Development of Drawing Program of Borehole Histogram Based on Delphi

Liu Yu1*, Zhang Lei1, Huang Zhengjun1, Zhang Dong1
1School of Civil Engineering and Resources, University of Science and Technology Beijing, Beijing, 10083, China
lyemilia@ustb.edu.cn

Abstract: Borehole data is basic in geological analysis in oilfield, geological and engineering exploration, and civil engineering departments, while the histogram that can visually represent borehole data is very important for extracting geological information and guide related work in the later stage. This paper develops the borehole chart automatic drawing program under Windows through the summary analysis of quantities of borehole data, based on the Delphi development platform, using the object-oriented programming method. This program can not only automate the mapping of single borehole histograms, but compare the porous histograms to draw the stratigraphic curve, so as to analyze the connection of different rock strata and their possible geological structures.

1. Preface
The borehole histogram is a comprehensive map showing the relevant information of a stratum through which a borehole passes. As one of the most basic and important maps in geological work, it boasts practical engineering significance in geological exploration. At present, there are many software for producing borehole histogram, and there are three main methods:

1) Semi-manual drawing using EXCEL, AutoCAD and CorelDraw software;
2) Secondary development based on GIS platforms such as MapObjects, MapX, and MAPGIS;
3) Mapping software that develops from the bottom by combining independent professional database based on the development platform of visual development language (such as Delphi, VC++, VB, etc.) in specific areas.

On the basis of fully referencing the functions of the existing drilled histogram software and abundant investigation, the development of this program takes Delphi7 as the development platform, using the relevant format of DXF files for drawing and the database of SQL Server2008 so as to improve work efficiency, simplify the drawing process, and obtain a pleasing, uniform, and accurate borehole histogram.

2. Program Development Platform and DXF

2.1 Delphi development platform
As a visual programming environment, Delphi provides a convenient and fast Windows application development tool. Adopting many advanced features and design concepts of the graphical user interface of Microsoft Windows, using a reusable, complete, object-oriented programming language, its compiler is the fastest one available today with the cutting-edge database technology. The integrated development environment means that all development tools are accessible through a single
control panel, thus greatly improving development efficiency.

2.2 DXF file
AutoCAD provides a format file for exchanging graphical information with other CAD systems and user programs, which is called the Drawing Interchange File, a rigorous and easy-to-read file format. AutoCAD exports graphics as DXF format files for other programs to read, analyze, and process; other programs can also generate DXF files according to the specified format, while AutoCAD can accept the DXF files and convert them into graphics.

The smallest component of DXF is the group, and a DXF file consists of multiple groups. A DXF file can be divided into multiple sections, each consisting of multiple groups and beginning with group 0 with the value of SECTION, followed by group 2 with the value representing the section name, and other groups making up the section, and finally ending with the group 0 with the value of ENDSEC. At the end of all sections, the end of the DXF file is the group 0 with the value of EOF (End of File). A typical DXF file consists of a HEADER, CLASSES, TABLES, BLOCKS, ENTITIES, and OBJECTS. This program mainly uses is the format of the physical section in DXF.

3. Program design
By using Delphi technology to design the program interface, users can adopt excel to import borehole data, and store the data in the database. They can modify the imported data by deleting, editing, inserting based on their own requirements, thereby meeting the drawing requirements. Finally, store the final data in the database for later use. The design framework of the automatic borehole mapping program is shown in Figure 1:

![Figure 1.Drilling automatic mapping program design frame diagram](image)

3.1 Database realization
The database used in the program is SQL Server 2008, which builds connection between the program and the database. The specific process is shown in Figure 2.

![Figure 2.Database establishment flow chart](image)

The SQL Server 2008 database is a relational database, in which data is logically stored in two-dimensional tables related to each other. This program mainly constructs two two-dimensional tables, namely, table of the basic information of borehole and table of the detailed information of single borehole.

Table 1 is a table covering the basic conditions of all boreholes in the site, through which users can
acquire the basic information of all boreholes, thereby understanding their overall layout.

Table 1. Basic information table

| Field meaning          | Keyword | Data type       | Empty allowed |
|------------------------|---------|-----------------|---------------|
| Boring number          | Yes     | Character type  | No            |
| Orifice height         | No      | Character type  | No            |
| Hole depth             | No      | Character type  | No            |
| Abscissa X             | No      | Real variables  | No            |
| Ordinate Y             | No      | Real variables  | No            |
| Profile control hole   | No      | Character type  | No            |
| Place names            | No      | Character type  | No            |

Table 2 is the table of the information of single borehole, through which users can know more about the information of a single borehole. By creating a two-dimensional table like Table 2 in the database, the information of single boreholes can be stored therein, which is convenient for query and use.

Table 2. Single borehole detail table

| Field meaning          | Keyword | Data type       | Empty allowed |
|------------------------|---------|-----------------|---------------|
| Serial number          | Yes     | Integer type    | No            |
| Boring number          | No      | Character type  | No            |
| Layer no.              | No      | Real variables  | No            |
| Initial positon        | No      | Real variables  | No            |
| End position           | No      | Real variables  | No            |
| Angle                  | No      | Real variables  | Yes           |
| Mining long            | No      | Real variables  | No            |
| Core recovery          | No      | Real variables  | Yes           |
| Lithology              | No      | Character type  | No            |
| Colour                 | No      | Character type  | No            |
| Rock mark              | No      | Character type  | No            |
| Lithologic description | No      | String type     | No            |

Excel can be used to delete, modify, insert the imported data, and the modified data will be stored in the database, so accidental shutdown of the program will not cause data disappearance. The storage of and access to the data is realized using the database, which can only be used locally, because the program is connected to the local database. This protects intellectual property to some extent, which is also important to database usage.

3.2 Filling algorithm and its implementation of legend
The lithology column in the borehole histogram is the core. Since this program pre-set the border width of the histogram, the width of the lithology column is also fixed with only its length changing with the thickness of the rock stratum.

The implementation of the program drawing is strictly performed in accordance with the format of the DXF file, and the pattern filling is no exception. However, the current DXF file format is relatively easy to use when it comes to the drawing of points, lines, and circles, but difficult and inconvenient when it comes to more complicated drawings. In order to solve this problem, it is necessary to find a balanced method.

Comparative research shows that each kind of legend has a pattern, and the filling of each legend is a cyclic process of drawing a smaller unit, which can be realized using DXF to draw points, lines, and circles. Therefore, compile the smallest unit of each legend into a procedure function according to the standard format of DXF using a procedural statement and store them in the program. By extracting the lithology information of each borehole, the lithology selection can be judged with the corresponding procedure functions of lithology filling legend; based on the layer thickness cycle of the layers, fill the entire rock layer with the corresponding legend, thereby completing lithology
filing.

3.3 Algorithm of lithology description with automatic line wrap

Based on the research on the storage of Chinese characters, with continuous efforts, a solution has been found. First, read the lithology description of each layer into the array, and use the length function to determine the number of characters in the description. Each Chinese word is composed of two characters, and the corresponding frame after the treatment can hold 20 words before line wrap. So, divide the number of characters by 40 and round the result up, thereby knowing the number of lines with lithological description, while the extra words can also be counted. The procedure of reading the information of the layer thickness, controlling the coordinates of the inserted text starting from the bottom is as follows:

1) Connect to the database, read lithology information of each layer into a one-dimensional array named ym
2) Use the “for” loop statement and the length function to calculate the length of lithology description of each layer and assign it to i1
3) Each line can hold 20 Chinese words, or 40 characters; round up i1/40 and assign to i2, so as to determine the number of displayed lines. If i2 is not equal to 0, it is proved that a line wrap is required, then execute 5); otherwise execution 7)
4) Initialize variable i3, which is equal to (i1-40*i1); i3 is the length of the remaining string.
5) Use the copy function to intercept the corresponding string and assign it to the array y
6) Insert the text into the corresponding position from the bottom layer of the rock
7) Insert the text directly into the corresponding coordinates

The method utilizes the storage principle of Chinese characters in the computer code, thereby realizing the automatic word wrap while ensuring the integrity of the Chinese words.

4. Realization of the main functions of the program

4.1 Introduction and use of the program interface

The program interface has six main modules:

1) Table of the basic information of the borehole, through which the user can have a preliminary understanding of the borehole layout of the entire site. It is worth noting that the information of “section control hole” can be used to decide the holes for drawing the geological profile.
2) Table of the detailed information of the single borehole, through which the user understand the details of each hole and draw a single borehole histogram.
3) The module of borehole basic information processing and query, through which the data can be imported, inserted, deleted, edited, and saved. The query can be realized through the borehole number.
4) Module of processing and query of detailed information of the single borehole, whose data processing function is the basically the same as that of the third module while their query functions are slightly different. Both tables can be queried using the borehole number; the fourth module also has the lithology query function, bringing even greater convenience to the user.
5) Drawing of the single borehole histogram, which can be realized by first selecting the scale, then selecting the borehole number, and finally clicking the Drawing button.
6) Draw geological sections. The user only needs to select the scale, and the borehole information to be drawn can be read out from the borehole basic information table. Click the drawing button to draw the diagram.

4.2 Drawing of the single borehole histogram

The following is the main process of drawing the single borehole histogram: after importing the data into the Table of the detailed information of the single borehole, select the scale, input the number of the borehole, and click the Drawing button. The file save window will pop up automatically. Then, enter the file name and save path, and click Save to complete.
By clicking the Preview button, the user can open the histogram of the single borehole. If the scale is not appropriate, change the scale to alter the size of the graphic. The program provides four scales, namely, 1:100, 1:200, 1:500, 1:1000 for selection.

4.3 Drawing of geological profile

The drawing interface of the geological profile is similar to that of the single borehole histogram, but the two also have many differences. For example, the two have the same selection of the scale and the save path, but different extraction of drawing information since the single borehole histogram is the information of one borehole, while the other is about many boreholes.

First, extract the content from the Table of the basic information of the borehole, in which the borehole with a “Yes” in the “Profile Control Hole” column will be selected as the geological profile. Then, use the number of the borehole with a “Yes” to extract data from the Table of the detailed information of the single borehole. Meantime, draw the lithology column of the selected borehole, and connect the strata of the same lithology using straight lines. The study of geological profile maps can help to preliminarily judge the geological structure phenomena such as the loss of stratum, folds, and faults.

The drawing of geological profile is conducted based on the rock layer markings in the Table of information of the single borehole (bottom layers with the same value are connected by straight lines). The missing stratum is represented by a triangular plate, as shown in Figure 3. Through the geological profile, users can have a general understanding of the stratum of the site, which is relatively flat and has a loss of stratum between boreholes 1 and 2 and between boreholes 2 and 3. There are many reasons for the loss of the stratum. Under normal conditions, erosion can lead to stratum loss; under the condition of tilted stratum, stratum loss will occur based on the location of the well; when the fault occurs, stratum loss and even stratum repetition will occur based on the location of the well. Crossover occurs between the boreholes 1 and 2. This indicates that there is dislocation between the strata, which is mainly because of the appearance of wrinkles.

Since the geological profile map only studies several boreholes in the whole site, it can only be used for the preliminary judgment of the geological structure. For further research, deeper research and analysis is required.

![Figure 3. Stratigraphic section](image-url)
5. Conclusion

This paper designs the automatic mapping program of borehole histogram and explores the related technology based on the research of borehole histogram and Delphi7 as the development platform. Case analysis makes possible the test of program function and further debugging, thus enhancing the stability of the program. The actual operation shows that the program is stable and can generate pleasing graphics. In the subsequent development research, it is hoped that more types of borehole histograms can be provided to meet the requirements of users in different fields. It is also hoped to complete the filling between the boreholes of the geological profile, so that the conditions of the stratum can be more clearly displayed, making it more convenient for users to study the geological structure of the site.

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