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Design of the Data Remote Monitoring System for Intelligent Vehicle

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Abstract: During the unmanned intelligent remaking process of electric vehicle, the steering system, the accelerate system and the brake system of the original car should be redesigned and updated. Cooperating with the computer platform, radar, navigation and the image processing unit, the modified cars could realize unmanned on the semi-structured road. The electric vehicle modifying contains the redesign and remaking operation of machinery and electron. The control process involves information collection, information processing, network transmission, intelligent control and machinery link. The errors of any link mentioned above could lead the intelligent vehicle driving bugs. Because of the particularity of the intelligent car test environment, it is very complex to complete trouble shooting. The data remote monitoring system for intelligent vehicle uses the method of control instructions monitoring and data flow monitoring to realize the remote trouble shooting and analysis by wireless. This data remote monitoring system has been made full use of unmanned vehicle. The effect is satisfied.

Key words: Intelligent driving, remote monitoring, trouble hooting

INTRODUCTION

The intelligent vehicle is a kind of car which could plan drive directions, percept around environment, make reasonable decisions based on real-time traffic situation and assist or take the place of drivers to complete vehicle driving by itself (Wang, *et al*., 2012). The intelligent vehicle could reduce the labour intensity of driver and make the driving process more comfortable, more efficient and safer. During the remaking process of intelligent vehicle, the steering system, the accelerate system and the brake system of the original car should be redesigned and updated. Meanwhile, a lot of radar and image sensors also should be installed on the redesigned car. After remaking, the car could realize autonomous run based on several IPCs (Industrial Personal Computer) and many kinds of intelligent sensor. The intelligent driving remaking is a long process. In order to complete the intelligent driving process, the information perception system, the decision-making system, the vehicle executing system should match perfectly. During the redesign and test process, the status information of the car and the commands which are sent to the executing institutions from several IPCs should be recorded and analyzed. But the space of the redesigned car is very narrow. Real-time testing on car is also dangerous. Thus, the testers couldn't stay on the car to develop test. A design of the data remote monitoring system for intelligent vehicle is brought forward by this paper. The data remote monitoring system could send the real-time status of the car, the control commands and the image information to the test set monitoring center and the headquarters monitoring center by wireless mode. In this way, the speed and the accuracy of trouble shooting would be improved effectively.

INTELLIGENT VEHICLE REDESIGN THOUGHT

System structure design: The original car of the redesigned vehicle is a pure electric two box car. In order to realize the vehicle unmanned driving, it has three parts needing remaking. As shown in Fig. 1, setting up the environment perception system is the first step. By adding GPS and inertial navigation system (are used to plan driving route), radar (is used to identify the barriers) and HD camera (is used to identify the traffic marks), the environment perception system of intelligent vehicle unmanned driving could be built. Setting up the necessary computing environment and network environment is the second step. The parameter from environment perception system could be converted into control command using intelligent decision-making algorithm. The vehicle redesign is the last step. The kernel work of this step is remaking the steering system, the shift

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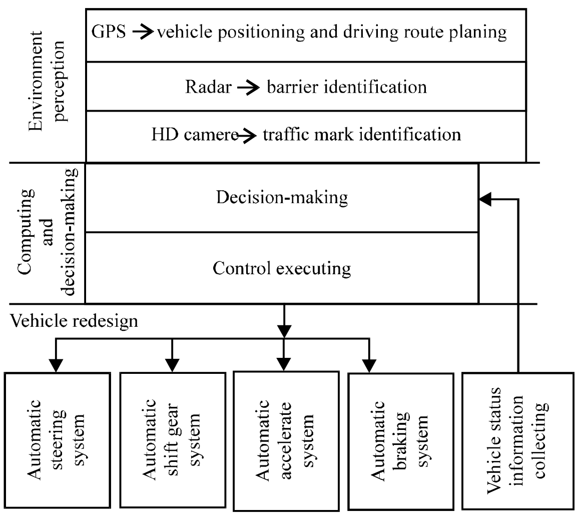

Fig. 1: Intelligent vehicle percept and control flow chart

gear system, the accelerate system and the brake system. Finally, the intelligent vehicle could run normally by the control command from computer which could control all part of the redesigned car to operate autonomously.

System control bus design: The accelerating, braking, steering and shifting gears operation of intelligent vehicle are all controlled by computer. Whether an intelligent vehicle could work normally, the follow systems are the determinant.

Environment perception system: If the camera discovers the barriers in front and tests their basic parameters, the system will send alarm signal.

Decision-making system: After receiving the alarm signal, the system could make the decision of vehicle controlling (such as braking) combining with the basic information of vehicle (speech, direction, etc.).

Control system: After receiving the control decision (such as braking), the system convert the decision into control command and send the control command to the executing part of the car.

Automatic executing cells of vehicle: The cells could receive the system control command and execute the command.

The normal working status of the four parts mentioned above is the correct driving guarantee of the intelligent vehicle. But the errors are essential during the intelligent vehicle control process. Once an error appears, the testers need to locate the position of the trouble and find the reason of the trouble as quickly as possible.

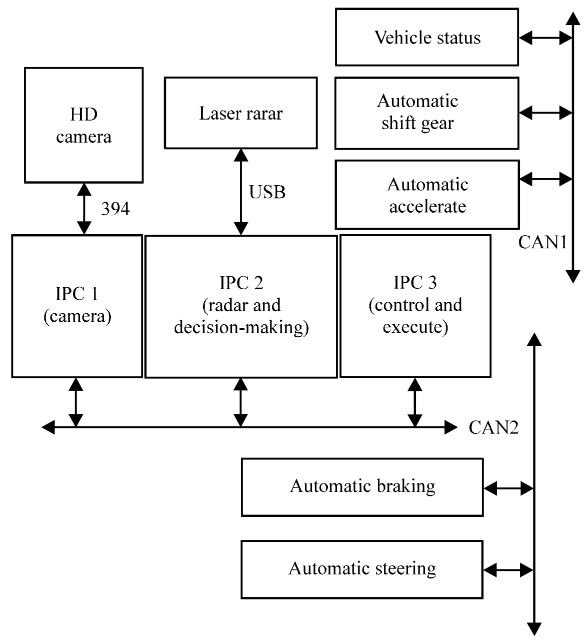

Fig. 2: Intelligent vehicle control structure

However, in ordinary intelligent vehicle, the environment perception system, the decision-making system, the control system and the automatic executing cells are consisted of several IPCs (Industrial Personal Computer) using multiple control methods and control interfaces. Once an error appears, locating and searching it are very complex. As shown in Fig. 2, in an intelligent vehicle system, the IPC 1 is a camera connecting with IEEE1394 interface. Using IPC 1, the image information processed will be sent to the IPC 2 by network (LAN). The IPC 2 formulates the control command based on the information from IPC1 and vehicle status information from IPC 3 and sends the control command to IPC 3 by network (LAN). After receiving the control command, the IPC 3 will translate the control command into corresponding instructions and send these instructions to every automatic executing cell by CAN bus. And then, after receiving instructions by CAN bus, the executing cells will begin working.

DATA REMOTE MONITORING SYSTEM DESIGN

The structure of data remote monitoring system is shown in Fig. 3. The monitoring system includes the vehicle data monitoring system, the test set monitoring center and the headquarters monitoring center. The vehicle data monitoring system is fixed on the tested car. This vehicle data monitoring system chooses a compact Industrial Person Computer (IPC) without fan as the computing kernel. It can send testing data to the test set

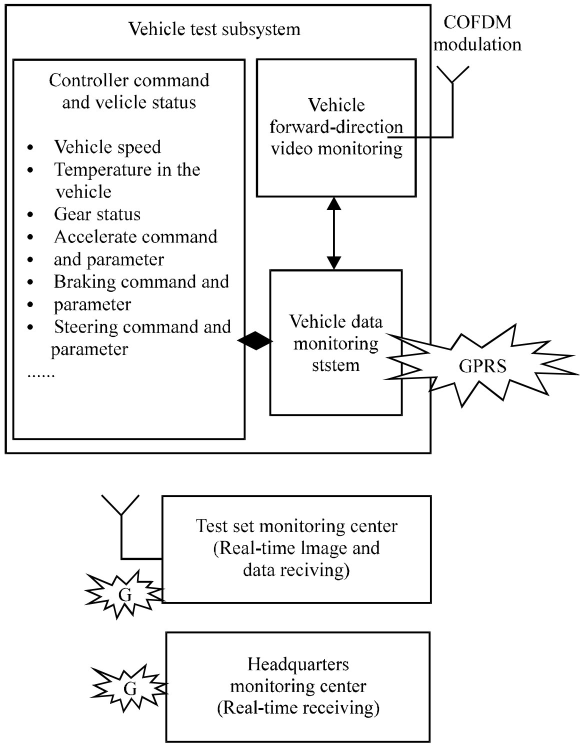

Fig. 3: Testing data remote monitoring structure of intelligent vehicle driving

monitoring center and the headquarters monitoring center by two wireless channels. One is GPRS public network data transmission. The other is point-to-point data transmission based on COFDM modulation (Ling *et al*., 2012).

- The data which is sent by GPRS contains the basic information of vehicle (the actual time, the real-time speed, the left oil mass/electric quantity and the vehicle temperature) and the intelligent driving control information (the automatic steering angle, the automatic shift gear information, the automatic accelerate percent and the automatic major braking command, etc.). The test set monitoring center and the headquarters monitoring center are the receivers of the data sent by GPRS
- The data which is sent by point-to-point data transmission based on COFDM modulation (portable narrow-band Standard Definition wireless image real-time transmitting system) contains the video signal (the vehicle forward direction video signal from the color camera fixed on the tested car) and the voice signal (the signal in car). Because the transmission distance is limited of this system, the error signal could be only transmitted to the test set monitoring center

Vehicle monitoring system design: The monitoring System chooses a compact Industrial Person Computer (IPC) without fan as the kernel microprocessor. There is a two-path independent CAN card fixed on this IPC. One path of the CAN card is connected with the CAN bus through the vehicle OBD diagnostic interface. This path is used to receive the basic information, such as the speed of the car. The other path of the CAN card is used to connect the steering controller and braking controller of the redesigned vehicle. The two controllers all have CAN interface. The two-path CAN card needs to be connected with different CAN bus, in order to realize the physical isolation. The IPC could obtain the basic status and the control command of the redesigned car by two-path CAN card.

Test set monitoring center design: The distance between the tested vehicle and the test set monitoring center should be less than 200 m (Liu *et al*., 2012). The test set monitoring center is the main part of the field test. It chooses the IPC as the kernel platform which includes a GPRS data receiving terminal based on 3G network card and a video signal receiving terminal based on portable wireless image transmitting-receiving equipment. The main duty of the test set monitoring center is shown as follow.

- The test set monitoring center could receive the real-time parameters of the vehicle and the control command from GPRS using software, display and save the information. During the field data analysis and the trouble analysis/adjusting later, the vehicle real-time parameter and control command are useful. The corresponding software interface is shown in Fig. 5
- The test set monitoring center could receive the real-time video signal of tested car by portable wireless image transmitting-receiving equipment, display and save the information on IPC using USB acquisition card

Headquarters monitoring center design: The location of the headquarters monitoring center could be everywhere if there's GPRS signal. The headquarters monitoring is the important method of senior monitoring. It could provide the real-time test data to the testers who aren't in the testing field. The headquarters monitoring center chooses the IPC as the main platform, including GPRS data receiving terminal based on 3G network card. The main duty of the center is receiving the real-time parameters of the vehicle and the control command from GPRS using software. The parameter and control command are also displayed and saved by this monitoring center. During the field data analysis and the trouble analysis/adjusting later, the information is useful.

SYSTEM APPLICATION IN TROUBLE SHEETING OF UNMANNED VEHICLE CONTROL

Trouble tree shooting method: There may be a lot of errors appearing during the driving process of the intelligent vehicle redesigned (Chen and Zhang, 2012). As shown in Fig. 1, the errors may be from one or multi parts of environment perception, computing and decision-making and vehicle redesigning. It is not easy to find the correct location of errors quickly by the traditional method. The usual method of troubles shooting is self-check of every function cell. In this case, it is very difficult to find the accidental errors. After using the data remote monitoring system of unmanned vehicle, the uniform command/data record and trouble tree method are used to locate the error position quickly. The troubles shooting could be finished in test set monitoring center outside the vehicle. The monitoring center could receive the real-time video image of the car (with time stamp) by wireless mode. The monitoring center also could receive the uniform system control instruction and status parameter of the car by GPRS mode. After finding the driving errors of intelligent vehicle, the testers could analyze the troubles, locate the position of the troubles and search the troubles in the test center outside the car in the actual time. An analysis example of “intelligent car running the red light error” using the trouble tree analysis method is shown in Fig. 4. As shown in Fig. 4, there are two necessary conditions for “intelligent car running the red light error”. One is “red light ahead” (the basic event). The other is “car driving out of stop line” (the trouble event). The trouble event of “car driving out of the line” has three different cases. The first case is “automatic braking system error”. The second case is “decision-making and control error”. The third case is “image identification error”. After subdividing again, “automatic braking system error” includes “electronic error” and “mechanical error". The “decision-making and control error” includes “deciding strategy error” and “control command error”. The “image identification error” includes “red light identification error” and “stop line identification error”.

Troubles shooting example: The paper chooses an example to explain the troubles shooting method using the monitoring system here. Supposing the intelligent vehicle is in the test driving process. The camera has discovered the red light ahead and the stop line. The correct operation of the car at this time should be braking automatically and make the car stop completely before the stop line. But during the test process, there are two errors appeared. The redesigned car doesn’t brake and run out of the stop line all these two times. Through the improved shooting method, the two errors are leaded by different reasons (Cheng and Deng , 2011).

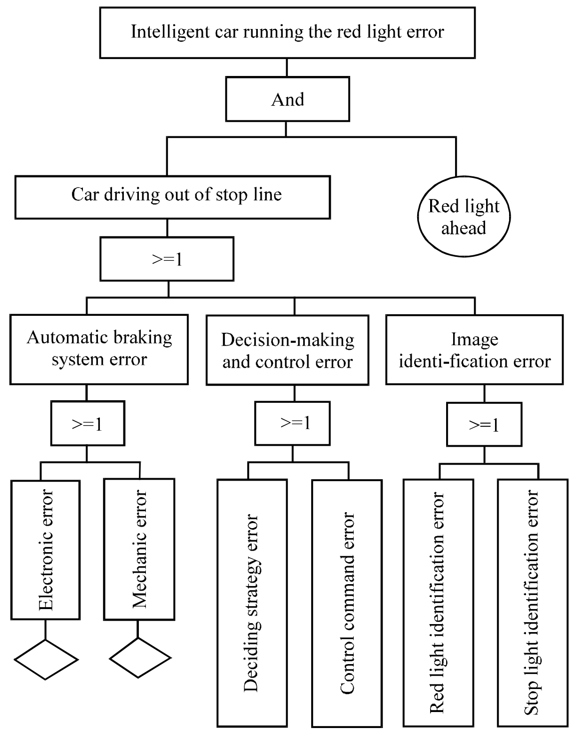

Fig. 4: Trouble tree analysis method-intelligent car running red light error

Test data analysis and troubles shooting(1)

Test method: The test set monitoring center which is 20 m from the running intelligent car, receives the image data and control command by wireless transmission mode. The test set has installed the red light, drawn the lane line and stop line on the running road. In the normal case, if the speed of the car is 15 km h^{-1}, the intelligent car will brake automatically after discovering the red light, when the distance between the stop line and the car is about 5 m.

Test result: The redesigned car keeps running which doesn’t brake normally as assumption.

Test result analysis: The test set replays the image by wireless transmission, finding the system time is 11:23:10.4 pm on June 30th 2013, when the distance between the stop line and the car is about 5 m. Based on the shooting

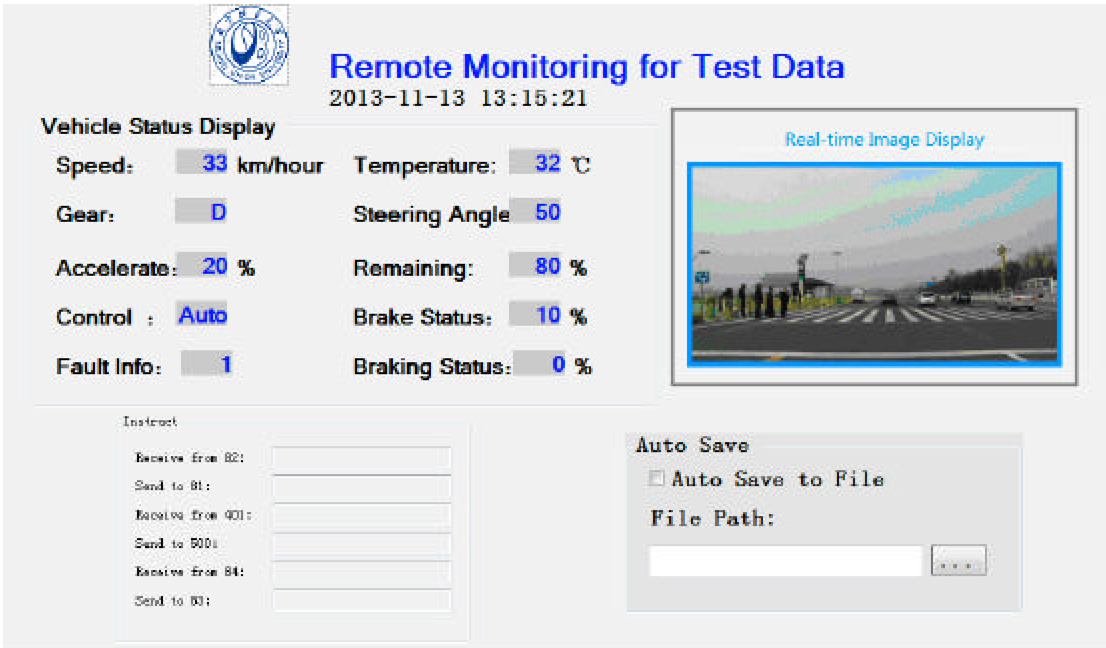

Fig. 5: Monitoring software effect chart

Table 1: Command of vehicle status from test set (1)

Uniform time stamp	Vehicle status parameter	Environment perception system result	Decision-making system result	Control system command	Automatic executing cells feedback
2013.6.30 11-23-10.4	E:0 S:15 P:D	R:SL-5;TL-R	D:BH	C: EMO	F: EMO

Table 2: Command of vehicle status from test set (2)

Uniform Time stamp	Vehicle status parameter	Environment perception system result	Decision-making system result	Control system command	Automatic executing cells feedback
2013.5.22 10-11-50.2	E:0 S:15 P:D	R:SL-5;TL-R	D:MS	C: NULL	F: Null

flow shown in Fig. 4, the vehicle status and control command with the time stamp (11:23:10.4 pm on June 30th 2013) is shown in Table 1.

As shown in Table 1, the tester could analyze the control command of all the systems at the same time (uniform time of time stamp). Based on analysis, the vehicle status and control command at 11:23:10.4 pm on June 30th 2013 is as follows.

- **Vehicle status:**

E:0 = The vehicle error step is 0. It means no vehicle error itself
S:15 = The current speed of the car is 15 km h^{-1}
P:D = The current gear of the car is D

The data mentioned above shows that the current status of the car is normal.

- **Environment perception result:**

R:SL-5;TL-R = It means the stop line is in front. The distance is about 5m. The red light is turned on

It's the normal state.

- **Decision-making system result:**

D:BH = It means taking braking action immediately

It's normal state.

- **Control system command:**

C:EMO = It means that the urgent braking motor brakes immediately.

It's normal state.

- **Automatic executing cells feedback:**

F:EMO = It means that the urgent braking motor has completed the braking operation.

It's normal state.

According to the trouble tree analysis method, the table data mentioned above means that the vehicle status and control command are all normal state. Why the intelligent vehicle couldn't brake itself automatically? The problem should be in the mechanical part of the automatic braking system. Through the deep searching, the reason of braking unsuccessfully is the wire damage of the braking motor.

Test data analysis and troubles shooting (2)

Test method: The test set monitoring center which is 200 m from the running intelligent car, receives the image data and control command by wireless transmission mode. The test set has installed the red light, drawn the lane line and stop line on the running road. In the normal case, if the speed of the car is 15 km h^{-1}, the intelligent car will brake automatically after discovering the red light, when the distance between the stop line and the car is about 5 m.

Test result: The redesigned car keeps running which doesn't brake normally as assumption.

Test result analysis: The test set replays the image by wireless transmission, finding the system time is 10:11:50.2 pm on May 22nd 2013, when the distance between the barrier and the car is about 5 m. Based on the shooting flow shown in Fig. 4, the vehicle status and control command with the time stamp (10:11:50.2 pm on May 22nd 2013) is shown in Table 2.

As shown in Table 2, the tester could analyze the control command of all the systems at the same time (uniform time of time stamp). Based on analysis, the vehicle status and control command at 10:11:50.2 pm on May 22nd 2013 is as follows.

- **Vehicle status:**

E:0 = The vehicle error step is 0. It means no vehicle error itself
S:15 = The current speed of the car is 15 km h^{-1}
P:D = The current gear of the car is D

The data mentioned above shows that the current status of the car is normal.

- **Environment perception result:**

R:SL-5;TL-R = It means the stop line is in front. The distance is about 5 m. The red light is turned on

It's the normal state

- **Decision-making system result:**

D:MS = It means keeping the original speed

It's the abnormal state.

- **Control system command:**

C:NULL = It means that no corresponding instruction is sent

It's normal state.

- **Automatic executing cells feedback:**

F: NULL = It means that no corresponding instruction is sent

It's normal state.

According to the trouble tree analysis method, the table data mentioned above means that the vehicle status is correct. But in the feedback data of control command, the decision-making result is D:MS (keeping the original speed). The correct result should be D:BH (taking braking action immediately). Thus the intelligent vehicle has no automatic braking error. The problem is from the decision-making system. The trouble is searched.

CONCLUSION

Development and application of the data remote monitoring system for unmanned vehicle play an important role during the intelligent vehicle test. On the premise of ensuring testers' safety, the monitoring system could realize long-distance analyzing and locating the errors quickly. The further study duty of this equipment is improving the responding speed and locating errors, etc.

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