Design of Simulation and Verification Software of Crew Operation Program

Shuo Yang *, Yingsheng Wang, Yi Man
China North Vehicle Research Institute, Beijing China

*shuoyang@noveri.com.cn

Abstract. For easily and timely simulating and verifying the design of crew operation programs, improving the rationality of the design, the open source graphic display framework Qt based on the Windows platform is used to design and development of crew display and operation software. It can provide support for the system designers to further optimize the design. This program has been adopted in a pre-research project with major background.

Keywords: Qt; crew operation program; simulation.

1. Introduction

Innovative points: 1. the signal and slot mechanism provided by Qt are used to reduce the degree of coupling among software modules; 2. software projects are organized in accordance with interfaces and external excitation interactions, it is convenient for the early development and later integration of software projects.

The design of crew operation program (COP) is an important part in the process of information system design. The crew operation program is directly related to whether the crew can quickly and effectively complete the mission. Simulation and verification are carried out for the design results of crew operation program, which can effectively improve the design, ensure the reasonable and effective design, and ensure the availability of the system.

2. The Design of Crew Operation Program

With the development of computer technology and the continuous improvement of equipment information level, information system has increasingly become an important part of tanks and armored vehicles, it is based on information theory and advanced electronic technology, adopts system engineering methods in the physical structure space of the vehicle, it combines functions such as detection, communication, navigation, identification, countermeasures, task management, driving and weapon control and corresponding electronic equipment into an organic entity by combining on-board network and software technologies, in order to achieve the goal of high sharing of system resources and great improvement of whole efficiency, moreover, it makes the system combat performance, availability and life cycle cost balanced with each other[1].

The armored vehicles belong to a class of complex equipment with human-computer interaction; it can accomplish various combat missions of armored vehicles only by using various functions of the vehicles. Therefore, human is an important part of the complex system of armored vehicles, and human-
computer interaction is an important content in the design of armored vehicles. The human-computer interaction system is a typical mission-critical system, and the complexity of the interactive task is the basis for building a suitable human-computer interaction model. This is mainly because of that in the complex interactive environment, the complexity of operating procedures of armored vehicles directly affects whether the task can be carried out normally and effectively. Therefore, the scientific and reasonable design of armored vehicles' human-machine interaction methods and interaction ways can significantly enhance the combat efficiency of armored vehicles, improve availability, enhance situational perception, reduce decision-making and reaction time, lower operating errors, and significantly reduce the cycle costs of the whole life.

The design of crew operation program (COP) is the most important part in the design of the information system. It is a technical document describing and explaining the relationship between the commander, gunner, driver's operation and the vehicle status and environment from the human-machine interface (Display, Crew, Control Interface) in the environment-vehicle-crew system. COP is the result of the crew’s correct operation of each step, and how the crew can operate the whole information system even the whole vehicle enters the state which is required by the crew, so as to complete the mission in the fastest, easiest and most effective way. In the human-computer interaction design verification link when the armored vehicles realize the "crew-centered", the virtual and actual verification environment should be comprehensively used to simulate and verify the design of crew operation program; only in this way can we ensure the best "crew-centered design" and ensure the availability of the system [2].

3. Software Development Preparations

3.1. Graphic development platform Qt

Qt is a cross-platform C++ graphic user interface application development framework developed by Trolltech in 1991. It can develop GUI programs as well as non-GUI programs, such as console tools and servers. Qt is an object-oriented framework, which uses special codes generate extension (called meta-object compiler) and some macros, it is easy to extend and allow component programming. In 2008, Trolltech was bought by Nokia, and Qt became a programming language tool of Nokia. In 2012, Qt was bought by Digia. Qt mainly has the following technological characteristics:

1) Excellent cross-platform characteristics

Qt uses the "write once, compile anywhere" way to provide a complete C++ application development framework for the development of cross-platform graphic user interface applications. Qt allows program developers to use a single source tree of applications to build different versions of applications that can run on different platforms, including Windows XP, 7, Mac OS, Linux, Solaris, etc.

2) Object-oriented

The good encapsulation mechanism of Qt makes its modularity very high, have better reusability, which is very convenient for user development. Qt provides a signal/slot safe type instead of the callback method, which makes the collaborative work among various components very simple.

In addition, Qt also provides more than 250 C++ classes, it has rich API for program developers to call; support 2D/3D graphic rendering. support OpenGL and other characteristics.

Signal and slot are the basis of Qt programming. It can make application programmers to bind objects that do not know each other together [3].

Slot is almost the same as ordinary C++ member functions, it can be virtual function, can be overloaded, can be public, protected or private, and can also be directly called by other C++ member functions; moreover, its parameters can be any type. The only difference is that the slot can be connected to signals, under this condition; this slot is automatically called whenever the signal is generated. When it is necessary to connect a signal and a slot, we can call the connect (sender, SIGNAL (signal), receiver, SLOT (slot)) function to achieve it, the sender and receiver are pointers towards the QObject type, Signal and slot are function names without parameters. In fact, the SIGNAL() macro and SLOT() macro convert their parameters into corresponding character strings.
3.2. Integrated development environment Visual Studio

Although Qt provides the integrated development environment Qt Creator for application development, the Visual Studio series development environment launched by Microsoft is the most used in application software development on the Windows platform, and Qt also provides integrated plug-ins that can be used for Qt software development in the Visual Studio environment.

Visual Studio is a basically complete set of development tools, which contains most of the tools needed in the whole software life cycle, such as UML tools, code control tools, integrated development environment, etc. The written target code is applicable to all platforms supported by Microsoft, including Microsoft Windows, Windows Mobile, Windows CE, etc. The user interface of the Visual Studio integrated development environment is shown in Fig.1.

![User interface of Visual Studio](image)

**Fig.1** User interface of Visual Studio

3.3. Build Qt runtime environment

Qt provides the authorization models with commercial version and open source version, the open source version can directly download the source code package from the official website, compile it in the corresponding compilation environment, and generate the library files required by the Qt application during compilation, linking and runtime. Download and run qt-vs-addin-1.1.11-opensource from the official website to install the Visual Studio integrated plug-in provided by Qt, after the installation is complete, when newly building a new project in the Visual Studio integrated development environment, the option to newly build a new Qt project will appear in the pop-up new project dialog box, as shown in Fig.2.
4. Software Design of Crew Operation Program

4.1. Graphic element preparation

In the design process of crew operation program, it is necessary to define the crew's display control interface plan and the response of the operation buttons. The design of the human-computer interface not only requires conducting reasonable design, classification and definition of the displayed information, so that the information which the crew receives is refined and accurate, but also the operation logic is simple and clear, and it is easy for the crew to control and make decisions. The design process forms various corresponding display interfaces when crew complete tasks. These display interfaces can be designed and optimized by art designer, and each graphic element in the interface form independent callable and displayable image resources. The designed human-computer display interface is shown in Fig.3, and the graphic elements are shown in Fig.4. The graphic elements are used in the crew control program simulation software development process, and display in accordance with the simulation data.
4.2. Organizational structure of the software project

Applying the solution provided by Visual Studio and the organizational structure of the project, each crew display interface specified in the crew operation program, data simulation software and externally stimulated communication software are managed as an independent software project. In the development process of separate software project, independent debugging can be carried out. In the process of integration, each software project is used as the static link library, compiled and linked by the main program, the initialization of the display interface and the excitation communication software are
conducted. The software project structure is shown in Fig.5, and CockPit1_COP1_Center is the main program.

![Software project architecture](image)

**Fig.5 Software project architecture**

The data exchange between the external excitation communication software and the display interface is through the signal and slot mechanism, which can effectively reduce the degree of coupling among software projects. The corresponding signals are defined in the external excitation communication software, for example:

**signals:**

```cpp
void sigCaptureData0(unsigned char *buf, long iSize);
void sigCaptureData1(unsigned char *buf, long iSize);
void sigCaptureData2(unsigned char *buf, long iSize);
void sigCaptureData3(unsigned char *buf, long iSize);
```

The slot after receiving the corresponding signal is defined in the display interface software, for example:

**private slots:**

```cpp
to slotRecvShootInfo(ObjectInfo *object);
void slotRecvCameraData(unsigned char *buf, long iSize);
```

On one hand, the display interface software needs to design the layout of the interface elements in accordance with the interface design specified by the crew display control program, this design can be realized by the Qt Designer tool, this tool provides the visual interface design methods, can arrange
various displayable controls provided by Qt on the interface. On the other hand, it can manage image elements as resources uniformly, which is convenient for integrated demonstration in the later stage of software development. The application interface of Qt Designer tool is shown in Fig.6.

![Fig.6 Qt Designer tool interface](image)

After completing the layout design of the interface elements, the interface display software mainly needs to design and develop the corresponding slot functions and interface update functions. The prototype of interface update function is virtual void paintEvent(QPaintEvent * event), this function is a virtual function inherited from QWidget, and it is used to update the elements in the interface display range based on the current state data. The slot function mainly completes sending out the interface update message after receiving the data information required for the interface display. For example, the slot function and interface update function of the shooting interface is:

```cpp
void Shoot::slotRecvCameraData(unsigned char *buf, long iSize)
{
    mutexPixmap.lock();
    srcPixmap->loadFromData(buf, iSize);
    mutexPixmap.unlock();
    this->update();
}
void Shoot::paintEvent(QPaintEvent *event)
{
    QPainter p(this);
    mutexPixmap.lock();
    p.drawPixmap(0, 0, 1600,1200, *srcPixmap);
    mutexPixmap.unlock();
}
```

In the development and debugging process of each independent software project, the software can be tested by writing corresponding test programs. When the main program is integrated, the signals and slots defined in the software are connected by calling the connect method, for example:

```cpp
connect(insThread_AVerCapture, SIGNAL(sigCaptureData1(unsigned char *, long)),
    insWidget_Center_Shoot, SLOT(slotRecvCameraData(unsigned char *, long)),Qt::DirectConnection);
```
In this way, when the simulation verification software of the whole crew operation program is integrated, the interface display can be updated with the change of the corresponding data of the excitation software, so as to verify the design of the crew operation program better.

5. Conclusion
The crew operation software can be developed conveniently and quickly based on the design results of the crew operation program by applying the graphic running framework Qt. Driven by the external simulation excitation signal, the interface display can be updated and driven through the signal and slot mechanism of Qt, in addition, signals and slots also reduce the degree of coupling among software modules. The cross-platform characteristic of Qt can also easily transplant the developed crew operation software to the embedded platform.

The simulation and verification of the crew operation program of a major background pre-research project was completed with this method, and it provides support for system designers to improve their design.

References
[1] Fu Qiansheng. 2005. Analysis and Design of Information System[M]. Beijing: National Defense Industry Press.
[2] Liu Xintang, Wu Xiaoyan. 2001. Modern System Modeling And Simulation Technology[M]. Xi'an: Northwestern Polytechnical University Press.
[3] Jasmin Blanchette, Mark Summerfield. 2008. C++ GUI Qt4 Programming[M]. Beijing: Publishing House of Electronics Industry.