Design and implementation of vehicle multimedia system automated test

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Abstract. With the development of electronic vehicle, there are plenty of new functions developing on vehicle multimedia system. New technologies, such as Bluetooth, navigation, multimedia, wireless network, applying to vehicle multimedia system, are leading to more human effort. This paper describes a new method of automated test, which is adopt to test product after design. With technique of image processing and audio processing, automated test platform shows good performances at verification of vehicle multimedia system.

1. Introduction

With the development of automotive electronics, vehicle multimedia terminals gradually became the standard configuration of vehicles. Navigation, Bluetooth, multimedia and other functions brought convenience and intelligent experience to users [1-2].

However, with more and more complex functions, the types of automotive electronic faults were increasingly diversified, which put forward higher requirements for detection technology and acceptance capability of automotive electronic products. Since the 1960s, Japan and the United States had introduced recall system and reliable technology into the automotive industry. At present, the ratio of time consumed by vehicle maintenance to time consumed by fault location is about 3:7 in the process of vehicle maintenance. Therefore, to strengthen inspection quality of automotive electronic products became important to the development of automotive industry.

According to the statistics of the Ministry of Industry and Information Technology of China, it was showed a steady growth overall, that China's total automobile output in 2017 was 29.015 million vehicles with a sales volume of 28.879 million vehicles.

According to the research report of the State Administration of Safety Supervision and the Ministry of Transportation, the annual death toll caused by road traffic accidents was about 63000 in 2017 in China, which ranked second in the world. With the increase of automobile production year by year, reducing traffic accident injuries became the primary problem of vehicle safety [3-4].

Aiming at the requirements of reliability, safety and stability of the product, this paper was about the design of an automatic testing platform for vehicle multimedia terminal. Based on this platform, an automatic testing method and software for the product was developed. At present, the test platform had been applied to fault detection and final acceptance in the development process.

2. System overall design

As showed in Figure 1, the system consisted of four parts, including an industrial computer, signal adapter, the equipment under test (i.e. vehicle multimedia system terminal), and peripheral equipment.
Figure 1. System diagram of multimedia automatic test platform

PC was responsible for software implementation. After PC issued instructions, the vehicle multimedia terminal equipment (hereinafter referred to as the terminal) sent control instructions through a signal adapter, and then multimedia automatic test platform obtained images, sounds, networks and other signals returned by the terminal. The desired results were compared to achieve automatic testing.

Signal adapter, encapsulated in a large box, was integration of multiple devices including a programmable power supply, external camera, CAN message transceiver tools, IO control board, image acquisition card, and audio acquisition card. PC and the signal adapter were connected by Ethernet, serial port, USB and so on. The signal adapter was responsible for parsing the instructions issued by IPC, and then converted them into triggering conditions for the terminal and uploaded sound and image signals from the terminal. For example, touch signal of touch screen simulated by I2C signal, network command of vehicle to terminal simulated by CAN network signal, and image and video information output from the terminal were all uploaded to industrial computer.

Peripherals were devices that the terminal needed to interact with in the testing session. For example, vehicle mounted camera information was needed to achieve reversing image showed on control screen and a U-disk or mobile phone connection was needed to display entertainment information such as music and video from control system.

The whole testing process included two stages. The one was that PC output instructions through the terminal produce actions by the signal adapter, and the other one was that to determine whether the output of the terminal was correct through comparing the template or calibration value to actions generated from the terminal.

3. Core module design method

After the test system was built, it was important to design various methods to verify the function of the vehicle terminal. The testing and verification methods of several core modules were introduced below.

3.1. Automatic detection of start-up time

Start-up time of vehicle-mounted multimedia terminal was a necessary measurement in the acceptance items. Start-up time out will cause obstacles in the use of customers on the one hand, and showed hidden problems from the software or hardware of the system on the other hand.

The start-up process of the system was divided into three stages. The first stage was when the system was not started, and the form of expression was black screen state. The second stage was system startup, and the form of expression was the appearance of the start icon. The third stage was system boot up, and the form of expression was to enter the main screen. As shown in Figure 2 to figure 4, process diagrams for different stages of initiation were presented.
The test of start time was to calculate the time until the terminal displaying the image. Because the system had not been fully started when doing this test, the detection method here was to use an external camera to capture the current image, and then identifying the current terminal image through the image processing method.

The template comparison method [5-6] was used initially, and the above pictures were directly used as templates to compare with the collected pictures. The results showed that the method was feasible at the same time and in the same environment, but it cannot recognize well when the illumination condition changed or the camera was slightly adjusted [7].

The main reason for the failure of the appeal method was that the RGB value of the pixel changed greatly after the illumination changed. In addition, the shadows produced by the light on the equipment were different after the daytime illumination changed, and the ripples produced by the reflection of the white background plate were also different.

Therefore, it is needed to design an algorithm to avoid the influence of illumination and color in the process of recognition. The method was as following: before the terminal started, the picture under the condition of black screen (Figure 2) was captured, and the color information was removed by grayscale [8]. After that, the edge of the image was detected by Canny operator [9]. Meanwhile, the outer frame of the screen was judged, and the size of the screen was recorded.

In practical application, the approximate position of the screen and the approximate position of the camera were basically fixed on the bench, so the position of the frame in the image was basically in a certain range. The purpose of the frame detection was to locate accurately and find the exact coordinates of the frame in the current image.

After completed the gray and edge detection, the image was taking binary processing, and three states binary results were shown in Figure 5. By calculating the number of points in the box, the ratio of the number of edge points to the frame size can be obtained. According to the size of the value, the system determined which stage it was to start, and then determined whether it is normal to start within the specified time.
3.2. Automatic detection of multimedia functions

Multimedia functions included video, audio, radio, picture and so on. The main method to detect these functions was to simulate the application of the operating vehicle, and then made a judgment on the functional logic.

As image checking was valid after the terminal started, the way to get screen pictures was not needed by peripheral cameras, but was obtained through the terminal operating system. As a result, the pictures obtained were from terminal UI outputs, which were not affected by illumination and angle. Multimedia image closed-loop judgment was basically based on this, that was through comparing current screen picture from screenshots with template picture comparison. As long as the similarity is
exceeded, the page, such as home page, clock page, navigation page and so on, was generally considered to be the expected page.

Figure 7 was the main page template, and Figure 8 was the current view captured by the test equipment. Although there were differences among the two, the current time, the geographical location, and the current sound source, the overall picture was the same.

For control function, local judgment method was used to provide contrast precision and threshold height. For example, “key on” and “key pause” images are compared for music function from corresponding local coordinates. As shown in Figure 9.

For the judgment of video playback, the method of sampling was generally used to fix the video playback to a certain point in time, and then to determine whether the picture was consistent with the expected. At the same time, the video was played while the screen was recorded, and the video files were uploaded to PC. Each frame was decomposed to determine its continuity, to identify whether it is fluent.

Another need to judge was the audio processing, such as multimedia functions, radio, video, music and so on. On the one hand, the high-definition microphone was used to record the audio output, on the other hand, the PWM output of the terminal audio port was collected. The two processes are processed to determine whether the output is normal[10].

3.3. Automatic detection of network functions

Network function was an important function of the vehicle terminal. On the one hand, the terminal participates in the vehicle network communication, that was to obtaining network signals from the vehicle and reacting and sending the results of its own processing to the vehicle network[11]. In addition, terminals also communicate with TBOX to get access to the Internet.

Automated testing based on vehicle network was relatively simple, that was, to simulate sending CAN network instructions, to make the terminal reacted accordingly, and then to use the method described in 2.2 above to determine whether it was normal. Automated testing based on multimedia of Internet functions was basically the same with that based on vehicle network, the main purpose was to see whether multimedia functions can update information through the Internet, such as downloading songs, looking up radio and so on.

The automatic test processing of speech recognition had more contents. PC recorded the voice command in advance, saved it in the form of sound file on the local disk, and broadcast it in turn. Then intercept the terminal's current screen image and judge whether there was a response through local
comparison. At the same time, for the commands with functional requirements, it was necessary to judge the actual output from the terminal on the network according to the voice instructions.

If the voice command "Open Skylight" was issued, the terminal will display the caption shown in Figure 10 below after recognizing it. At the same time, the CAN network will issue the command to open the skylight. Therefore, according to this strategy, the corresponding test method can be established to judge whether the voice command was successful or not by local image contrast and network signal.

![Voice recognition display content](image)

**Figure 10.** Voice recognition display content

In actual verification, voice recognition rate cannot reach 100%. The result of voice recognition was affected by the accent and intonation of the pronouncing. The validation strategy here needed to be adjusted according to the combination of multiple instructions to judge.

4. Test and effect analysis

The development of the test system was made based on the on-board multimedia terminal of a Dongfeng Fengshen vehicle, and was put into the test and verification of the terminal. Figure 11 was a partial function point test case based on an automated test system. For each button, a corresponding function point can be tested.

![page of Automatic test software](image)

**Figure 11.** page of Automatic test software(part)

For points that fail the test, a file is generated in the system that recorded the modules and test points that fail the test. As showed in figure 12, there were three parts of information in the record file. The first one was the module class that represented the function, the second was the failure of the first test case, and the third was following by the time information.

```
scn: 7 fail2018-03-22 09:47:132038
usb: 1 fail2018-03-22 13:58:37.857239
scn: 8 fail2018-03-22 18:21:35.828370
```

**Figure 12.** records of failure date

After adopting the automatic test system, the development quality of the project was greatly improved, and the testing time period was shortened. The advantages were mainly shown in the following aspects:

1) Functional design and test development can proceed synchronously after the project was started, and there is no need to wait for the product to be produced to start the test work.

2) The automatic test was completed by the equipment, which saved much man power and made full use of the off-duty and weekend time.

3) Low probability contingency problems of software can be tested and verified repeatedly by automated test equipment.

5. Test and effect analysis

In this paper, a set of design method of vehicle-mounted multimedia automatic test system was presented. At the same time, the development and production of the test system were realized and put into use in the project.
At present, the equipment had been put into use in several model types of Dongfeng. It will save 1-2 man power testing engineers for each project after preliminary calculation. Next steps were following, combining with the use of the project, communicating with the factory, upgrading the quality of the test system, making it meet the factory requirements, gradually replacing the factory manual verification link, and making a batch of products acceptance system.

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