Software Design and Realization of Communication Training Simulation System of Certain Radar

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***Abstract*—Aiming at the issue of communication training in radar equipment with great difficulty, this paper advances the solution of designing radar communications training simulation system. Researching the simulation system functional orientation, programs the system required modules. Focuses on the modeling method of training effect evaluation model and mechanism model, and gives the realization idea. Finally, building a communication training simulation system, gives the software process and typical software interface. The research and application of communication training simulation system has very important reference value for radar equipment modernization of communication training.**

Keywords-communication training; mechanism model; training effect evaluation model

I. INTRODUCTION

Certain radar adopts advanced technology, with complex operation, as in war, it needs commanding of higher level command system to work. In order to ensure the effectiveness of the equipment, it is important to pay more attention to the communication training of maintenance personnel. For the factor of cost, space, equipment and other factors, it is difficult to organize regularly communicate training with the actual equipment, and it is urgent to adopt a more advanced and efficient, low-cost, low-risk means of communication training.

In recent years, with the development of computer technology, modeling and simulation technology is becoming the third important way to understand and transform the objective world after theoretical and experimental studies[1,2]. Communication training simulation system applying computer modeling technology, simulation and virtual reality technology, realizes interaction training without actual equipment by simulation target equipment, men-machine interaction and interaction with command system, and be able to achieve a good training effect by lower cost.

II. SYSTEM STRUCTURE OF COMMUNICATION TRAINING SIMULATOR

Radar communication training simulator involves radar simulator and higher command system, units distributing wide, crossing the great time zones, with a great deal of information interaction between nodes and other nodes, considering the above factors, and limited space, this paper focuses on the radar node design of communication training simulator.

In order to ensure consistent training effectiveness with actual equipment and easy generalization, the system should have the following function:

- Using the mouse and keyboard which is the same as actual equipment as an input device;
- Meeting the operation training need of the radar equipment;
- Supporting the communication training between radar equipment and higher command system;
- Supporting the evaluation of training effect; collecting some information of the training process, and then use intelligent evaluation algorithm to evaluate the result of operation training and communication training;
- The system should minimize requirement of the hardware platform, and can smoothly run on an ordinary PC.

Considering the above functional requirements, system architecture is designed as fig.1:

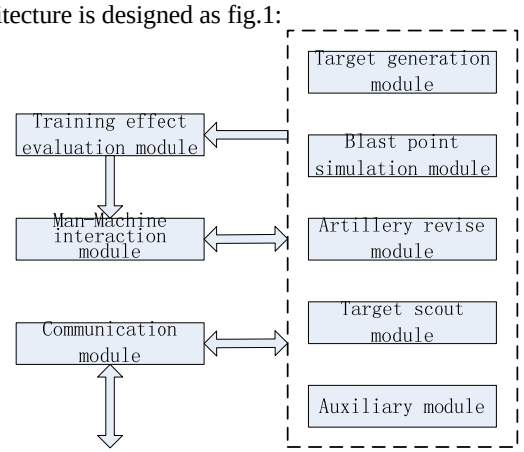

Figure 1. Software structure of radar communication training simulator

The software of radar communication training simulation system contains the following module: target generation module, blast point simulation module, men-machine communication module, target scout module, artillery revise module, communication module, auxiliary modules and

training effect evaluation module, the function of each module as follows:

- Target generation module generates the specified objectives according to the demands, not only including both single-target and multi-objective, but also including moving targets and fixed target;
- Blast point simulation module generates blast point which accords with actual circumstance near shooting target, not only including blast point near fixed target, but also including the blast point near moving target;
- Men-machine interaction module is mainly used to collect keyboard information, the software interface information, and other information and processes it, and then passes them to the appropriate module or software interface for display;
- target scout module is based on the operation operator to complete the single-target scout, tracing training, and multi-target detection and tracing training;
- Artillery revise module completes the artillery revise training by capturing the blast point round shooting target;
- Communication module is mainly responsible for the coding, decoding, communicating of information;
- Auxiliary module completes the system time management, message management and parameter management, and so on;
- Training effect evaluation module mainly evaluates the training effect based on the training process data.

III. CONSTRUCTION OF SIMULATION MODEL OF COMMUNICATION TRAINING SIMULATOR

As figure 1 shows, the model of radar communication training simulation system can be divided into men-machine interaction model, mechanism model(target generation model, blast point simulation model, target scout model and artillery revise model, etc.) and evaluation model. As men-machine interaction model is mainly used to transform the men's operator to equipment mechanism model as input, and sends the mechanism model's output to the software interface for display, the realization principle of men-machine being relatively simple, this paper pays more attention to the construction of mechanism model and evaluation model.

A. Mechanism Model Modeling

The mechanism model of communication training simulation system includes target generation model, blast point simulation model, target scout model and artillery revise model, these model's realization principle as following:

1) Target generation model. Target generation model providing needed information for target scout model, and it is the basis of target scout training. Target generation model not only generates single target but also multiple targets, and the initial distance and velocity is variable. Supposed the initial distance of single target being s_0, velocity being v_0, space between x direction and target moving direction being d, after t time, the distance s and azimuth θ can be calculated as following equation:

$$\begin{cases} s = s_0 - v_0 t \\ \theta = a\tan(s/d) \end{cases}$$

If generating multiple targets, the calculating method of distance and azimuth of each target can be disposed as single target.

2) Blast point simulation model. Blast point simulation model providing needed information for the artillery revise model, is basis of artillery revise training. Blast point simulation model not only simulates single blast point round fixed target but also simulates single blast point round moving target, and simulates blast point round multiple targets, the basis of which is blast point simulation round single target.

As distribution of shooting projectile obeys two dimensions independent normal distribution, obtaining one dimension normal distribution of X direction and Y direction is enough. There are several methods to obtain sample value obeying normal distribution, after testing, the statistical performance of random numbers which produced by central limit theorem[3] is better, the principle is as follows:

Firstly, producing n independent random numbers ξ_1, ξ_2, $\cdots$, ξ_n, which obey uniformity distribution and lies in space $(0,1)$, according to central limit theorem, the random variable $\eta = \left(\sum_{i=1}^{n}\xi_i - \frac{n}{2}\right)\Big/\sqrt{\frac{n}{12}}$ obeys $N(0,1)$ normal distribution. In order to guarantee the precision, the n in above equation should be exceed 10. After obtaining the random number obey $N(0,1)$, it is simple to obtain the random number obey $N(\mu,\sigma)$ by transforming the random number which obeys $N(0,1)$.

Supposing the coordinate of shooting target is (s_0,θ_0), the error of X direction of blast point obeying $N(\mu_X,\sigma_X)$ distribution, the error of Y direction blast point obeying $N(\mu_Y,\sigma_Y)$ distribution, the coordinate of blast point i is as following:

$$\begin{cases} s_i = \sqrt{(s_0\sin\theta_0 + \sigma_X\eta_i + \mu)^2 + (s_0\cos\theta_0 + \sigma_Y\eta_i + \mu)^2} \\ \theta_i = a\tan((s_0\sin\theta_0 + \sigma_X\eta_i + \mu)/(s_0\cos\theta_0 + \sigma_Y\eta_i + \mu)) \end{cases}$$

3) Target scout model. Target scout model simulates the scout and trace process, and measures the distance and azimuth information after detecting target. The detection range of radar not only correlates with the target type, but also correlates with the power, gain, limitation, information processing parameter of radar.

After the target is detected, the information of distance, direction, speed, reflection section of target is displayed, and the type of target can be judged by these information. For different scout mode, the radar displays different results. As manually scanning, the target appears in the specified beam; As electronic scanning, the target appears in the each beam. After detecting target, tracing target can be executed. At this

time, the target locating in the center of the field, and the target point mark doesn't move. In order to ensure that the target is always in the center of the field, the range of field is changing.

4) Artillery revise model. Artillery revise model simulate the process of artillery emendation. After receiving the order of observing the blast point, the radar begins to scan the area round shooting target. When detecting the blast point, pitch on this area by rectangle pane. Supposed the blast point coordinate of rectangle top left corner is (s_1, θ_1), and the blast point coordinate of rectangle bottom right corner is (s_2, θ_2), then the central coordinate (s, θ) of rectangle pane is as following:

$$\begin{cases} s = (s_1 + s_2)/2 \\ \theta = (\theta_1 + \theta_2)/2 \end{cases}$$

After obtaining the central coordinates of the rectangle pane, selects the blast point which satisfies the following conditions as the average blast point:

$$M = \min\{(s_i, \theta_i) \,|\, (s - s_i, \theta - \theta_i)\}(i = 1, 2, \cdots, n)$$

B. Training Effect Evaluation Model Modeling

Training effect evaluation reasonably assesses the operator of technical personnel, so as to provide reliable reference for arranging work and training.

There are many training effect evaluation method, such as analytic hierarchy process, fuzzy comprehensive evaluation method(FCE), TOPSIS method[4], of which the fuzzy comprehensive evaluation method is used more widely. FCE not only can be used to assess subjective index, but also can be used to assess objective index, and can be used to assess qualitative index. Above all, this paper adopts the FCE to evaluate the training effect, and the specific flow is as following:

1) Determine the factor set. U ={the ratio of correct operation, the ratio of error operation, the ratio of dangerous operation, the ratio of repeat operation, the completion status of training, the consuming time of training}.

2) Determine the remark set. V = {Very good, good, average, poor, very poor}.

3) Establish the weight set. In the factor set, the importance of each factor isn't the same. In order to express the importance of each factor, it is need to give a corresponding weight for each factor, and all of the weight of each factor composes weight set.

This paper using AHP method to determine the weight of each factor, and the principle of AHP method can be referenced literature [5].

4) Establishment of fuzzy membership matrix. Any factor u_i which is in factor set has certain impact on any factor v_j which is in remark set, and this impact coefficient can be marked as r_{ij}, and then all the r_{ij} composes the fuzzy membership matrix. The fuzzy membership matrix expresses the impact degree of factor in factor set on factor in remark set.

5) Comprehensive assessment. $B = A \cdot R$, the factor of B represents the operator training effect membership degree of very good, good, average, poor, very poor. According to the maximum membership degree principle, the membership level of operator training effect can be determined.

IV. Realization of Simulation System

A. Software Simulation Flow

The simulation software is utilized to communicate with higher command system, and complete the task under the circumstance of receiving instruction from higher command system. The premise of the software development is to define communication information between radar simulation training system and higher command system, communication information generally including the following categories: command information from higher command system, scouting and revise information of communication simulation training system, and flag information of information receiving and sending between higher command system and simulation system. After defining the communication information, specific information flow can be seen from fig.2:

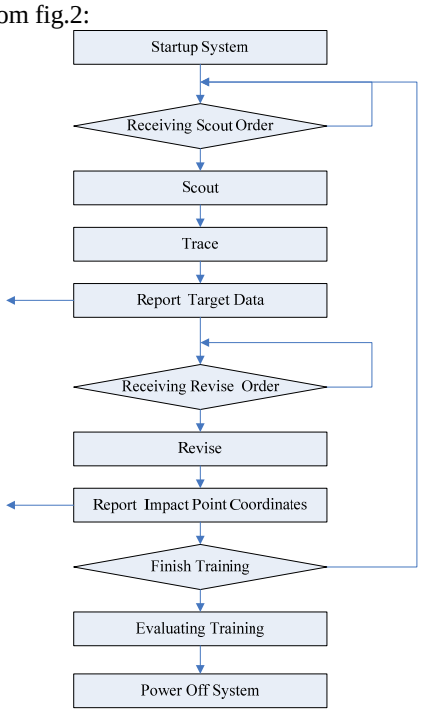

Figure 2. Information flow of software

Information flow of communication training simulation system can be seen form fig.2. Communication training software not only completes the function of radar power on and power ff, target scouting, target tracing, artillery revising, communication training and effect evaluation, but also collects the keyboard information, so as to receive the order from keyboard, such as parameter setting, orientation navigation.

B. System Integration Management Platform

System integration management platform is the core of the radar communications training simulation system, which integrates the radar function model and database by software interface. In order to replant the communication training simulation system between different platforms, all the radar functional model, such as target generation model, blast point simulation model, men-machine interaction model, target scout model, artillery revise model, will be packaged into standard Win32 DLL libraries or COM component.

In this condition, no matter whether the visual studio development environment or dot net development platform is adopted, it is convenient to integrate these functional model into simulation system. Dot net platform is adopted in this system, specific usage step of DLL and COM component in dot net platform can be seen from literature [6].

C. Typical software interface

There is so much interface in radar communication training simulation software, such as start-up interface, the information transmission setting interface, the main interface, radar parameter setting interface, the target scout interface, artillery revise interface, target information reporting interface and blast point information reporting interface. For the limitations of space, it is impossible to list all of the interface, listing only some typical interface.

Taking scout training for example, there is part of the software interface, shown in fig.3 and fig.4.

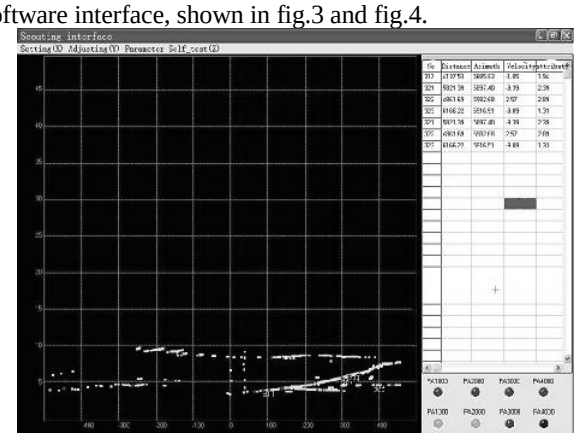

Figure 3. Software interface of target scout training

V. CONCLUSION

Aiming at the issue of communication training being of great importance but communication training in radar equipment with great difficulty, this paper advances the solutions of design radar communication training simulation system. Researching the simulation system functional orientation, plans the system required modules. Focuses on the modeling method of training effect evaluation model and mechanism model, and gives the realization idea.

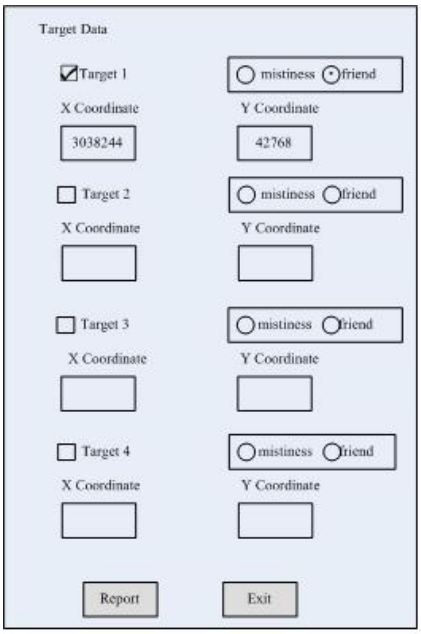

Figure 4. Target information report interface

Finally, introduces the system work flow and software integration platform, and lists some typical software interface. The research and application of communication training simulation system has very important reference value for the modernization of radar equipment communication training.

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