Design & Implementation of the Pulse Calibration Processing System for Seismic Network

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Abstract. Pulse calibration is an important work for the regional seismic network center. With the scaled amplitude and period from pulse calibration, engineers can understand the running state of the seismographs. A variation above %5 usually means a fault and there should be something wrong with the sensors or digitizers. The various faults are important references for station maintenance, but some of them are ever ignored by the engineers due to the lack of specialized storage and management procedures. In order to make better use of the faulting records, we have developed software SPMIS with VC++ for the regional seismic network center. With the software, users can not only achieve the routine work of pulse calibration measurement, but also the fault classify and storage. The application of SPMIS will be helpful to improve the efficiency of the operation maintenance work for the seismic network center.

Introduction

In the seismic network center, it is necessary to scale the seismograph at the station with pulse calibration to check up on the running state as a matter of routine, which will help to enhance the earthquake monitoring efficiency [1, 2]. From the results of pulse calibration, we can calculate the change rate of parameters such as the frequency, damping and linearity of the seismometer. In normal circumstances, the values of these parameters are almost identical with their initials, whereas in some cases, for example, when the seismometer goes wrong, the values may bias from the initials. In practice, when the bias is over 5%, it usually means a fault and it is necessary to get the instrument fixed [3, 4]. In addition to the overrun, there are some other faults, such as the pulse distortion, noise jamming and etc.. The various faults are important references for network maintenance, but some of them are ever ignored by the engineers due to the lack of specialized storage and management procedures. In order to make better use of the faulting records, we have developed software SPMIS with VC++ for the regional seismic network center. With the software, users can not only achieve the routine work of pulse calibration measurement, but also the fault classify and storage. The application of SPMIS will be helpful to improve the efficiency of the operation maintenance work for the seismic network center.

System Design

System Structure

SPMIS includes three main functional modules: one for the pulse calibration processing module, two for the data management module and three for the system management module. The module one supports the following functions: (1) reference parameter setting; (2) waveform file importing; (3) pulse wave scaling; (4) fault handling; and (5) result storing. The module two is responsible for the following work: (1) the browsing, querying, collecting and reporting on the pulse data; (2) the adding, deleting, altering and querying on the station data; (3) the adding, deleting, altering and querying on the reference parameter. The module three provides two main functions: (1) user management, including the adding, deleting, altering and querying on the user data, and (2) systematic logging.
Pulse Calibration Processing Module

The basic process of pulse calibration is that, for the first step, send certain pulse signals in voltage or current into the seismometer and get corresponding pulse waveforms; and for the second step, measure and analyze the pulse waveforms to verify the transfer function of the seismometer (Huang et al., 1999). In the practice of seismic network maintenance, we usually get two kinds of waveform from step one, which are the correct and wrong. When the waveform is correct, we will measure it to get the frequencies and amplitudes and store them into the database. However, when the waveform is wrong, we will do nothing but ignoring. Actually, the wrong pulse waveforms usually imply instrumental faults, and different faults will lead to different waveforms. Therefore, there are certain patterns for the variation of the pulse waveform, and we can get more knowledge on the running state of the instruments by observing and summarizing of the patterns. So we use the word fault to represent the wrong pulse waveform and its implications. When faults appear, we should make a classification firstly, and store their information into the fixed datasheet, other than ignoring them as before. This design is good for the integrity of the pulse data.

According to the practice, we designed a data dictionary for the known faults (Table 1). For example, practice indicates that: the incomplete pulse waveform always caused by the interruption of the communication link; and the out of gauge of certain parameter reflecting the variation of the instrumental properties, etc.. We also suggest that, users can customize the dictionary according to their own needs.

| Code | Type                   |
|------|------------------------|
| 1000 | Correct                |
| 1001 | Pulse out of gauge     |
| 1002 | be a bye               |
| 2000 | Pulse fault            |
| 2001 | No pulse               |
| 2002 | Incomplete pulse       |
| 2003 | Pulse without zero-crossed |
| 2004 | Pulse distortion       |
| 4000 | Inference              |
| 8000 | Others                 |

Data Management Module

In order to achieve efficient management of the pulse data, we use DBMS to manage all the parameters and results, and design database tables for each kind of data, for example, the structure of the pulse data table is shown in table 2. To simplify development, we use the MS Access as the database management system and use ODBC specification to interact with the database.

System Management Module

This module has two main functions including user management and systematic logging. Based on security and convenient considerations, we design four types of group with different privilege, as
shown in table 3. Each user must belong to one of the groups, generate logs. The system automatically maintains a log file, and will write a log record for each operation of users.

| Field Name | Data type | Description |
|------------|-----------|-------------|
| PulseDate  | Date      | Key: date of pulse calibration |
| StationName| Text      | Key: station name |
| WaveStartTime | Date/Time | Start time of the pulse waveform |
| WaveEndTime | Date/Time | End time of the pulse waveform |
| WaveFileName | Text | Path of the pulse waveform file |
| UDAAbnorm | Number | Pulse abnormal of the UD channel |
| EWAbnorm  | Number | Pulse abnormal of the EW channel |
| NSAbnorm  | Number | Pulse abnormal of the NS channel |
| UDPeriod  | Currency | Measured period of the UD channel |
| EWPeriod  | Currency | Measured period of the EW channel |
| NSPeriod  | Currency | Measured period of the NS channel |
| UDAmplitude | Number | Measured amplitude of the UD channel |
| EWAmplitude | Number | Measured amplitude of the EW channel |
| NSAmplitude | Number | Measured amplitude of the NS channel |
| Analyzer | Text | Identifier of the operator |

| Group     | Read/Write pulse data | Read/Write reference data | Read/Write station data | Read/Write user data |
|-----------|-----------------------|---------------------------|------------------------|---------------------|
| Guest     |                       |                           |                        |                     |
| Analyzer  | √                     |                           |                        |                     |
| Engineer  |                       | √                         |                        |                     |
| Administrator | √ |                        | √                      | √                   |

**Implementation**

SPMIS is designed to be an easy-to-use tool without any complex algorithms for users to achieve routine work on the pulse calibration. Therefore, the data integrity should be checked by the users. The Software is developed with VC++, and its running environment is Windows 7. In this paper, we will only introduce the implementation of some key modules.

**Pulse Measurement**

The main form of SPMIS is shown in figure 1. There is a list of the seismic stations on the left side, and 3-channel pulse waveforms of the selected station on the right. The main form supports interactive waveform measurement, for example, if users want to check the pulse calibration of a station, they should click the station in the left list, and then the pulse waveforms will be displayed in the right frame. When to get the scaled result, they can draw a rectangle surrounding a full period of pulse at any of the channels by dragging the mouse, then the system will automatically measure the maximum amplitude and period in the selected time range and mark them to all the components, and display the results in the left list.
Fault Handling

In SPMIS, we designed a pulse fault automatic detection module to make a preliminary determination with the faults. This module will automatically detect three default faults according to the feature of the curve, including that of no pulse (code 2001), pulse without zero-crossed (code 2003), and pulse out of gauge (code 1001). To ensure the correctness and integrity of fault information in the database, each fault record should be checked manually before storing. The fault of no pulse (code 2001) includes two situations, one for the station that should be a bye, and one for that with lost pulse. For the former one, users should make a label with the fault setup dialog box (Fig. 2). And for the later one, users should make a new pulse calibration. The SPMIS will automatically make a comparison between the measured value and the reference value of the period and amplitude. If the changing rate exceeds certain percentage (5% e.g.), the channel will be marked with the label of pulse out of gauge.

Data Querying

Users can browse result of pulse calibration with the pulse data browsing dialog box (Fig. 4). There is a result list at the center of the box. There provides two querying methods including querying by date and by station.
Summary
In this paper, the software SPMIS that we developed for the seismic network is introduced. With SPMIS, users can not only achieve the routine work of pulse calibration measurement, but also the fault classify and storage. We have employed SPMIS in the seismic network center of Hebei province. It has been proved that the features and performance of the system meet well with the requirements of the routine work.

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