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A feasibility study of the remote data acquisition system on vehicles

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Abstract

As vehicle systems become more complicated, it takes longer to analyze the malfunctions. Collecting the useful data can shorten the time to analyze such malfunctions in vehicle systems which consist of many sub-systems. The conventional remote data acquisition systems can only collect the fixed set of data, and the dedicated measurement instruments are required to collect the data under various conditions. We proposed a new system which can collect data under various conditions by effectively utilizing the existing resource of the car navigation head unit. The system is designed to be a useful tool for the engineers to collect data to identify the unknown cause of the vehicle malfunctions. Our proposed system connects the center and the vehicle via the wireless network. The center sends the condition of data acquisition to the vehicle. The condition is described by the script language. The navigation head unit has an interpreter program to interpret conditions, and is equipped with several APIs to allow the data acquisition system to use some of the Navigation functions including location. The engineers can describe the various conditions to get variety of data from the vehicle by the language operator, control statement, and various APIs. We chose the interpreter program which is commonly used in embedded devices. The system is capable of collecting various data from the vehicle without adding any resource to the existing navigation head unit. We conducted the actual vehicle experiments to verify the basic performance of the system. Our proposed system is able to collect all CAN data frames under the test condition using the six different types of CAN-ID.

Keywords: remote, data acquisition, analysis of the vehicle malfunctions

1 Introduction

As the vehicle systems become more complicated, the time required for the analysis of malfunctions is becoming longer. To reproduce the phenomena or to analyze the cause of the malfunctions is especially difficult and requires a very long time. The several types of remote data acquisition systems were developed to shorten the time to reproduce the phenomena. These systems connect the center and the vehicle via the wireless network, and collect data from the vehicle when the malfunction happens. The engineer became

able to get the data of the trouble vehicle directly. However, the trouble shooting engineers cannot get the useful data for the analysis with the conventional embedded remote data acquisition systems when the cause of the malfunction is unknown. The engineers need to equip the target vehicle with the measurement instrument and try to reproduce the phenomenon and get the associated data by driving around the test course.
The electric vehicles have sophisticated electrical systems. In order to analyze the anticipated malfunctions with such complicated systems effectively, the engineers need to have the tool which can collect only the useful data to shorten the time to reproduce the phenomenon and analyze the cause. Conventional remote embedded data acquisition system can only collect the fixed set of data. It is difficult to implement the full set of the functions to the embedded data collection system for cost restriction.
We proposed a new system which can collect data under various conditions by effectively utilizing the existing resource of the car navigation head unit. This system connects the center and the vehicle via the wireless network. First of all, the engineer decides the condition of data acquisition, and registers it on the center. The center sends the condition of data acquisition to the vehicle, the vehicle interprets it and collect data depending on the condition and sends the collected data to the center. The engineer is able to get the vehicle data from the center. The engineers can describe such conditions by the script language to get various data from the vehicle.

2 Related technology

The remote FFD (Freeze Frame Data) and the remote DTC (Diagnostic Trouble Code) are used to analyze the remote vehicle malfunctions quickly and efficiently. These systems can get data depending on fixed condition which was set at the development/design phase. They can provide very useful data from the vehicles if the cause of the malfunction is known. However, they do not help much if the cause or the mechanism of the malfunction not known.
Varieties of dedicated measurement instruments are available in the market. With these instruments, the engineer can set various conditions by programming to collect specific set of data. These instruments typically require a PC to use and it is not realistic to make it standard with all the vehicles.

3 Remote Data Acquisition System

It is most convenient to use the wireless network to collect data from the vehicles which move around. On our proposed system, the condition of data acquisition is sent from the center to the vehicle in the form of the script, and the data is collected based on the condition then sent back from the vehicle to the center.
The vehicle needs to have the function to collect data, communicate with the center via the wireless network, has sufficient memory, capability to communicate with the vehicle network system like CAN. So we choose the car navigation head unit as the control unit of the vehicle.
To collect various data from the vehicles, the engineer set the conditions by using the script language and sends it to the vehicles through the center and the vehicle head unit interprets it. The script language was chosen for this because it is more suitable for the embedded devises.
Our proposed system can collect not only the vehicle data available through CAN but also the data form the navigation system including GPS data. (accurate position and time) . We cannot collect all the CAN frame data because of the performance limitation of the CAN microprocessor in the navigation head unit. We customized the software of the CAN microprocessor to collect useful CAN frames for analysis as many as possible.
The vehicle head unit communicates with the center using the original function of navigation/telematics unit via the wireless network.

3.1 Overview

Figure 1 shows the overview of our proposed system. The system consists of the center, the vehicle, and the engineers. The conditions of the data acquisition are described in the script language and the collected data is sent back to the center via the wireless network. Following is the description of each component’s function.

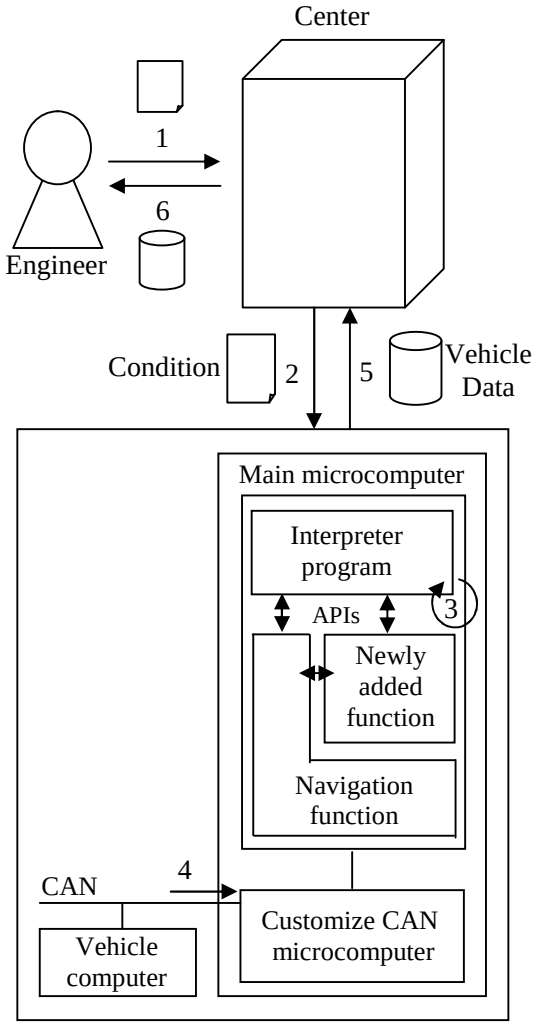

Figure 1: Overview of our remote data acquisition system

3.1.1 Center

The Center has the function of sending the condition to the vehicle, managing the received data and providing the data to the engineers. The Center also manages the vehicle information (e.g. type of vehicle, location, network status) and the owner information, so that the Engineers can get data collected from various vehicles systematically.

3.1.2 Vehicle with navigation unit

The vehicle has the function of interpreting the conditions described by the script language, collecting the data and sending the collected data to center. To interpret conditions, navigation unit has interpreter program. The vehicle data is collected from the vehicle network (e.g. CAN) depending on the set condition. The navigation system is equipped with several APIs to allow the data acquisition system to use some of the Navigation functions (e.g. GPS data, communication to the center via the wireless network) for the script language.

[Interpreter program]

Interpreter program interprets and runs the condition which is described by the script language. We chose the interpreter program which is commonly used in embedded devices. So the engineer is able to use the language's operator and control statement to describe the condition. Following is the example of the operator and the control statement.

Table1: Example of the operator and the control statement

Operator/Control statement		Outline
Operator	Arithmetic operator	[USE] Calculation of parameter, etc. [EXAMPLE] +, -, *, /, %
	Bit operator	[USE] Data extraction from CAN frame, etc. [EXAMPLE] &, |, <<, >>
	Logical operator	[USE] Combination of multi-conditional expression of conditional branching processing, etc. [EXAMPLE] &&, ||
Control statement	Repetition processing	[USE] Process to check the CAN frame's value every a certain period of time, etc. [EXAMPLE] for, while

	Conditional branching processing	[USE] Change the process depending on he result of the CAN frame's value check, etc. [EXAMPLE] if, else if

[Navigation function]
We added the remote data acquisition functionality to the existing navigation head unit. We also added several APIs. The APIs enable Interpreter program and Newly added function to use some of selected Navigation function. Following is the example of the functions which our proposed system can use.

Table2: Example of the Navigation function

Function	Outline
GPS Info	The function to output the GPS information which navigation head unit has. [Output Infomation] - Date(year, month, day, hour, minute, second) - Location(latitude, longitude, altitude) Updating cycle of these information depend on the specification of the navigation head unit.
Data Send / Receive	The function to connect the vehicle and the center which are used by the conventional telematics service.

[Newly added function]
Newly added function is the functions which are necessary for our proposed system except for the Navigation function. These functions are implemented by utilizing remainder resource. Our proposed system is equipped with several APIs across Interpreter program by using Navigation function's APIs. These APIs enable Interpreter program to use Newly added function. Following is the example of the Newly added function.

Table3: Example of the Newly added function

Function	Outline
CAN Log	This is the function to record the required CAN frame. The Target CAN frame is required by CAN-ID with the argument of API.
CAN Send	This is the function to send the required CAN frame to the CAN bus. The target CAN frame is required by CAN-ID and data with the argument of API.
Force-quit	This is the function to perform a force-quit the running condition script on Interpreter program.

3.1.3 Engineers

The Engineers defines the condition, program the condition with script language and analyze the obtained vehicle data. The condition is set by the types of the target data and the trigger of the data acquisition. The conditions are described by the script language so that the Engineers can use the function of the script language to program the condition: not only the raw data from the vehicle network but also the calculated result (e.g. statistical value) by the language operator, and the trigger of the data acquisition can use conditional branching processing, repetition processing etc. by language control statement.

3.1.4 Vehicle Data

Vehicle Data is the record of CAN frame which is collected by our proposed system depending on the condition which the Engineers set. The Engineers utilizes this data for the analysis of the unknown vehicle trouble.

3.1.5 Condition

The condition is described by the engineers with script language, and sent to the vehicle from the center via the wireless network. The analysis can describe the condition freely by utilizing some parameters, language function (operator and control statement), and the APIs (Navigation function's and Newly added function's). Following is the example of the condition's parameter.

Table4: Example of the Condition's parameter

Parameter	Outline
Number of target CAN ID	This it the number of target CAN ID which are used in the condition.
Target CAN ID	These are the target CAN-ID which are used in the condition. These frames are recorded or used in the conditional branching processing.
Execute time	The condition script runs on Interpreter program through this time.
Check time	This time is the cycle of checking CAN frame's value to catch the trigger.

3.2 Process of data acquisition

Following is the process of data acquisition with our proposed system (Figure 1). Our system can store useful data for analysis through the repetition of this process.

1. The Engineers decides the conditions and programs it with the script language.
2. The center sends the condition to the vehicle via the wireless network.
3. The vehicle interprets the condition described by the script language.
4. The vehicle collects the data depending on the condition from the vehicle network (CAN).
5. The vehicle sends the collected data back to the center.
6. The Engineers uses the data to analyze the vehicle malfunction.

It is difficult to get all the necessary data for the analysis the unknown vehicle malfunction by the single condition of data acquisition even if it is an expert engineer. Firstly, the engineer may set the rough condition to understand the phenomenon of the malfunction. Next, he may analyze with the data depending on the rough condition, and set next condition for more extensive analysis. Finally, he may set the detailed condition to get necessary data to pinpoint the factor of the unknown vehicle malfunction through the iteration of data acquisition and analysis process.

We proposed the remote data acquisition system which can collect the various set of data from the vehicle so that the engineer can get the useful data for each analysis step.

4 Experiment

We actually collected data from the test vehicles to confirm whether our proposed system is working fine. We set the following condition commonly used to collect data for malfunction analysis on conventional remote data acquisition system.

[Condition]

CAN frame of ID B, C, D, E and F are collected for 30 seconds before and after the trigger point when the 4th byte value of ID A becomes above the threshold X.

Table 1 shows the details of ID A, B, C, D, E and F frame.

Table1: Details of CAN frames

ID	Data length (byte)	Cycle (millisecond)
A	6	8
B	8	12
C	8	16
D	8	24
E	8	48
F	8	100

We compared the result data to the data from the measuring instruments. Table 2 shows result of comparison. All frames are collected 100% with our test model.

Table2: Result of experiment

ID	Rate of data acquisition (our test model / measuring instruments)
A	100% (3663 / 3663)
B	100% (2491/ 2491)
C	100% (1832/ 1832)
D	100% (1245/ 1245)
E	100% (623/ 623)
F	100% (300/ 300)

5 Conclusion

We proposed a new remote data acquisition system embedded on the existing navigation head unit to shorten the time required to identify the cause of the troubles in the vehicle systems. Our proposed system can collect the flexible data from vehicle by describing condition in the script language. The system is capable of acquiring necessary data without adding any resource to the existing navigation unit. However, if we use our system under more difficult situations, we may not be able to collect all the data with the navigation unit meeting the present specification. To collect the detailed data, more cost is needed for upgrading the navigation unit. So we have to determine the product specification by the balance of the cost and the performance.

Additional consideration for the information security and the personal information protection would be needed for the practical use. This system can also collect the owner's personal information, so we have to establish a system to protect the personal information.

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