Optimization of Mapping Based on Points Mark

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Abstract. Mapping based on points mark is a widely used method in the process of digital surveying and mapping. The traditional mapping method based on points mark is difficult to meet the needs of rapid mapping with the use of advanced surveying and mapping instruments such as RTK and non prism total station in surveying and mapping. This paper presents an optimized method of mapping based on points mark through the in-depth analysis of the characteristics of the method, and gives the block diagram and idea of the implementation of the method based on the AutoCAD platform, in order to reduce the unnecessary information input and raise the efficiency of the elevation number mapping.

1. Introduction

Mapping based on Points mark is commonly used in digital mapping. It is a method of semi-automatically drawing digital terrain maps on a computer using points mark interactively input by users[1]. The corresponding coordinates of the point marks are looked up in data files and positioned on the screen. This is a basic function of digital mapping software.

In general, the process of points-mark based mapping is as follows: The user selects a drawing command for the corresponding surface feature in the mapping software; the user inputs the point marks of the surface feature’s corresponding measuring points according to the field sketch or the recording book, as prompted by the mapping software; the software looks up coordinates corresponding to the points mark from the data files, and positions the points on the screen; the user inputs the point-marks of the next point of the surface feature, and the software looks it up and positions it. The above steps are repeated until the last point of the surface feature is mapped, and finally, the mapping software draws the surface feature. The point marks are manually input in this process, which results in wastage of time and energy, and there may be input errors, resulting in the need to rework the entire process.

However, irrespective of the different point marks, or the process of point-mark based mapping, as well as the collection process of field data, they are more or less standardized. Due to such standardization, computer software can be used to substitute manual labor to a large extent, thereby not only improving point-mark based mapping efficiency, but also mitigating the risk of manual data entry errors[2-6]. This paper proposes a modified point-mark based mapping method through in-depth analysis of the composition of point marks and their characteristics, the collection process of field data, and the process of internal mapping. It provides corresponding mapping procedures in an attempt to create a more automated digital mapping solution.
2. Analysis of Point-mark Based Mapping

2.1 Analysis of Point Mark Characteristics
The point marks of field measuring points are codes, consisting of numbers, alphabets and underscores. The coding rules for the point marks should not only meet the need for distinguishing measuring points, but should also be easy to use by field data collecting personnel. Simplistic point marks are unsuitable for distinguishing the large number of field-collected measuring points, while, over-complex point marks increase the workload for field data collecting personnel, requiring them to memorize large amounts of coding rules. In addition, the point marks cannot be repeated in the same data files.

There are many kinds of coding rules for the point marks, however, in most cases, the point marks consist of a small number of alphabet prefixes (i.e., point mark prefix) and numbers. The point mark prefix plays a simple role in differentiating the codes (for example: differentiating the operating personnel), and in general, cannot be easily changed in the same data file. Whereas, the numbers are used to differentiate each measuring point, and enable the field collector to automatically increase or decrease the number of points, to automatically generate point marks, thus reducing input workload of the field data personnel and improving field data collection efficiency. There are frequent changes in this part of the point mark.

When a large number of measuring points are collected in the same data file, the numeric part of the point mark shows another feature of regularity, that is, among adjacent points, there is a slower change in the higher place value of the number, whereas there is a faster change in the lower place value of the number. Therefore, the numeric part of the point mark can be further decomposed into a difficult-to-change or nearly constant component (i.e., the number’s higher place value) and an easy-to-change or variable component (i.e., the number’s lower place value).

2.2 Analysis of Field Collection Process
From the process of point-mark based mapping, we can see that the method of field data collection has a significant influence on point-mark based mapping. There are different methods for field data collection of different surface features, and they require different instruments[1]. In general, during field data collection, completeness of the same surface feature needs to be considered for recording properties of the surface feature and for internal mapping[7-9]. The contiguity of different surface features also needs to be considered for collecting more points within a smaller collecting distance.

For example, when RTK is used to collect data, three corner points or two corner points and widths need to be collected for a regular four-point house; for parallel roads, the coordinates of the inflection-point on one side of the road and one road width point or road width need to be collected, or the coordinates data of the inflection points on both sides of the road need to be collected in a zigzag manner; for a low slope, the data is collected from top to bottom in a zigzag manner; for a high slope, the slope data on the top is collected first, and then the slope data at the bottom is collected (or reverse order), or else, only the slope data on the top is collected and is used with the slope height; when collecting data for several surface features, such as slopes, cliffs, steep ridges, etc. the characteristics of non-contact measurement (for prism-free feature), or where the prism head easily lifts or falls and can be positioned, can be used to collect the inflection-point coordinates according to the up-down staggered zigzag method.

From these data collection methods, it can be seen that for continuous data collected of linear surface features, regardless of the collection methods, there is always some regularity among the points. For example, for a section of roadside whose data is continuously collected, in general, the difference between the numbers of adjacent points is 1; for surface features collected in the zigzag method (such as slopes), in general, the difference between the numbers of adjacent points of upper slope and lower slope is 2. In order to facilitate the internal mapping using point marks, some simple conventions can be used during data collection of some surface features, for example: for some regular
houses, in general, 3 adjacent points need to be collected in order; for parallel roads, the last point of the point string is the road-width point according to the convention.

2.3 Analysis of Internal Mapping Process

As mentioned previously, the traditional point-mark based mapping method involves the manual input of the complete point mark for each point, in the software; the software then looks up coordinates corresponding to the point mark from the corresponding data files and draws a graph. This method doesn’t take advantage of the characteristics of point marks, the regularity between adjacent point marks and in the field data collection process. This method requires extensive manual effort and is liable to input errors, resulting in repetition and corrections of the entire mapping process, leading to overall reduction in the point-mark based mapping efficiency.

Through the above analysis of the standardization of point marks (such as the difficult-to-change prefix and high place value of the numeric part, and easy-to-change low place value of the numeric part), and the characteristics and conventions of adjacent point marks in the data collection process, the traditional point-mark based mapping method and program can be modified to some extent. This can help reduce the manual labor and automate some repetitive and standardized work, thereby reducing the workload of mapping personnel, and improve the overall efficiency of the point-mark based mapping system.

To take advantage of the standardization of the point mark, each point mark can be decomposed into three parts according to the change frequency: point mark prefix, point mark base, and point mark variable. The frequency of change of the first two parts is slow, and their input can be automated using a computer program, whereas the frequency of change of the last part is frequent, and this can be input manually through an interactive method.

To take advantage of the standardization of adjacent point strings, the input process of the point string can be modified, for example, for a section of single-line surface feature where the data is continuously collected, only its starting and ending point marks need to be input manually, whereas, the input of the interim point marks can be automated using a computer program, by adding 1 successively based on the starting point mark. In the case of double-line surface features, such as a slope, steep ridge, etc., where the data is collected in a zigzag manner, only the starting and ending point marks need to be input manually; the input of the interim point marks in the first line can be automated using a computer program, by adding 2 successively based on the starting point mark. For the second line, 1 is added to the starting point mark for the first point mark in the second line, and 2 is successively added for all subsequent point marks. In the case of regular surface features with fixed number of points, such as a three-point house, the point mark of the first point needs to be input manually, and the other two points are automatically input by the computer program by adding 1 and 2, respectively. In the case of linear surface features whose data is collected according to edge points, such as parallel roads, etc., only the starting point and ending point need to be input manually, where the ending point is treated as the road width point; the other points on the roadside can be got by adding 1 successively based on the starting point. After the roadside is automatically plotted according to the point marks, the other side of the road can be plotted automatically based on the ending point. After the roadside is automatically plotted according to the point marks, the other side of the road can be plotted automatically based on the ending point.

As mentioned previously, it can be seen that compared to the traditional point-mark based mapping method, the improved point-mark based mapping method enables automation of a large number of point marks (such as the prefix of the point mark, high place value of the numeric part, and the interim point marks of the feature) through a computer program. This greatly reduces manual input and improves the overall efficiency of the mapping.

3. Achievement and Effect of the Program

At present, many domestic digital mapping software, such as CASS, SCS, and Weltop have been developed based on AutoCAD. In order to facilitate integration with the above-mentioned digital mapping software, the author has developed an improved point-mark based mapping program based
on AutoCAD2008, using Visual C++ 2005 and combined with AutoLisp, while utilizing the ObjectArx2008 development library.[10-12].

The program is mainly composed of two parts—the main point-mark based mapping program and customized CAD commands. The main point-mark based mapping program is based on the ObjectArx2008 development library, and developed using Visual C++2005. Its main functions include: Setting and obtaining the variables, such as data file, point mark prefix and point mark base, as well as interactive input of necessary point marks, number of points, and surface features, and automatic plotting of surface features. The customization commands are mainly used to pre-input the parameters required by the main point-mark based mapping program, and to customize the command name as per requirements, so that the operating personnel can easily use the program. This part adopts AutoLisp, which is AutoCAD’s in-built development language and it uses plain text format, which is easy to modify and customize.

3.1 Main Point-mark based Mapping Program

The AutoCAD commands implemented by this main program include parameter settings (DHSetup), non-fixed point string draw command (DepDraw), and fixed point string draw command (BdcpDraw). The settings commands are relatively simple, and are used to set the name of the data file, point mark prefix, point mark base and other basic variables used for mapping.

The commands for DepDraw and BdcpDraw are complicated, and are the main component of the point-mark based mapping program. DepDraw is mainly used to plot linear or planar surface features whose number of inflection points are indefinite, such as paths, vegetation boundaries, ditches, etc. The implementation idea is roughly as follows: 1) Prompt the number of points to be input, surface feature

![Figure 1. The flow chart of DepDraw.](image)

BdcpDraw is used to plot the surface features whose number of inflection points are fixed, such as point-mark based surface features, two-point house edge, three-point house, four-point house, etc. The implementation idea is roughly as follows: 1) Prompt the number of points to be input, surface feature
codes, and the first point mark; 2) Generate a point mark string according to the variables, such as point mark prefix, point mark base, number of points, and the first point mark; 3) Read the data file, and look up the corresponding coordinate string according to the point mark; 4) Plot according to the coordinate string and set the surface feature codes.

3.2 Customization of Commands

The program is implemented using AutoLisp, which is mainly used to pre-input some parameters in DepDraw and BdcpDraw and to customize the command name, to facilitate use by the mapping personnel. Taking the three-point house in CASS as an example, the section of the customized command program (the command name adopts a simple code for the house) is as follows:

```lisp
(defun c:f3()
  (command "BdcpDraw" "3" "141101")
  (princ)
)
```

3.3 Pre and Post Optimization Comparison

Plotting a path with 10 inflection points as an example, we assume that the point mark string corresponding to the original data file is 112-121 continuous arrangement. When the non-optimized point-mark based mapping program is used (such as the CASS 7.0 point-mark based mapping program), the number of keyboard inputs for the point marks is: (3 characters + 1 ENTER button) × 10 inflection points = 40 inputs; whereas, when the optimized point-mark based mapping program of this paper is used, if the point mark base is set to 100, the number of keyboard inputs for the point marks is: (2 characters + 1 ENTER button) × 2 (starting and ending points) = 6 times. Plotting a dry land block with 50 inflection points as an example, we assume that the point mark string is AA1021—AA1070 continuous arrangement, the point mark prefix is set as AA, and the point mark base is set as 1000; when the non-optimized point mark mapping program is used, the number of keyboard inputs is (6 characters + 1 ENTER button) × 50 inflection points = 360 inputs; when the optimized point mark mapping program is used, the number of keyboard inputs is: (2 characters + 1 ENTER button) × 2 (starting and ending points) = 6 times. There is an obvious optimization effect; if the point marks are longer and if the surface feature has more points, then the optimization effect will be more obvious.

4. Conclusion

Mapping based on points mark is a kind of method commonly used by various digital mapping software. In the field mining process, it is becoming more and more common to collect all the feature points of a ground object at one time with the extensive use of advanced instruments such as RTK and prism-free total station. Thus, the regularity between the points is more obvious. Making full use of these regularities can not only facilitate the field picking, but also fully improve the internal industry mapping, thus reducing the workload of the surveying and mapping staff.

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