Design and Implementation of Real-Time Display Curve of Embedded Cabin Control System Based on Qt/E

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Abstract. Based on the development of embedded system, real-time monitoring of the cabin environment, including monitoring of the energy data of carbon monoxide (CO), hydrogen sulfide (H2S), oxygen (O2), combustible gas (GAS) and node modules. The precise monitoring of the environmental variables in the cabin has the function of multi point monitoring and wireless transmission as well as the early warning value. Based on QT4.8.6, the interface of cabin control system was developed, and the real-time curves of carbon monoxide (CO), hydrogen sulfide (H2S), oxygen (O2), combustible gas (GAS) and electric quantity data were drawn out. At the same time, the function of data storage and callback can be realized. In QT4.8.6, the method of combining external class QCustomplot and List container is used to realize the rendering of real-time data curve more efficiently. Compared to the traditional double buffering drawing, the efficiency of development has been greatly improved.

1. Introduction
With the vigorous development of Internet of things, embedded technology is widely applied to all sectors of social production, such as industry, agriculture, food industry, shipbuilding industry and so on. During the daily driving of ships, a series of harmful substances, such as carbon monoxide, hydrogen sulfide and methane, will be generated inside the cabin. These harmful gases are a serious safety hazard for people to produce and live in the cabin. In the cabin, once the combustible gas reaches a certain concentration, fire will be induced by exposure to open fire, which greatly threatens the safety and safety of people.

Aiming at these hidden dangers in the cabin, combined with embedded technology, sensing technology and wireless transmission technology, a set of monitoring system for cabin environmental parameters is designed. The function of remote transmission is realized by internal network penetration and WIFI technology. The cost of wiring is saved, the stability of transmission is improved, and the anti-interference ability is improved. And based on the Qt4.8.6 design of the cabin environment monitoring system interface, combined with the method of Qt external QCustomplot, the real-time data curve to real-time monitoring of carbon

Monoxide (CO) hydrogen sulfide (H2S), oxygen (O2), combustible gas (GAS) consumption data and node module. It has the advantages of higher development efficiency, more beautiful system interface, more intuitive data display and so on.
2. Qt/E structure Introduction to
Qt/E is specially developed for embedded system, and is used for embedded graphic interface. The structure system is mainly divided into graphic engine and event driving layer, upper graphic layer and upper layer control layer. The graphics engine and event driver layer are implemented by invoking and accessing the underlying device Frame buffer and device driver of Linux. There is a simplified and efficient Server terminal for the embedded platform, which is connected by Unix and Socket communication mode. The upper layer is abstracted as a graph of paint brush, painting line, rectangle and other operation. The upper control layer implements the user's main control requirements through the public abstract class QWdiget.

At the same time, Qt/E provides cross platform support in the case of the same API, in which a dedicated server client architecture is the biggest difference between the desktop system.Because of the Qt/E version of the Server is relatively simple, and in order to adapt to the huge differences in the embedded system hardware platform to do a lot of compatible work, makes for the transplantation of Qt/E is relatively easy, as long as the realization of the mouse, the keyboard driver, can realize the transplantation of Qt/E screen corresponding.

QCustompPlot is a third party tool that needs to be downloaded from the Qt official network.In Qt, the curve can be drawn by QCustompPlot, and the drawing process is very simple.QCustomPlot is a class of drawing board, which inherits from Widget, and the Widget class in the interface is promoted to QCustomPlot to be able to draw.Every curve in QCustomPlot is a Graph object. Whenever we display data, we operate on Graph or invoke methods provided by Graph objects.

3. System design

3.1. Design of system framework
The system uses a distributed structure, which is divided into three layers: acquisition layer, transmission layer and monitoring layer. The acquisition layer is composed of 3 node modules.Each node has the same function and is responsible for measuring data at different locations. The node module consists of carbon monoxide (CO) module, hydrogen sulfide (H2S) module, oxygen (O2) module, combustible gas (GAS) module and electricity module. Each node is collected by the sensor module, encoded by the microcontroller to send data packets to the sink node, and the transport layer is mainly composed of sink nodes and routing devices. The sink node in STA+AP mode to receive data, and error check on the data, and then connected with the server through the TCP/IP mode, the data transmitted to the server, at the same time to check and correct data preservation. The monitoring layer is composed of the client and the database server connected by the LAN. The server receives the packet of the aggregation node, and after it is parsed, it is saved into the database. The client software is designed based on Qt, which has data display, data query, early warning, and display function of real-time data curve. The system framework diagram is shown in Figure 1:

![Figure. 1 System framework diagram](image-url)
3.2. Design of system hardware

The environment acquisition module is the most basic equipment of the system. It is made up of all kinds of sensors and signal conditioning circuits. It is used to collect information about carbon monoxide (CO), hydrogen sulfide (H2S), oxygen (O2), combustible gas (GAS) and electric quantity and so on. Carbon monoxide sensor, hydrogen sulfide sensor, oxygen sensor and combustible gas sensor are calculated by A/D conversion circuit, and the corresponding data information is calculated by single chip microcomputer. The carbon monoxide sensor is based on the theory of constant potential electrolysis of GTH1000. When carbon monoxide diffuses to the gas sensor, the output current of the carbon monoxide sensor is directly proportional to the concentration of carbon monoxide. The hydrogen sulfide sensor, based on the principle of CLH100's gas sensor electrochemistry, measured the concentration of hydrogen sulfide by measuring the current in the electrochemical process. The oxygen sensor using the Nernst principle, the potential difference by measuring oxygen concentration generated by measuring oxygen concentration. The combustible gas detection circuit uses the enterprise level sensor MQ-5, which has a good sensitivity to the alkane gas.

The data processing and sending module is a transmission device in the middle of the system, which is composed of data processing circuit and data transmission circuit. The data processing circuit is responsible for the data collected by the sensor, and is encoded into the corresponding data packet, and the data is uploaded by the WiFi module. It adopts the STC90C58AD series microcontroller produced by macro crystal technology. It has 16 bits timer / counter, 8 channels 10 bit high speed AD converter (up to 250 thousand times / sec), 35 general I/O ports and a strong duplex serial communication port. The data transmission part uses USR-WIFI232-B module with IEEE802.11b/g/n wireless standard embedded module based on UART interface, built-in TCP/IP/UDP network protocol stack and the WiFi driver, the wireless network can be configured as a STA/AP/STA+AP type, and support a variety of wireless network encryption method can fully guarantee the security of data transmission.

The assembly module is a system that connects with the system. The core processor nodes selection of the stmicroelectronics production STM32F407ZGT6 MCU as the processor, the 32 bit Cortex-M4 core, clocked at 168MHZ, with SDIO interface, there are 112 common I/O, 6 serial bus, can fast data processing, good data processing and transmission, which greatly improves the system efficiency. The peripherals of the module include the power supply module, the relay module, the LCD module and the SD card storage module and the serial WIFI module, as shown in Figure 2. The voltage can be obtained by transferring the voltage to the 5V DC adapter through the 220V AC, and the 3.3V voltage can be obtained after the conversion of the 5V voltage and the AMS1117 3.3V power chip.

4. Design of system software

4.1. Software design of system client

The client interface management software is designed under the windows system, using QT as the development environment. Its function is mainly to monitor the real-time data information of each
node. By parsing the information received by the Json to the internal network, the SQLITE database is entered and then returned to each node. The operator can set the early warning value flexibly. Once the data exceeds the early-warning value, the warning will be displayed immediately and the corresponding data turn red. By looking at the real-time curve, we can observe the trend of data information more intuitively, and we can also view historical data, and facilitate the analysis and management of staff. The interface is shown in Figure 3.

![Figure 3 main interface of cabin control system](image)

**Figure. 3** main interface of cabin control system

4.2. **Real-time dynamic curve display software design**

4.2.1. **The overall design of the curve display interface**

According to the requirements of the project design, the display interface function is divided into the curve display part and the key part. Keys include data collection, callback, save, exit and other functions. Curve display is the way to draw the data obtained by curve drawing on the mobile device. Before the program is transplanted to the handheld device, the program compilation and debugging are completed on QT. The following figure is the curve display interface:
4.2.2. Real time dynamic curve drawing

This design uses the way of adding qcustomPlot external classes to the project. The first step is to configure the environment. First, we need to download the header file qcustomplot.h and source file qcustomplot.cpp from the official website, add it to the project, and add it to the .pro file:

```
QT += widgets printsupport
```

Finally, enter the graphical design interface, add a widget area to the main window, click the right button on the added widget area, and choose the "upgrade" button.

In the design, the data extracted by regular expression is stored in the “mList” list of the string list QStringList, and “mList” stores the data of each curve point, for example:

```
QStringList mList = rx.captureTexts();
```

The drawing statement used is:

```
Ui->qcustomPlot->graph(x)->addData (key, valuex);
```

The x value is 0, 1, 2, 3 and 4 respectively represent the five curves, key is the current time point, valuex is the data of point, and addData is the current point to add data to the corresponding data curve, and then by calling the qcustomPlot class to draw a curve, and effectively improve the development efficiency.

The code that defines the brush is:

```
Qcustomplot->addGraph();
Qcustomplot->graph(x)->setPen(QPen(Qt::blue))
Qcustomplot->graph(x)->setName("CO");
```

The first line adds the curve, the second line sets the brush's color to blue, and the third line sets the data name corresponding to the curve, such as CO.

Because of the rendering interface, widget is promoted to qcustomPlot, so the real-time dynamic curve display interface is shown as shown in the diagram:

![Real time curve interfaces](image-url)
Because the time interval is short, the data will not change too much in the short time, so the corresponding data curve is not fluctuant. The time interval can be manually modified in the background, and the code is:

QCustomPlot->xAxis->setTickStep(8);

At this time the interval is 8 seconds, and if you need to add 8 to other numbers, the curve will fluctuate over time.

4.2.3. The realization of data preservation and callback function

QT provides QTextStream class read-write text files, and other formats such as HTML. In the design, the data of node1 is written to the node1.txt while drawing the curve, and then the document can copy the target file:

QFile datas("node1.txt");
Datas.open(QFile::Append);
QTextStream out(&datas);
Out<<node1<<endl;

The first line defines a QFile object file node1.txt, the second line defines the way of writing, and the three or four line writes the data to the file through the file stream QTextStream.

5. Conclusion

In this design, the multi point monitoring, multi point collection and wireless transmission, the function of early warning and thresholding are realized. At the same time, based on QT/E, the qcustomPlot external class method is applied to realize real-time dynamic curve rendering, and the simultaneous presentation of multi point data curves and real-time data is compared, which greatly improves the
efficiency of development, and achieves data storage and data callback function. The scheme has been applied to embedded devices.

References
[1] Wang H, Chen Z. The Outdoor Data Collection System with GPRS [J]. Advanced Materials Research, 2014, 846: 1098-1101. Shengyi Yang, Fang Wen , Jiao Shi. Real time data curve drawing of Qt programming [J].Journal of Sichuan University (Natural Science Edition),2008, 45 (2).
[2] Shengyi Yang, Fang Wen , Jiao Shi. Real time data curve drawing of Qt programming [J].Journal of Sichuan University (Natural Science Edition),2008, 45 (2).
[3] Haoqiang Tan .C++ program design [M]. Beijing: Tsinghua University press Society, 2006.
[4] Debin Fan. The Design and Implementation of a Wireless Remote Image Monitoring System Based on the ARM and GPRS[J].Procedia Engineering24(2011):83-89.
[5] Maohua Xiong, Zhenlun Yang, ARM9. Design and development of embedded systems. Beijing: Tsinghua University press, 2008.
[6] Zhang Ying, Yang Hua, Ai Diming,Wang Jiasi. Research on the embedded real-time database key characteristics analysis and testing technology[J]. Applied Mechanics and Materials Vols.263-266(2013):1721-1727.
[7] Juan Zhang, Xuelan Zhang. Implementation of an embedded GUI application. Computer applications, 2003, 23 (4): 115-117.
[8] Renshan Quan, Qiang Lv, et al. The implementation of an embedded Linux application based on Qt/Embedded. The computer is applied to software, 2006.2.
[9] Wang M. Research and design of an infrared remote-control general self-learning set[J]. Electronic Test, 2008.
[10] Hongbo Ni, Xingshe Zhou, Jianhua Gu. An embedded graphics support system based on QT/E[J]. Computer Engineering, 2007 (10): 256-258.