Remote Data Transmission of Intelligent Cloud Robot Based on Google Protobuf

Weidong Huang, Yuan Qi, Weiguo Zhang, Lan Pang and Pengcheng Fan
Xi’an Institute of Applied Optics, Xi’an 710065, China
Email: 228821951@qq.com

Abstract. With the maturity of robotic remote control technology, it plays an important role in military, exploration and industry. Their application in the field of daily life is also expanding. The development of 4G Mobile Internet and cloud computing technology provides a new platform for robot remote control technology. In order to realize the communication function of robot remote control, this paper designs a data transmission method based on protobuf tool. According to the characteristics of various operating systems, we choose the Linux system as the robot platform, the Alibaba Cloud server as the relay platform, and the Windows application program as the implementation platform. After the system test, when the network is in good condition, through the control terminal, the real-time video collected by the robot can be viewed smoothly, and the command can be sent to control the motion of the robot.

1. Background

With the development of intelligence technology and the Internet, people's way of life has been greatly change. Also it provided a new solution for robots. Traditional robots, especially rescue robots, do not have remote control functions or can not timely feedback important information to control terminals. Therefore, the research on remote data transmission of intelligent robots has become the focus of research.

At present, the data transmission between robot and control terminal is mostly carried out by wireless or data link. This kind of method always has the limitation of distance, and can not run the new generation of algorithm because of the limitation of CPU and GPU based on the robot. With the development of 4G, 5G and cloud computing technology, a new generation of robots can transmit data to the cloud and implement core algorithms by cloud servers. However, because the traditional network efficiency is not enough to support the current huge amount of information transmission, an efficient protocol data exchange format tool library is needed.

Protobuf is an efficient and quick serialization frame provided by Google [1]. Java, C++, and Python are three kinds of language provided by Google, which contains the compiler and library files of corresponding language. Also protobuf is a serialization tool with a higher data exchange efficiency compared with XML and JSON [2].

Using the efficiency of protobuf, the data is transferred to the cloud server, and then processed by the cloud server program and transmitted to the terminal. At present, the command transmission, state feedback and image transmission of the robot are realize.
2. Current Result

As shown in figure 1, System is divided into three modules: Robot, Alibaba Cloud, and Terminal. The data flow chart of the whole system is shown. The command transmission system is first sent by the robot system. The data is serialized by protobuf, and then the information header, length and check are added to prevent TCP/IP packet loss. After receiving the data, the server parses and processes the data, then packages the data and sends it to the control terminal. In this way, the information that should be processed by the robot system is changed to be processed by the Alibaba Cloud server, which greatly reduces the information processing burden of the system. Because of protobuf’s higher data exchange efficiency, the real-time problem of information processing is guaranteed.

In the process of data transmission, the problem of data sticking and unpacking should also be dealt with. As shown in figure 2, since TCP provides a connection-oriented byte stream service, it is impossible to predict how many bytes will be returned by reading TCP data at a time. Therefore, in the process of using TCP/IP protocol for transmission, the phenomenon of sticking and unpacking often occurs.

The first case is that the receiver receives only one packet. Since TCP will not lose the packet, the packet contains the information of two packets sent by the sender. This phenomenon is called sticky packet. This situation is difficult for the receiver because the receiver does not know the boundaries of the two packets [3].

The second case: There are two forms of this situation, as shown below. The receiver receives two data packets, but the two data packets are either incomplete or one more, which means unpacking and sticking. If these two situations are not handled specially, they are also not handled by the receiving end [4].

In this paper, format data method and segment reading method are used to deal with this phenomenon. Firstly, data header, length and check bits are defined in data format. Each time, the length of the information header is read first, and then the remaining data is read according to the length information in the information header. However, due to the real-time requirements of the system, there will be several more packets of data each time. Therefore, we need to build a buffer in the cloud server to store unused data, connect unused data with the next package of data, and then reprocess it, as shown in figure 1.

By protobuf data structure and serialization method, and on the basis of protocol architecture, the serialized data are modified. The remote data transmission is realized through Alibaba server. Protobuf's streamlined data structure improves the efficiency of data transmission. By encapsulating the data structure into the transmission message, it can transmit instructions and images as shown in figure 1.

The data structure of the system has three layers:

Data information structure layer:

The root data information structure layer is the first layer of nested data, which is only used to distinguish command information (terminal data information) and status information (business layer data information).

Second layer data information structure layer:

The second layer is further divided according to the command information and state information of the first layer. The command information is divided into image command information, sensor command information and control command information. The state information is divided into image state information, target recognition state information, target tracking state information and sensor state information.

The third layer data information structure layer:

The two layers already contain most of the command information and state information, but the sensor command and state information still need to be subdivided in the third layer of data information structure layer. The sensor command information is divided into power command information, temperature and humidity command information, GPS command information and IMU command information. Sensor status information is divided into power status information, temperature and humidity status information, GPS status information and IMU status information.
The data structure defined above is for developers and business programs, not for storage and transmission. Therefore, you need to use the protoc compiler for compilation. For the control platform, it needs to serialize command information and provide write interface, deserialize state information and provide read interface; for the business layer (i.e. controlled terminal), it needs to deserialize command information and provide read interface, serialize state information and provide write interface.

When using protoc to compile and generate read-write interfaces, you can directly specify which development language code you need to generate. For example, it can be read-write interface of C++ language. protoc --cpp_out=./project.proto. Protoc is the tool name and can run commands directly. --cpp_out is a parameter that specifies to generate C++ code, followed by = to specify the generated directory. project.proto is a defined file. A total of two files (i.e. execution files) are generated. Executables include project.pb.h and project.pb.cc There are several methods for setting properties in the generated account class.

Executable project.pb.h and project.pb.cc Some function methods are defined in, such as how to serialize, deserialize and what nesting rules to generate nested data structures.

Compared with JSON files, protobuf provides a standard label form, which does not need the complicated syntax logic of JSON, so it is readable. JSON is vulnerable to cross Site Request Forgery and cross site script attack. Cross Site Request Forgery is a way to attack the user's browser trust by using the site, and cross site script attack is an injection attack. A common security vulnerability when using JSON usually occurs when JavaScript gets a JSON string from the server and converts it to a JavaScript object. Protobuf does not have these two security issues. Therefore, the application of protobuf can improve information security. And it can support more kinds of data structures. In the aspect of updating data structure, it is also easier to implement.

3. Figure

Figure 1. The data flow chart of the system.

Figure 2. The problem of data sticking.
Figure 3. Dismantling flow chart. Figure 4. System composition structure diagram.

Figure 5. Display and control terminal.

References
[1] Kalman M. 2013 8th International Conference for Internet Technology and Secured Transaction (ICITST) London IEEE 208-13
[2] Kaur G, Fuad M M. 2010 Proceedings of the IEEE SoutheastCon 2010 (SoutheastCon) Concord NG IEEE 459-62
[3] YANG F S. 2010 Android Application Development Revelation Beijing: China Machine Press 1-5
[4] Corke P I, Good M C. 1996 IEEE Transactions on Robotics and Automation 12(5) 345-78
[5] Simmons R, Fernandez J L, etal. 2000 IEEE Robotics & Automation Magazine 12-26
[6] Schulz D, Burgard W, etal. 2000 IEEE Robotics & Automation Magazine 78-86