Computer Simulation of Angle-measuring System of Photoelectric Theodolite

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Abstract. In this paper, a virtual test platform based on malfunction phenomena is designed, using the methods of computer simulation and numerical mask. It is used in the simulation training of angle-measuring system of photoelectric theodolite. Actual application proves that this platform supplies good condition for technicians making deep simulation training and presents a useful approach for the establishment of other large equipment simulation platforms.

1. Introduction
Training simulator of large equipment is a valid approach to improve the quality and effectiveness of training. It has become the preferred method of training. Our country has done lots of study on training simulator and acquired a lot of achievements which contains multimedia-teaching type \cite{1}, operation-training type \cite{2}, simulation--maintaining type \cite{3} and simulation-demonstrating type \cite{4} and etc. All these methods have the drawback of disability to train the technicians in deep levels. Though some types have strong mutual capability \cite{5, 6}, its working state is controlled by appointed programs. The state cannot be set at random. Say nothing of simulating actual malfunction work process.

Photoelectric theodolite is the main outer trajectory measurement equipment. In order to make full use of theodolites, it is necessary for professional technicians majoring in photics measurement to have the ability of mastering its working principles, detecting malfunctions in time and solving them. But the training of them isn’t enough because it is carried out on the actual equipment, it will be restricted by distributed geography position, life span of system, condition of starting up the equipment and so on. Furthermore, those large equipment at work need to be kept in good condition, we can’t set man-made malfunctions in it to supply daily training, so the chance is not much for technicians to detect, find and remove malfunctions. It is hard to satisfy applied demands.

This paper comes true malfunctions simulation and recurrence using simulated technology. The simulation node can be set in every circuit cell. It is possible to display on screen the outline and configuration of the equipment, positions of every subsystem, circuit combination, panel, testing bore and its waveform if needed. It also can display the waveform and signal flow of subsystems and main circuit boards; also can give state parameters e.g. waveform, voltage and so on; show the correct and incorrect testing waveform during circuit running process, and can set malfunctions at random to train technicians’ ability of analyzing, judging, finding and eliminating malfunctions.

2. Design of system function
The angle-measure system of photoelectric theodolite mainly includes photoelectric coder, digital processing and logic processing, lattice display. Absolute angle-measure system principle is shown in Figure 1:
This system uses absolute photoelectric code disk which is scored by cyclic code as angle switching part. It has 12 coarse code tracks, 5 mid-fine code tracks and 4 fine code tracks. These codes will become 18 bits binary codes after magnifying, storing, decoding and emendation. Any signal error in code track will affect the whole testing data and has corresponding phenomenon on display screen.

For concrete circuit, simulation system has the following functions:

1. Simulating angle-measure and showing assembled panels, hardware switch (such as electrical source, inner and outer collection, switching between azimuth and elevation), circuit panel.
2. Simulating the code disk signals and supplying information source for circuit processing system of coder.
3. Simulating the angle code outputs and working process of circuit processing system.
4. Simulating panel display and coder states.
5. Analyzing system states. Simulating state parameters and waveforms of test bores and main nodes in circuit panel.
6. Simulating malfunction situations of coder. Showing basic malfunction phenomena of coder system, such as light or dark of code track all the time, abnormal carry and flash, obtaining value at random.
7. Open malfunction library. The library permits basic lookup based on malfunction phenomena and can be maintained, added, deleted and modified etc. Malfunction items can be set automatically or artificially.
8. Simulating malfunction removal. It can set malfunction on any node of every data channel and change its logic state and signal parameter so that technicians can find and judge malfunction point.
9. It has the intelligent functions of diagnosing malfunction phenomena and finding the possible reasons according to malfunction phenomena.

Figure 1. The principle of angle-measure system.
3. Concrete realizations

3.1. Simulating the panel, function of hardware switches, circuit combination and circuit panels of the instrument.

Adopting the 3D technique, generate various figures in proportion according to practical picture and video. The interface of the simulation test is shown in Figure 2.

When the system works, the data manifestation area shows the angle after the theodolite rotates and state of every code track. The 3D equipment models can rotate or reverse according to given speed. The test bores can output the signal waveform of current state. Each circuit panel in the combination can be showed independently and signal on each function node can be tested. It’s convenient for technicians to get familiar with the circuit and its work state.

3.2. Simulating Code disk information

According to the different speed of the code disk rotating or reversing, the computer can output different code in real time in terms of cyclic code. The speed rate of the code depends on the rotating speed of the theodolite. The encoding rule of the cyclic code is: in the two continuous adjacent codes, only one bit changes in all bits of one code. The way is to make the computer generate 16 bits binary codes using different increase step or decrease step first, then transform the binary codes to cyclic codes, finally send them to the simulative assembled circuit as information source.

3.3. Simulating Angle code output

The angle code from the coder is the binary code generated by the photoelectric apparatus’s electric signal, which is enlarged, compared, stored, encoded, added and averaged, emended and subdivided by the circuit system of the coder. All the process is completed by computer. Every input and output of the function node is added with state mask. Pass the signal to the next level when the channel is...
normal, otherwise change the signal according to the malfunction kind and then pass it to the next
level.

3.4. Analysis of the system states
According to the formation and principle of actual circuit, analyze the signal process and set testing
points in the rule of reflecting the work state of the logic circuit as well as possible. The relation
between signals is decided by the signals of the actual apparatus. The basic relations are expressed
with several two-dimension arrays. Actual test simulates the proportion and schedule relations only.
After the test points are confirmed, generate waveforms and then display them on oscillograph. For
example, one circuit panel and the waveform of one test point on it are shown in figure 3.

![Figure 3. Circuit panels and test waveforms.](image)

3.5. Establishment and maintenance of malfunction library.
We considered the maintaining convenience and its openness while design the malfunction library.
Users can add, delete, or change the library and so on according to actual situations. The basic form of
the library is shown in figure 4.

The malfunctions set by the training system can’t cover all the possibilities. It’s necessary to
establish an open library in which users can accumulate malfunction items and enrich the library
according to actual situations. Only do this, the training system can be as similar as possible to the
actual situation. Because the design aim of the training simulation system is the malfunction library
based on malfunction phenomena, every malfunction phenomenon should be shown according to its
respective reason. Then users can judge the malfunction point quickly according to the
malfunction phenomena after much repeated training. In the design process we study the possible
malfunction phenomena of the angle-measuring system and their regulations deeply. Finally we make
the open library successfully through simple algorithm.
3.6. Eliminating malfunction simulation
The system has the function of identifying malfunction point and judging whether the malfunction point is found correctly. If it is found correctly, the malfunction can be solved. Otherwise the system will prompt that the malfunction still exists. Malfunctions are found through simulation tests of the main nodes in the circuit. In other words, the system compares the normal signal and malfunction signal, then judges whether the work state of this node is correct. If it’s not correct, show the malfunction and then solve it. The state parameters of different nodes are relative. The change of one node state parameter will influence the state parameter of other nodes after it. Only finding the malfunction source, the malfunction reason is considered to be found.

4. Conclusion
Primary applications show that this method solves the difficult problem of eliminating malfunction on actual apparatus, improves the training deepness and intensity and advances the training effect. It also presents references for the improvement of other large apparatus training methods. It is very popular in technical officers and has a wide application outlook.

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