

Method for analyzing malfunctions of a system and associated devices

The present invention relates to a method for analyzing the malfunctions of a system. The invention also relates to a computer program product, a readable information medium and a related cloud computing platform.

In the field of transportation, some systems, such as trains, are difficult to maintain because it is impossible to stop traffic outside of reduced time slots. This difficulty is compounded for a maintenance worker by the complexity of the set of equipment forming the train, resulting in delicately determining the fault or the corrective action to be taken.

For this purpose, it is known to have documentation indicating the steps to be taken in certain very specific cases. This documentation is, for example, available in paper form or in electronic form after the documentation has been scanned.

In practice, however, the fault encountered is often different from the elements present in the documentation, leaving the maintenance worker powerless to find the appropriate corrective action.

There is therefore a need for a method for analyzing the malfunctions of a system with a plurality of elements that is easier to implement.

For this, the present description proposes a method for analyzing system malfunctions, the method comprising an initialization phase and an operating phase. The initialization phase includes a step of receiving information relating to the maintenance of the system, to form a database, and of obtaining decision trees from at least part of the information in the database received, a decision tree defining a set of sequences of maintenance operations to be performed in order to carry out the maintenance of the system. The operating phase comprises a step of providing a maintenance agent with the set of decision trees as well as the database, of the maintenance agent performing a sequence of maintenance operations on the system according to at least part of the decision trees, of sending at least one piece of information relating to the sequence of maintenance operations performed, of updating the database using the at least one piece of information sent, selecting decision trees comprising at least one maintenance operation in common with the sequence of operations performed by the maintenance agent, in order to obtain selected decision trees, extracting the information relating to the selected decision trees from the database and updating all the selected decision trees by applying a learning technique applied to all the information extracted, the updating being carried out by a data processing unit of a computer platform. The operating phase is repeated for a plurality of maintenance operation sequences.

According to particular embodiments, the analysis method includes one or more of the following characteristics, taken alone or in any technically possible combination:

- the operating phase also includes a step in which the maintenance agent requests information relating to decision trees comprising at least one common maintenance operation with the sequence of maintenance operations to be performed, and return of the requested information to the maintenance agent on a mobile terminal.
- the information returned during the return step is information that is contained in the database includes at least one item chosen from the list consisting of an image, a video or a comment from at least one maintenance agent having performed the same sequence of maintenance operations.
- the information returned during the return step includes the display on the mobile terminal of a sequence of maintenance operations to be performed in virtual reality.
- the information returned during the return step is returned using an enhanced reality technique.
- the learning technique is a statistical study.
- the update step involves processing by a supervisor of the information sent to obtain processed information and adding the processed information to the database.

This description also describes a computer program product comprising a readable information medium on which a computer program containing program instructions is stored, the computer program being loadable onto a data processing unit and adapted to cause the implementation of at least the updating step of the method as previously described when the computer program is implemented on the data processing unit.

In addition, this description provides a readable information medium on which a computer program product as previously described is stored.

This description also describes a computer platform (10) suitable for implementing certain steps of the method as previously described, the platform comprising a set of mobile terminals, the mobile terminals being used during the sending step of the method, and a data processing unit adapted to cause the implementation of at least the updating step of the method when a computer program is implemented on the data processing unit and comprising program instructions stored on a readable information medium of a computer program product, the computer platform being a cloud platform, is implemented on the data processing unit.

Other features and advantages of the invention will appear upon reading the following description of embodiments of the invention, given as examples only and with reference to the drawings, which are:

- Figure 1, a schematic view of an example of a computer platform interacting with its users, and
- Figure 2, a schematic view of an example of a central station forming part of an IT platform, and
- Figure 3, a schematic view of a set of facilities in which the system is to be used.

A computer platform 10 is shown in Figure 1.

The platform 10 is a cloud platform.

The term "cloud" refers to the exploitation of both the storage capacity of remote computer servers via a communications network, typically the internet, and the ability to run computer programs.

This is sometimes referred to as "distributed" in the literature.

The platform 10 is suitable for implementing steps in a method for analyzing system malfunctions.

In this case, the platform 10 includes mobile terminals 12, a server 14 and a central station 16.

The mobile terminals 12, the server 14 and the central station 16 are able to interact via a communications network. These interactions are visible in Figure 1 in the form of dotted arrows with a reference sign 18.

Each mobile terminal 12 is a tablet.

Each mobile terminal 12, in the example shown, is specific to a maintenance agent 20, a maintenance agent 20 being an operator in charge of servicing and maintaining a system.

Each mobile terminal 12 serves as a human-machine interface for the maintenance agent 20, enabling him to interact with the network and its elements.

The server 14 is a computer server that provides services to network operators.

The server 14 operates permanently, automatically responding to requests from mobile terminals 12 or from the central station 16 according to the client-server principle.

As will be detailed later, the server 14 is used in particular to store the database obtained with the method.

The central station 16 is a computer shown in figure 2.

Also, the central station 16 and a computer program product 22 are shown in Figure 2. The interaction of computer program product 22 with the central station 16 enables a method for analyzing system malfunctions to be implemented.

More generally, the central station 16 is an electronic computer capable of manipulating and/or transforming data shown as electronic or physical quantities in computer registers and/or memories into other similar data corresponding to physical data in memories, registers or other types of display, transmission or storage devices.

The central station 16 comprises a processor 24 with a data processing unit 26, memories 28 and a drive 30. The central station 16 also includes a keyboard 32 and a display unit 34.

The computer program product 22 comprises a readable data medium.

A readable data medium is a data medium that can be read by the central station 16, usually by the reader 30. The readable data medium is a medium suitable for storing electronic instructions and capable of being coupled to a bus of a computer system.

As an example, the readable data medium is a floppy disk, an optical disk, a CD-ROM, a magneto-optical disk, a ROM, a RAM memory, an EPROM memory, an EEPROM memory, a magnetic card or an optical card.

A computer program containing program instructions is stored on the readable information medium.

The computer program can be loaded on the data processing unit 26 and is suitable for driving the implementation of the analysis method.

For the following, it is assumed that the central station 16 is part of a supervisory control center 36, with the supervisory control center 36 also having supervisors 38.

In the proposed example, the supervisors 38 are human experts 38.

Alternatively, consideration could be given to replacing the experts 38 with computer supervisors 38.

The operation of the platform 10 is now described with reference to an example of the implementation of a method for analyzing system malfunctions.

The analysis method is applied in a case where the system is likely to be used in multiple different facilities during its lifetime. Such a set of facilities is shown in Figure 3.

In the example shown, the facilities are a station 40, a maintenance center 42, a repair center 44 and three power plants 46, 48 and 50, each belonging to a respective supplier of repair center 44.

The set of facilities is thus a maintenance and operation facility for a train 52.

Each train 52 comprises a plurality of equipment 54 each with a plurality of parts.

The equipment 54 is, in the following, train equipment.

A fan, motor or wheels are examples of such equipment 56.

In the station 40, a plurality of trains 54 is ready to depart and to arrive.

5 The station 40 specifically comprises sensors capable of measuring environmental conditions. For example, the sensors are capable of measuring track temperature, amount of rain or visibility.

Each train 54, and in particular each piece of equipment 56 on the train 54, is subject to strict monitoring in the maintenance center 42.

Each piece of equipment 56 is tested by a number of sensors.

10 The plurality of sensors thus gives access, by way of illustration, to the mechanical resistance of the equipment 56 or to electrical reference values for the equipment 56.

When a piece of equipment 56 malfunctions, the equipment 56 is sent to a repair center 26. The term "malfunction" includes both a fault, that is, a failure to operate, and an operation that does not conform to the expected operation of the equipment 36.

15 In this way, the method makes it possible to promote both preventive and corrective maintenance.

In the repair center 44, each part is tested to find the origin of the malfunction.

In particular, the test comprises using sensors to establish the electrical response of the equipment 56, a response that includes all the electrical values and not just the
20 electrical reference values.

As an example, it is assumed that three parts of the equipment 56 are considered defective and that each of these parts is supplied by a different supplier.

Each part is then returned to the central office 46, 48 or 50 of the supplier concerned for repair or replacement.

25 In each of the central stations 46, 48 and 50, the supplier shall re-test one of the pieces of equipment 36 with its own sensors.

In such a case, it is clear that the information relating to the malfunction is shared between multiple separate facilities.

In this case, the maintenance center 42, the repair center 44 and the control
30 centers 46, 48 and 50 of the three suppliers each have at their disposal data relevant to the maintenance and repair of the equipment 56 of the train 54.

In addition, it should be noted that the simple case illustrated is more complex in most cases. because the number of facilities is greater and that this issue must also be considered for each piece of equipment 56 and each train 54. In particular, a fault in a set

of equipment 56 may be due to the weakness of a single piece of equipment 56 or relative only to a particular type of train 54.

The method for analyzing malfunctions of equipment 56 aims to use all this data to ensure better maintenance (prevention) and better repair of malfunctions.

5 The analysis method comprises an initialization phase and an operating phase.

According to the example described, the initialization phase includes a receiving and an obtaining step.

In the receiving step, information about system maintenance is received to form a database.

10 Receiving can be performed by providing existing documentation, either in paper or computer format.

For example, in the proposed case, it is assumed that the maintenance center 42 provides all the information available to the maintenance center 42, which is contained in paper documentation.

15 In such a case, the content of the documentation is digitized to form the database.

In another embodiment, the database combines multiple sources of information.

For example, according to the example described, the information is all the information from the service center 42, the repair center 44 and the three centers 46, 48 and 50, each belonging to a respective supplier of the repair center 44.

20 This results in a central information database that is generally not shared.

During the obtaining step, decision trees are obtained.

By definition, a decision tree defines a set of sequences of operations to be performed to carry out the maintenance of the train 54.

25 A decision tree details all the steps to be performed by a maintenance agent 20 in order to properly analyze a malfunction.

The term "analyze" is used to describe two distinct types of situation: on the one hand, to determine the origin of the malfunction and, on the other hand, to carry out physical actions to correct the malfunction. A decision tree may relate to one or both of these aspects, depending on the case.

30 For example, the decision tree gives a certain number of measures to be performed and makes it possible to indicate, according to the measures performed, the appropriate action to make the system functional again.

In this way, a decision tree corresponds to a set of maintenance operations.

It is implemented from at least part of the information in the database received.

For example, the experts 38 of the supervision center 36 will publish in the tool all the documents necessary for the maintenance of the system. The documents can be of any type and contain decision trees in particular.

According to a variant, the initialization phase is implemented by digitizing all the documentary resources relating to the trains 54 requiring maintenance.

According to another variant, the decision tree is obtained by implementing a statistical study on the data in the database received.

For example, supposing that for a type X train, a frequent malfunction implies the implementation of the same repair actions and a two-step test protocol in more than 70% of the cases. The decision tree will then include the following actions: determine the type of train, if the train type is type X, implement the two-step test for the presence of the malfunction and then implement the protocols.

From this very simple case, it is possible to deduce how to form each part of the decision tree.

At the end of the initialization phase, a database is thus obtained, and decision trees that the method aims to optimize.

In the proposed example, the operating phase includes a provision step, an implementation step, a sending step, an updating step, a selection step, an extraction step and an update step.

During the provision step, all the decision trees as well as the database are made available to the maintenance agent 20.

During the implementation step, the maintenance agents 20 perform a sequence of maintenance operations on the system, the sequence of operations taking into account at least part of the decision trees.

Indeed, the maintenance agents 20 access the database at their place of intervention. The maintenance agents 20 can then consult the documents and decision trees relating to their intervention. The access is made either by browsing through computer directories or by using the search function.

The maintenance agents 20 can then decide to choose a decision tree that they find suitable and display it graphically, for example.

The decision tree allows the maintenance agent 20 to be guided step by step.

During the sending step, at least one piece of information is sent to the maintenance agent concerning the sequence of operations performed.

The sending step is easily implemented, using the mobile terminal 12 belonging to the maintenance agent 20 and being part of the platform 10.

The nature and content of the information sent can vary greatly from one case to another.

For example, if an operation in the monitored decision tree is not detailed enough, a maintenance agent 20 has the possibility of requesting a modification of the operation.

5 The maintenance agent 20 can also propose loading multimedia content in such a case.

According to another example, the maintenance agent 20 can raise an alarm corresponding in particular to the fact that the operation is unsuitable or has failed.

10 From the maintenance agent 20's point of view, the entire platform 10 can be used as a social network.

Preferably, the maintenance agent 20 indicates which operations he has actually performed, to enable the implementation of statistical studies.

During the update step, the database is updated with at least one piece of information sent.

15 According to a simple embodiment, all the information sent is added to the database.

According to a more elaborate embodiment, a filtering of the information sent is performed, in particular to avoid inconsistencies or repetitions.

Such filtering is performed by a moderator, for example.

20 During the selection step, decision trees containing at least one operation in common with the sequence of operations performed by the maintenance agent are selected.

According to the example described, the data processing unit 26 performs this selection step.

25 At the end of the selection step, selected decision trees are selected.

During the extraction step, information about the selected decision trees in the database is extracted.

According to the example described, the data processing unit 26 performs this selection step.

30 During the update step, all selected decision trees are updated.

For this purpose, a learning technique is applied by the data processing unit 26 to all the extracted information.

Multiple learning techniques can be envisaged.

35 In one particular example, the learning technique exploits a statistical study of the extracted information.

By way of illustration, if an operation can never discriminate a failure, it should be eliminated.

According to another case, if the operation to be performed corresponds to a case occurring in 2% of the malfunctions, it will be more advantageous to perform it at the end of other tests to speed up the performance of the decision tree considered.

In summary, the statistical study allows the automatic detection of the places to be improved in the decision tree to be optimized.

The statistical study enables decision trees to be optimized according to the decision trees performed by all the maintenance agents 20.

A specific statistical study is a filtering with a threshold, for example. In particular, depending on a particular case, the filtering rule is that if, under certain predefined conditions, more than a certain threshold, such as 70% of cases have the same sequence of actions, then this sequence of actions is defined as the sequence to be followed.

In addition, or alternatively, a filtering rule is that if the same sequence of actions under such predefined conditions is performed in less than a certain threshold of cases, such as 10%, then this option should be removed.

In another particular example, the learning technique is a supervised technique with the help of supervisors 38.

Any combination of the above learning techniques is possible. In particular, it is possible to implement a statistical study and a supervised learning technique followed by each other, particularly in the most appropriate direction depending on the intended use. The operating phase is then repeated for a plurality of maintenance operation sequences.

The analysis method thus makes it possible to obtain a database with enriched content as compared to the state-of-the-art databases.

In particular, the database capitalizes on the knowledge and know-how of all the maintenance agents 20. This applies both in cases of rotation of teams of maintenance agents 20 on the same system and also in the event of the departure of an agent from the maintenance team.

The maintenance agents 20 can thus take part in the continuous improvement of the database.

The improvement of the database also comes from the use of the learning technique, which can be applied to a large amount of data. The large amount of data ensures that the learning technique is implemented efficiently.

The database is also enhanced by the fact that the supervisor 38 or the expert 38 is in direct contact with the field at multiple intervention sites. This allows the expert 38 to

take a position on the problems of maintenance agents without having to travel, but above all, it allows him to deal with each problem that comes before him.

The database also provides access to the history of data relating to the decision tree in question.

5 It should be noted that the database has the advantage for a maintenance agent 20 of centralizing all of the above-mentioned information in a single place, and above all to the expertise of the supervisors 38 but also to the expertise capitalized by the experience of the other maintenance agents 20.

10 This centralization is all the more advantageous if the information is all information from different sites, such as the maintenance center 42, the repair center 44 and the three central offices 46, 48 and 50, each belonging to a respective supplier of the repair center 44.

15 In addition, deploying the method on a cloud-based platform 10 facilitates access for the agent, since all the information in the database can be accessed using a mobile terminal 12.

Due to the ease of access to the database, agents' loss of time in accessing relevant information is greatly reduced.

This results in an efficient resolution of the malfunction in question. In particular, it prevents agents from finding themselves helpless when faced with system failures.

20 The method also makes it possible to ensure that maintenance operations are performed by the maintenance agents under the security conditions adapted to the system and guaranteeing the integrity of the agents. The control of the maintenance activities of the agents is easier.

25 The method can be applied to any system regardless of its complexity. For example, no limitation on the quantity of equipment is involved.

The method also enables the increasing complexity of systems and their rapid evolution to be taken into account. Indeed, the updating of the database and the updating of decision trees can be implemented in real time.

30 The method manages in particular the case of a change in the system to be maintained.

Finally, it should be noted that the method also works even when the documentation relating to the maintenance of the system's equipment is either not relevant enough or non-existent.

35 This means that, for error modes not envisaged when the initial documentation was written, the method can generate the appropriate decision trees very quickly.

In short, the method for analyzing system malfunctions is therefore easier to implement.

According to a particular embodiment, the operating phase also includes a step in which the agent requests information relating to a decision tree comprising at least one common maintenance operation with the sequence of maintenance operations to be performed.

The operating phase also comprises a step of returning the information requested from the agent on a mobile terminal 12.

The return can take several forms. As an example, three forms are developed in the following.

For example, the information returned during the return step is information that is contained in the database and that includes at least one item chosen from the list consisting of an image, a video or a comment from at least one agent who has performed the same sequence of operations.

According to another example, the information returned during the return step includes the display on the mobile terminal 12 of a sequence of maintenance operations to be performed in virtual reality.

The use of virtual reality allows the agent to be better guided in delicate operations.

In addition, this guidance can be done remotely, which makes it possible to put the maintenance agent 20 in contact with a supervisor 38.

According to yet another example, the information returned during the return step is returned using an enhanced reality technique.

For example, if the maintenance technician 20 is unsure of which part to dismantle, the mobile terminal 12 can display light signals indicating the part to be dismantled.

Advantageously, enhanced reality is used as a remote support for maintenance teams by experts 38.

This also allows the experience acquired by the expert 38 to be capitalized directly by adding the data to the database.

The forms described above as examples can be used cumulatively during the same return step.

According to a variant, the update step involves a supervisor 38 processing the information sent to obtain processed information and adding the processed information to the database.

According to one embodiment, assuming that the maintenance agent does not have the time to finalize the entire sequence of operations to be performed, the agent has the possibility of saving his work and providing all the information he deems necessary for a new team to continue the sequence of operations.

5 In such a case, the method also serves as a communication tool between maintenance agents 20.

This method has been presented for the specific context of use in train maintenance 52.

10 However, the method also applies to the maintenance of other equipment such as a ship or kitchen appliances, provided the equipment is to be used in a plurality of facilities. For example, in the case of the ship, the facilities are the construction site, the maintenance center and the repair parts supplier's warehouse, while for the kitchen, the facilities are the housing containing the kitchen and the various warehouses of the suppliers of each appliance.

15 According to a variant, any combination of the above-mentioned embodiments can be envisaged.

CLAIMS

1.- A method for analyzing malfunctions of a system, the method comprising:

- an initialization phase comprising:

- 5 - receiving information relating to maintenance of the system, to form a database, and
- obtaining decision trees from at least part of information in a database received, a decision tree defining a set of maintenance operations sequences to be performed to maintain the system, and

10 - an operating phase comprising:

- providing a maintenance agent with a set of decision trees as well as a database,
- performing by the maintenance agent of a sequence of maintenance operations on the system according to at least part of the decision trees,
- 15 - sending at least one piece of information relating to the sequence of maintenance operations performed,
- updating the database using at least one piece of the information sent,
- selecting decision trees including at least one common maintenance operation with the sequence of operations performed by the maintenance agent, to obtain selected decision trees,
- 20 - extracting the information related to the selected decision trees from the database, and
- updating the set of selected decision trees by applying a learning technique applied to the information sent, the updating being carried out
- 25 by a data processing unit (26) of a computer platform (10),

the operating phase being repeated for a plurality of maintenance operations sequences.

30 2.- The method according to claim 1, wherein the operating phase additionally includes:

- requesting by the maintenance agent information relating to decision trees comprising at least one maintenance operation common to the sequence of maintenance operations to be performed, and
- 35 - returning the information requested from the maintenance agent on a mobile terminal.

3.- The method according to claim 2, wherein during a return, the information returned is information that is contained in the database and which includes at least one element chosen from a list consisting of an image, a video or a comment from at least one maintenance agent that has performed the same sequence of maintenance operations.

4.- The method according to claim 2, wherein during a return, the information returned includes a display on the mobile terminal of a sequence of maintenance operations to be performed in virtual reality.

5.- The method according to claim 2, wherein during a return, the information returned is returned using an enhanced reality technique.

6.- The method according to claim 1, wherein the learning technique is a statistical study.

7.- The method according to claim 1, wherein the updating comprises processing by a supervisor of the information sent, to obtain processed information and adding the processed information to the database.

8.- A computer program product comprising a non-transient information readable medium on which is stored a computer program including program instructions, the computer program being loadable onto a data processing unit and adapted to cause at least updating of the method according to claim 1 to be performed when the computer program is implemented on the data processing unit.

9.- A non-transient readable information medium on which a computer program product according to claim 8 is stored.

10.- A computer platform adapted to carrying out steps of the method according to claims 1, the platform comprising:

- a set of mobile terminals, the mobile terminals being used during the sending of the method, and

- a data processing unit adapted to cause implementation of at least the updating of the method when a computer program loaded on the data processing unit is implemented

on the data processing unit and comprising program instructions stored on a readable information medium of a computer program product,
the computing platform being a cloud platform.