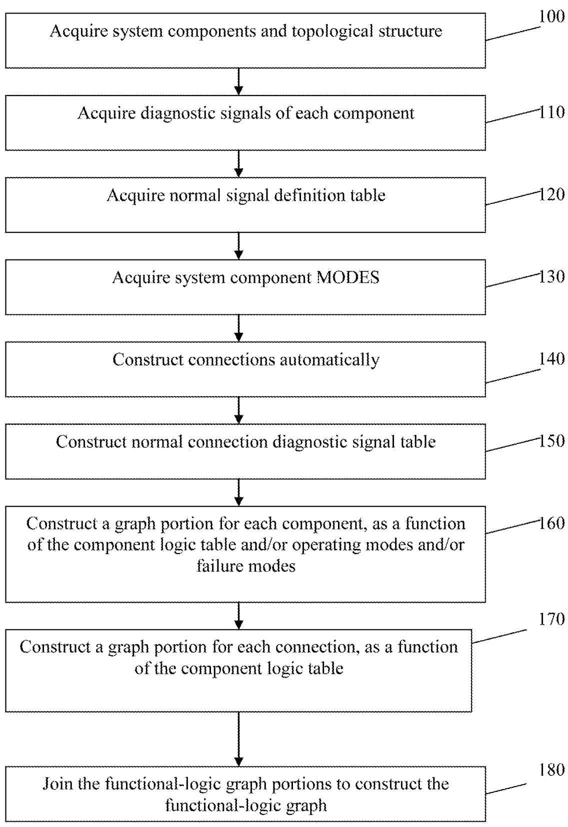

Fig. 2

EP 2 169 634 A1

Description

[0001] The present invention relates in general to automotive fault diagnosis, and more specifically to automatically generating a model-based functional-logic graph representing an automotive system, and that can be implemented in a system fault diagnosis algorithm.

[0002] Diagnostic systems are known, designed to locate faults in automotive electric and/or electronic and/or mechanical systems, to assist operators in detecting the cause of a fault and/or faulty system components.

[0003] Some such diagnostic systems analyse the vehicle using a diagnostic method substantially based on a so-called model-based "functional-logic" graph structure.

[0004] The model-based approach to automotive diagnosis - as explained, for example, in the article "Model-based Diagnosis for Automotive Repair" by Marialuisa Sanseverino and Fulvio Cascio, in the November 1997 issue of "IEE Intelligent Systems and their Application" - is substantially based on the principle of representing the monitored system by a so-called functional-logic model, i.e. comprising a number of monitored "objects" related to system signals or components, and a number of "functional-logic" connecting branches or connections linking the objects to form a functional-logic graph.

[0005] The method implements a fault analysis process that comprises working along the object-related nodes of the graph in orderly manner, following the set functional-logic connections, and at the same time implementing procedures that propagate the logic state of an object dynamically by assigning it each time to a subset of objects having a given functional-logic relationship with it, so as to exclude subsets of objects, i.e. correctly operating graph "portions", from analysis.

[0006] More specifically, the objects represented by the functional-logic graph nodes relate to characteristic components or signals of the monitored system, while the node connecting branches represent the functional-logic dependency between components and signals and between signals.

[0007] The procedures propagate a signal state along the graph node connecting branches to a graph portion comprising a subset of objects related to the object itself. By so doing, diagnosis quickly rules out all the correctly operating objects, and gradually targets in on critical-state objects, i.e. more likely to be faulty.

[0008] More specifically, the procedures propagate the variation in the state of an object, e.g. the state of an electric signal, to a portion of the graph containing objects related to it, by implementing one of three propagation strategies : a first based on a "functionality" rule; a second based on a "failure rule"; and a third based on a "focusing rule".

[0009] More specifically, the "functionality rule" states that, if a signal related to a first object in the functional-logic graph is correct, all the signals related to objects connected functionally to the first must be correct.

[0010] The "failure rule" states that, if all the input signals of a given component related to a first object in the functional-logic graph are correct, but at least one output signal of the component is incorrect, the diagnosis method must diagnose a component fault.

[0011] The "focusing rule" states that, if a signal related to an object in the graph is diagnosed incorrect and the failure rule is not activated, the following steps must be implemented : extrapolate all the causes of faults in components related to objects connected functionally to the object related to the faulty signal; list the fault causes in order of probability; check the state of signals related to the most likely cause; and repeat the propagation rules described above until the fault is detected.

[0012] Using the above strategies, diagnostic methods employing a model-based functional-logic graph representation of automotive systems provide for quickly determining and discriminating between faulty and correctly operating portions of a system, and so greatly reducing fault-finding processing time.

[0013] Though efficient, model-based diagnostic methods have a major drawback, and which lies in the time taken to construct the functional-logic graph of the system for diagnosis. More specifically, the time taken to generate the functional-logic graph is directly proportional to the degree of complexity of the system circuitry, and to the number of components/signals/causes involved in malfunctioning of the system.

[0014] At present, a system model functional-logic graph is constructed manually by an operator, who must determine all the objects characteristic of the system and potentially related to any malfunctioning of it, and also establish the correct functional-logic relationships between the objects.

[0015] Constructing a functional-logic graph is therefore a time-consuming job, particularly in the case of a complex system, and so increases diagnostic system costs.

[0016] Moreover, constructing a functional-logic graph manually can prove extremely complicated and, as such, is subject to error, even by the most experienced operator.

[0017] It is therefore an object of the present invention to provide a method of automatically generating a model-based functional-logic graph of an automotive system, and which provides for greatly reducing the overall time taken to construct the graph.

[0018] According to the present invention, there is provided an automotive system diagnostic method as claimed in Claim 1 and preferably, though not necessarily, in any one of the Claims depending directly or indirectly on Claim 1.

[0019] According to the present invention, there is also provided a computer system as claimed in Claim 7.

[0020] According to the present invention, there is also provided a software product as claimed in Claim 8.

[0021] According to the present invention, there is also provided a method of constructing a functional-logic graph, as claimed in Claim 9.

[0022] According to the present invention, there is also provided a computer system as claimed in Claim 10.

[0023] According to the present invention, there is also provided a software product as claimed in Claim 11.

[0024] A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows, schematically, an electronic system for diagnosing an automotive system, and implementing the functional-logic graph construction method according to the teachings of the present invention;
Figure 2 shows a flow chart of the operations performed in the functional-logic graph construction method according to the present invention;
Figure 3 shows a simplified schematic example of a system to be represented by a functional-logic graph using the method according to the present invention;
Figure 4 shows a logic table of the Figure 3 system components, and relative input, output and check signals;
Figure 5 shows a table defining normal Figure 4 system component diagnostic signals;
Figure 6 shows an operating mode table of the simplified Figure 3 system components;
Figure 7 shows a failure mode table of the simplified Figure 3 system components;
Figure 8 shows a functional-logic table of the Figure 3 system connections;
Figure 9 shows a table defining normal Figure 3 system connections;
Figure 10 shows the graph portions of the Figure 3 system components, constructed automatically using the method according to the present invention;
Figure 11 shows the graph portions of the Figure 3 system connections, constructed using the method according to the present invention;
Figure 12 shows the functional-logic graph of the Figure 3 system, constructed using the method according to the present invention.

[0025] Number 1 in Figure 1 indicates schematically as a whole an electronic diagnostic system connectable to a system 2 of a vehicle 3 and designed to implement a diagnostic method of locating faults in the components of system 2, and/or the causes of the faults, and/or the steps to be taken on the faulty components detected.

[0026] The electronic diagnostic system comprises a diagnostic unit 4 implementing the diagnostic method; a test unit 5 for conducting measurements/tests on system 2 and supplying diagnostic system 4 with measurement signals related to system components, and each containing an electric voltage or current quantity and/or a logic state of the relative component; and a user control interface 6 by which the user, during diagnosis, assigns logic states to system 2 signals and monitors the fault/s detected by diagnostic unit 4.

[0027] Diagnostic unit 4 may, for example, comprise a computer which communicates with and receives system 2 component measurement signals from test unit 5, and is designed to implement the model-based, object-oriented method of diagnosing operation of system 2 of vehicle 3.

[0028] The diagnostic method substantially comprises a process of automatically constructing a functional-logic graph of the components and diagnostic signals of the vehicle 3 system for diagnosis; and a system fault-finding analysis process that implements an orderly signal logic state assignment procedure based substantially on dynamically propagating signal logic states along the functional-logic graph, and a comparison procedure that compares the fault state of one or more component signals, associated with one or more failure modes, with the actual states of the signals.

[0029] The analysis process based on propagating states within the functional-logic graph is not the object of the present invention, and is therefore not described further.

[0030] For a clearer understanding of the present invention, a software formalism describing and establishing the structure of functional-logic graphs used in model-based systems to represent automotive systems must first be defined.

[0031] The functional-logic graph (Figure 12) of a system comprises a number of functional-logic graph portions, each of which is associated with a component of the system for diagnosis, and comprises one or more nodes representing objects associated with the component diagnostic signals.

[0032] Each functional-logic graph portion also comprises a number of node connecting branches or functional-logic connections, each of which establishes a direction in which the objects in the graph are travelled, i.e. between signals, and between signals and the component, and which complies with a logic relationship and a functional relationship between the signals.

[0033] With reference to the Figure 2 flow chart, the process of automatically constructing a functional-logic graph representing the system for diagnosis is implemented by the computer, i.e. diagnostic unit 4, and comprises a step of acquiring topological information about the system (block 100).

[0034] More specifically, this step comprises acquiring information about the system components, the signals associated with operation of each acquired component, and the functional dependency between component signals. In the example shown, at this step, the user enters system component/signal data into diagnostic unit 4 from user control interface 6.

[0035] Using the acquired information, the method at this step comprises constructing a topology table of the system comprising a list of system components and, for each component, diagnostic signals associated with the operating logic of the component, and the functional dependencies between the component signals.

[0036] More specifically, a diagnostic signal may comprise a component input/output signal, and/or a check signal containing an indication of the operating condition of the component.

[0037] The automatic functional-logic graph construction process also comprises the step of acquiring, for each diagnostic signal, data relative to a predetermined diagnostic signal check procedure, and to a predetermined normal condition of the diagnostic signal obtainable in the course of the check procedure (block 120).

[0038] Using the acquired data, diagnostic unit 4 at this step constructs a normal component diagnostic signal definition table (block 120) comprising, for each diagnostic signal, the predetermined diagnostic signal check procedure, and the predetermined normal diagnostic signal condition obtainable in the course of the check procedure.

[0039] The automatic functional-logic graph construction process also comprises the step of acquiring logic dependencies between the component diagnostic signals - hereinafter referred to as "operating modes" and "failure modes" (block 130).

[0040] More specifically, each component operating mode or failure mode defines a logic dependency between the diagnostic signals of the same component.

[0041] Signal logic dependencies are based on the principle that, if a diagnostic signal corresponding to a component output signal complies with the normal state set out in the operating mode, then the relative component and the relative diagnostic signal corresponding to the input signal are operating correctly.

[0042] Signal logic dependency is also based on the principle that, if the diagnostic signal corresponding to a component check signal complies with the relative operating mode, then the corresponding component is operating correctly.

[0043] The operating state of a component input signal and/or check signal therefore has a direct correlation, i.e. logic dependency, with the operating state of the output signal, while the component operating state has a logic dependency with the operating state of the component check signal.

[0044] At this step, diagnostic unit 4 therefore acquires, for each component, operating modes corresponding to respective logic dependencies, and comprising a number of normal diagnostic signal states in correct operating conditions.

[0045] Diagnostic unit 4 also acquires, for each component, failure modes comprising diagnostic signal states associated with failure of the component.

[0046] On the basis of the user-entered operating modes, diagnostic unit 4 then constructs a system component operating mode table comprising one or more operating modes for each component, and one or more normal component operating conditions for each operating mode.

[0047] More specifically, each component operating mode establishes a normal component operating condition, and is defined by a number of component diagnostic signals in check priority order, and by a number of predetermined logic operating states corresponding to diagnostic signal logic states associated with correct operation of the component.

[0048] It should be pointed out that, in the diagnostic method according to the invention, a diagnostic signal may assume a "normal" OK logic state indicating it is operating correctly, or an abnormal NOK logic state indicating it is operating abnormally.

[0049] The automatic functional-logic graph construction process also comprises a step of acquiring, for each component, failure modes associated with possible failure conditions of the component.

[0050] More specifically, each component failure mode is defined by a number of logic dependencies associated both with component diagnostic signals having a relative check priority order, and with a number of predetermined logic failure states corresponding to diagnostic signal logic states associated with failure of the component.

[0051] The process also comprises a step of automatically constructing the connections of the system for diagnosis, on the basis of topology table data, and various user-established component connection data (block 140).

[0052] On the basis of the connections determined, the process at this step constructs a functional-logic table of system connections.

[0053] More specifically, the functional-logic connection table may comprise, for each connection, an indication of the type of connection, e.g. one or more wires or pipes connecting system components; and an indication of the logic dependency of the signals relative to the connection, i.e. an operating mode and/or failure mode. It should be pointed out that the operating modes and/or failure modes of each connection may be either user-assigned or predetermined.

[0054] The functional-logic connection table may also comprise, for each connection, an indication of the corresponding diagnostic signals, which may comprise component input/output or check signals.

[0055] The process also comprises the step of generating data relative to normal diagnostic signals of each connection.

[0056] More specifically, at this step, the method constructs a table of normal connection diagnostic signals (block 150), and which comprises, for each diagnostic signal, a predetermined diagnostic signal check procedure, and a predetermined normal condition of the diagnostic signal obtainable in the course of the check procedure.

[0057] Finally, the process comprises the step of constructing the relative functional-logic graph portion of each component (block 160).

[0058] More specifically, this step comprises defining and assigning objects (shown by the rectangles in Figure

10) to a component; and defining and assigning objects (shown by the circles in Figure 10) to a diagnostic signal.

[0059] At this point, the process determines, for each component, the logic and functional dependencies between the component-assigned and signal-assigned objects, so as to accordingly assign the functional-logic connections between the functional-logic graph nodes.

[0060] More specifically, at this step, the process processes the system component topology table, the operating mode table, and the failure mode table, to determine the functional-logic dependencies between signals and between signals and the relative component.

[0061] More specifically, each functional-logic dependency is characterized by a travelling direction between two consecutive nodes, and is determined to comply with both the logic and functional relationships set out in the operating and failure modes.

[0062] At this point, the process comprises the step of constructing a graph portion for each system connection (block 170).

[0063] More specifically, at this step, the process defines objects (shown by the rectangles in Figure 11) and assigns some of them to a connection; while other objects (shown by the circles in Figure 11) are assigned to a diagnostic signal of the connection.

[0064] At this point, the process determines, for each connection, the functional-logic dependencies between the connection-assigned and signal-assigned objects, so as to accordingly assign the functional-logic connections between the connection subgraph nodes.

[0065] More specifically, at this step, the process processes the functional-logic connection table to determine the functional-logic dependencies between the diagnostic signals of each connection.

[0066] More specifically, each functional-logic dependency is determined so that: the output signal has a functional-logic connection to the input signal; and/or the output signal has a functional-logic connection to the check signal; and/or the check signal has a functional-logic connection to the component; and/or, in the absence of a check signal, the output signal has a functional-logic connection to the component.

[0067] At this point, the process constructs the functional-logic graph by joining the component graph portions to the connection graph portions. More specifically, at this step, the common nodes, i.e. nodes associated with the same objects in different graph portions, are connected/joined to one another to complete the functional-logic graph of the system.

[0068] For a clearer understanding of the present invention, the operations performed by the automatic functional-logic graph construction process will now be described assuming the system for diagnosis is the simplified electric system 2 shown schematically in Figure 3.

[0069] It is understood, however, that the operations performed by the construction process as shown in the Figure 2 flow chart also apply to automatically constructing the functional-logic graph of any automotive system.

[0070] In the Figure 3 example, the electric system 2 to be diagnosed is represented by a topological diagram comprising electric components in the form of a battery, a switch, and a bulb; and a number of electric connecting components comprising a connection C4 between the battery and switch, and a connection C5 between the switch and bulb.

[0071] With reference to Figures 3 and 4, the process acquires the components/signals, i.e. information about the topology of the system, as shown in block 100, and lists in the Figure 4 topology table : a battery, a switch, and a bulb. At this step, the process also assigns respective diagnostic signals to each component in the list : an electric output signal S1 to the battery; an electric input signal S4, an electric output signal S3, and a check signal S2 to the switch; and to the bulb an electric input signal S6 and a physical output signal S5 corresponding to the light emitted by the bulb.

[0072] At this point, the process acquires data relative to the normal component diagnostic signal table, as shown in block 120. At this step, the process establishes, for each electric signal S1, S3, S4, S6, the respective predetermined check procedure which, in the Figure 5 example, amounts to indicating the component connection terminals used to determine an electric quantity of the signal; and the corresponding predetermined normal condition shows a physical quantity range of values corresponding to normal operation of the component. The process also establishes for each check signal, in particular S5, the relative check procedure which, in the Figure 5 example, amounts to observing the operating state of the component; and the corresponding predetermined normal condition shows the required operating state of the component when operating correctly.

[0073] At this point, the process acquires the component-associated operating modes and/or failure modes.

[0074] More specifically, on the basis of the input operating mode data, the method constructs the system component operating mode table which, in the Figure 6 example, comprises four operating modes for the battery, switch and bulb.

[0075] On the basis of the user-entered failure mode data, the method also constructs the system component failure mode table which, in the Figure 7 example, comprises four failure modes for the battery, switch and bulb.

[0076] At this point, the process processes the topology table and the user-established connections to automatically generate connection information and so construct a logic table of system component "connections". More specifically, with reference to Figure 8, the process constructs a connection C4 between the battery and switch, and a connection C5 between the switch and bulb. At this step, the process assigns electric input signal S1, output signal S4 and check signal S7 to connection C4, and electric input signal S3, output signal S6 and check signal S8 to connection C5.

[0077] At this point the process constructs the normal connection diagnostic signal table.

[0078] At this step, for each connection check signal, the process establishes the relative check procedure which, in the Figure 9 example relative to signals S7 and S8, amounts to indicating the connection connecting terminals used to determine an electric quantity, in particular an electric resistance, of the signal; and the corresponding predetermined normal condition shows a physical quantity value relative to normal operation of the connection and corresponding to no resistance in the wire.

[0079] The process processes the component topology table, the component operating mode table, and the component failure mode table to determine the relationships between the battery, switch and bulb and respective signals S1, S2, S3, S4, S5 and S6.

[0080] At this step, the process processes the component topology table, the component operating mode table, and the component failure mode table to establish the functional-logic dependencies between the objects determined above, and obtains, as shown in the Figure 10 example, a graph portion 10 representing the battery; a graph portion 11 representing the switch; and a graph portion 12 representing the bulb.

[0081] At this point, the process constructs a connection graph portion for each connection C4, C5.

[0082] More specifically, at this step, the process assigns connections C4 and C5 to the connection-assigned objects, and diagnostic signals S1, S4, S3, S3, S6, S8 to the signal-assigned objects.

[0083] At this point, the process determines, for each connection C4, C5, the functional-logic dependencies between the connector-assigned and signal-assigned objects as a function of the connection logic table, and constructs the subgraphs 20 and 21 shown in Figure 11.

[0084] Once functional-logic graph portions 10, 11, 12 associated with the battery, switch and bulb, and functional-logic graph portions 20, 21 associated with connections C4, C5 are determined, the process completes the functional-logic graph shown in Figure 12.

[0085] The automatic functional-logic graph construction process of the diagnostic method described above has the major advantage of not only simplifying graph construction by the operator, but also completing the graph extremely quickly.

[0086] Clearly, changes may be made to the method as described herein without, however, departing from the scope of the present invention as defined in the accompanying Claims.

Claims

1. A computer-implemented method of diagnosing a fault in an automotive system (2);
   the method comprising the steps of:

   - constructing a model-based functional-logic graph representing said system (2) to be diagnosed, and comprising a number of objects associated with corresponding components, component connections, and signals of said system (2), and a number of connecting branches between said objects and each defining a functional-logic dependency between said objects;
   - analysing operation of the components and/or signals of said system (2) as a function of said functional-logic graph;

   said method being **characterized in that** said step of constructing said functional-logic graph comprises the steps of:

   a) acquiring the components of said system (2);
   b) acquiring the topological structure of said system (2);
   c) determining the connections between the components of said system (2) as a function of the acquired said components and said topological structure of the system (2);
   d) acquiring the signals associated with operation of each component and/or connection of said system (2), and the functional dependencies between the signals;
   e) determining, for each component and/or connection, the logic dependencies between the relative signals;
   f) assigning the components, connections, and relative signals to corresponding objects in said graph;
   g) establishing the connecting branches between said objects in said graph as a function of said logic dependency and/or said functional dependency between said signals;
   h) constructing the functional-logic graph as a function of said objects and the relative connecting branches.

2. A method as claimed in Claim 1, and comprising the step of acquiring, for each component, failure modes, each of which corresponds to a logic dependency between signals, and comprises predetermined states of one or more diagnostic signals associated with a failure condition of the component.

3. A method as claimed in Claim 1 or 2, and comprising the step of acquiring, for each component, operating modes, each of which corresponds to a logic dependency between signals, and comprises predetermined states of one or more diagnostic signals associated with a normal operating condition of the component.

4. A method as claimed in any one of the foregoing Claims, and comprising the step of constructing a functional-logic graph portion for each component.

5. A method as claimed in any one of the foregoing

Claims, and comprising the step of constructing a functional-logic graph portion for each connection.

6. A method as claimed in any one of the foregoing Claims, and comprising the step of constructing the graph by joining said graph portions of the connections to said graph portions of the components of the system (2).

7. A computer system programmed to implement a method as claimed in any one of the forgoing Claims, to diagnose a fault in an automotive system.

8. A software product loadable into a computer (4) and configured to implement, when executed, the diagnostic method as claimed in any one of the foregoing Claims.

9. A computer-implemented method of constructing a model-based functional-logic graph usable in a method of diagnosing an automotive system (2) as claimed in any one of Claims 1 to 6, **characterized by** comprising steps a) to h).

10. A computer system programmed to implement a method as claimed in Claim 9, to construct a model-based functional-logic graph.

11. A software product loadable into a computer and configured to implement, when executed, the method as claimed in Claim 9.

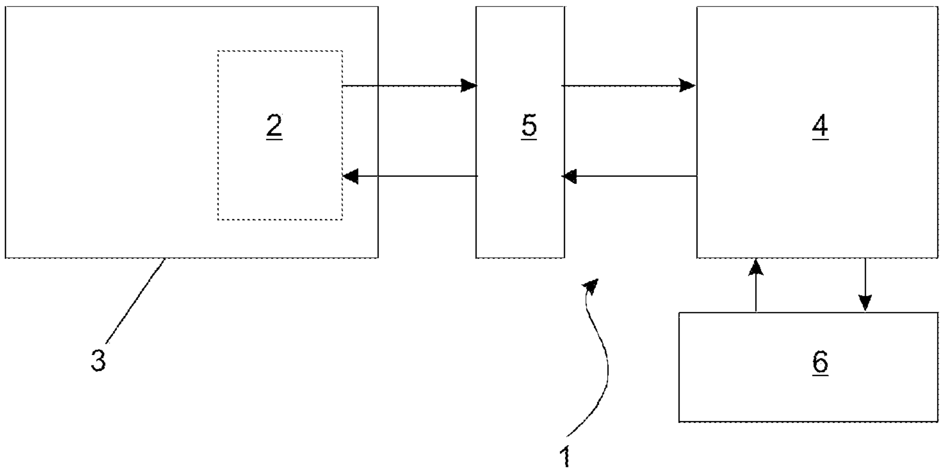

Fig.1

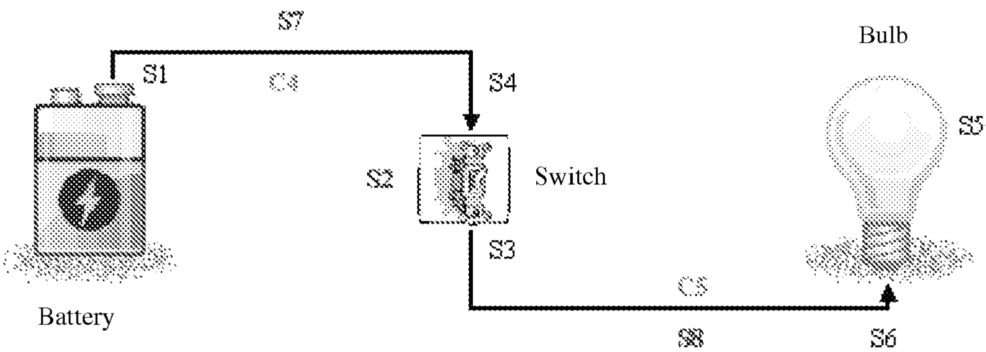

Fig. 3

• Input	• ← Output →	• Check →	• Component
• -	• S1	• -	• Battery
• S4	• S3	• S2	• Switch
• S6	• S5	• -	• Bulb

Fig. 4

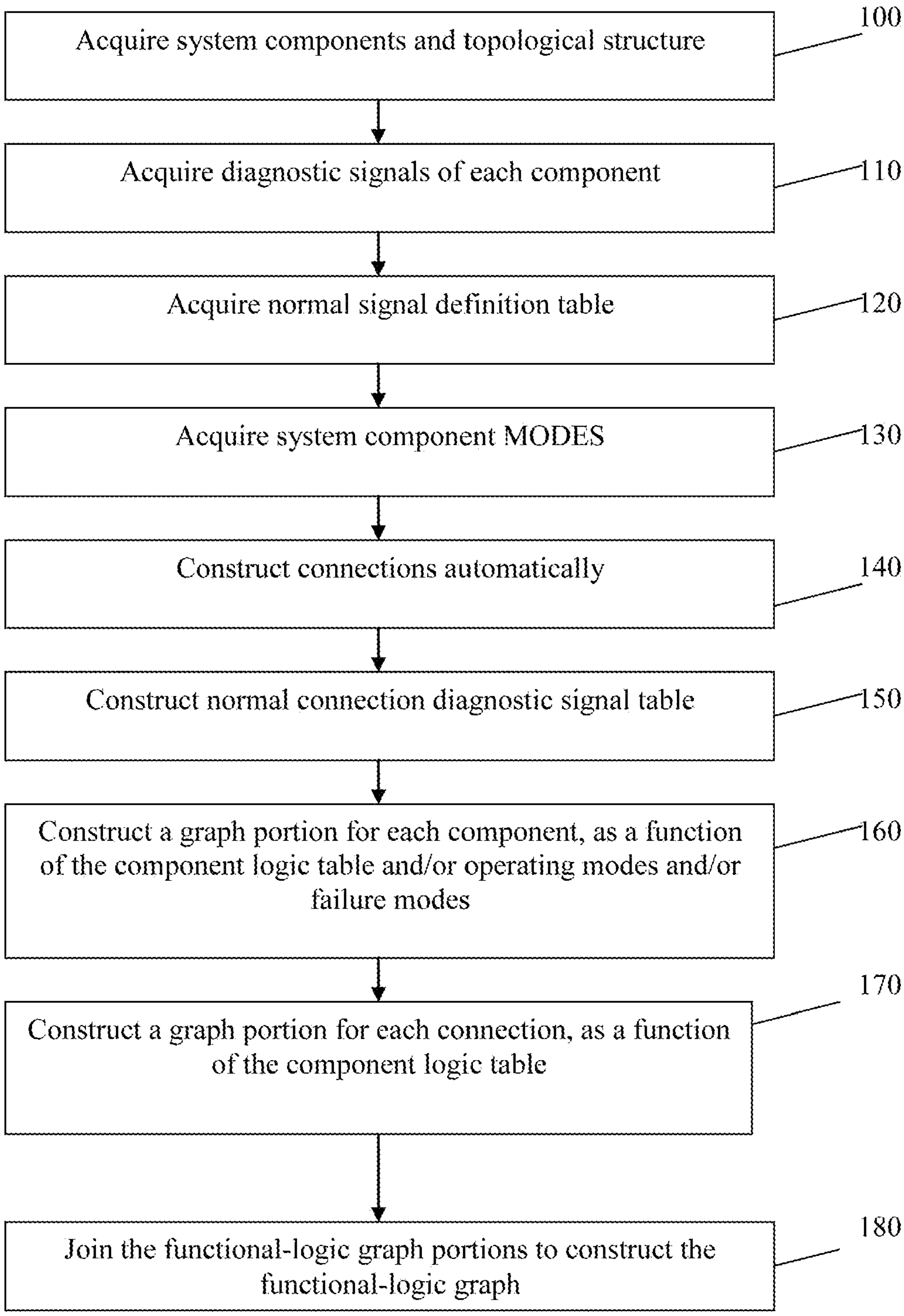
Acquire system components and topological structure
100
Acquire diagnostic signals of each component
110
Acquire normal signal definition table
120
Acquire system component MODES
130
Construct connections automatically
140
Construct normal connection diagnostic signal table
150
Construct a graph portion for each component, as a function of the component logic table and/or operating modes and/or failure modes
160
Construct a graph portion for each connection, as a function of the component logic table
170
Join the functional-logic graph portions to construct the functional-logic graph
180

Fig. 2

Normal definition table		
Signal	**Procedure**	**Normal condition**
S1	Connect red tester cable to "+" battery terminal, and black tester cable to ground (any metal part of the vehicle)	Voltage S1 between 11 and 13 volts
S2	Observe switch	Switch is on
S3	Connect red tester cable to the switch output, and black tester cable to ground (any metal part of the vehicle)	Voltage S3 between 11 and 13 volts
S4	Connect red tester cable to the switch input, and black tester cable to ground (any metal part of the vehicle)	Voltage S4 between 11 and 13 volts
S5	Observe bulb	Bulb is on
S6	Connect red tester cable to bulb input, and black tester cable to ground (any metal part of the vehicle)	Voltage S6 between 11 and 13 volts

Fig. 5

From	← To →	Check →	Component
S1	S4	S7	C4
S3	S6	S8	C5

Fig. 8

Normal definition table		
Signals	**Procedure**	**Condition**
S7	Connect red tester cable to cable between battery and switch, and connect black tester cable to ground (any metal part of the vehicle)	No resistance
S8	Connect red tester cable to cable between switch and bulb, and connect black tester cable to ground (any metal part of the vehicle)	No resistance

Fig. 9

	signal		state	component
MODE 1	S5	bulb on	OK	Bulb
	S6	bulb powered	OK	
MODE 2	S2	switch setting	OFF	Switch
MODE 3	S2	switch setting	ON	Switch
	S4	switch powered	OK	
	S3	switch output voltage	OK	
MODE 4	S1	battery output voltage	OK	Battery

Fig. 6

	signal		state	component	mode	intervention
MODE 1	S5	bulb on	NOK	Bulb	faulty	change
	S6	bulb powered	OK			
MODE 2	S2	switch setting	OFF	Switch	off	set to on
MODE 3	S2	switch setting	ON	Switch	broken	change
	S4	switch powered	OK			
	S3	switch output voltage	NOK			
MODE 4	S1	battery output voltage	NOK	Battery	run-down	charge

Fig. 7

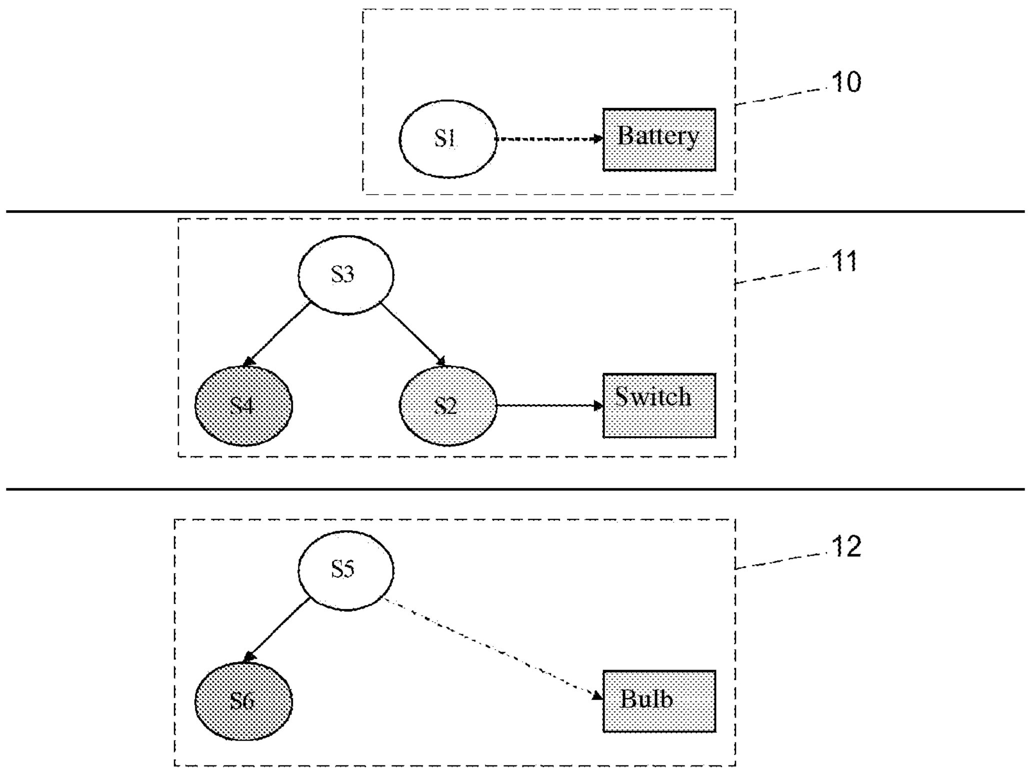
10
S1
Battery
11
S3
S4
S2
Switch
12
S5
S6
Bulb

Fig. 10

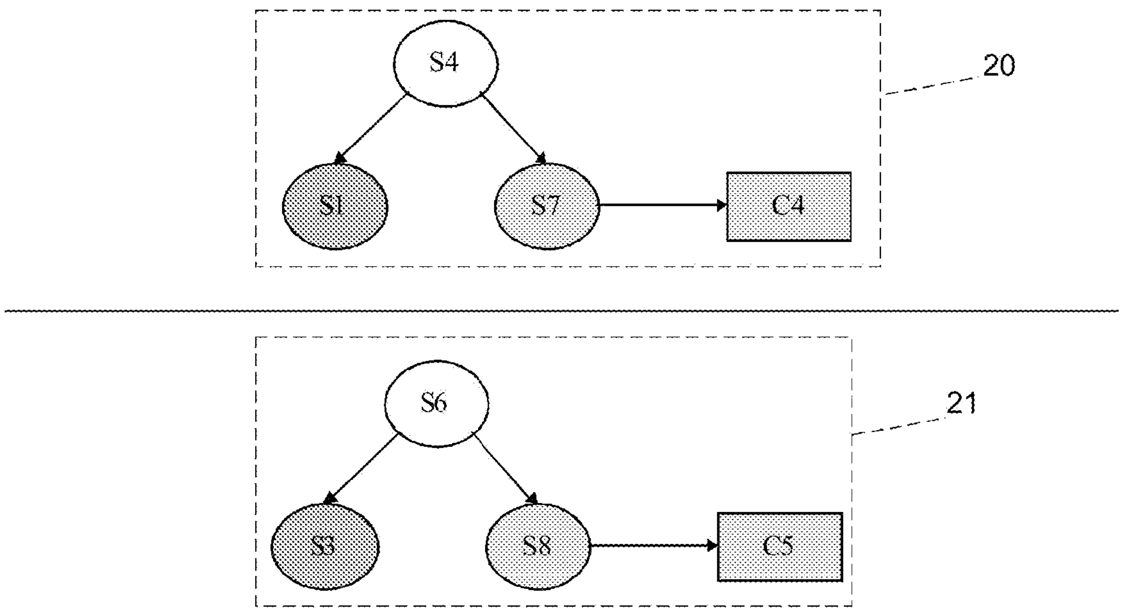
20
S4
S1
S7
C4
21
S6
S3
S8
C5

Fig. 11

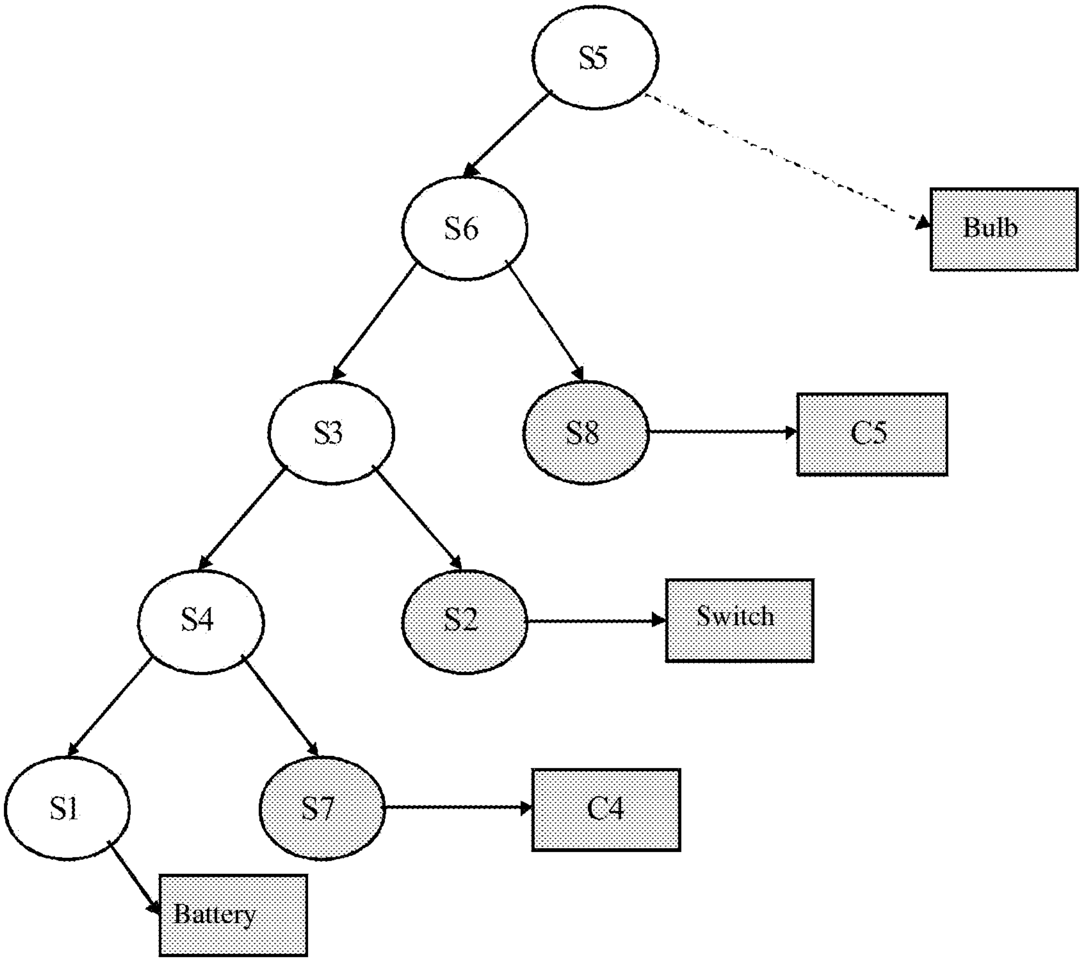

Fig.12

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 08 42 5613

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
D,X	MARIALUISA SANSEVERINO, FULVIO CASCIO: ""Model-Based Diagnosis for Automotive Repair" IEEE EXPERT MAGAZINE, vol. 12, no. 6, 1997, pages 33-37, XP002517320 ISSN: 0885-9000 * the whole document * -----	1-11	INV. G07C5/08 G06F17/50
			TECHNICAL FIELDS SEARCHED (IPC)
			G07C G06F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	2 March 2009	Stenger, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
....
& : member of the same patent family, corresponding document

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- **Marialuisa Sanseverino ; Fulvio Cascio.** Model-based Diagnosis for Automotive Repair. *IEE Intelligent Systems and their Application,* November 1997 **[0004]**