QUALITY DETECTION AND CONTROL FOR PAPER CHART PRODUCTION & UPDATING BASED ON STANDARD QUALITY DATABASE

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ABSTRACT:

The production and updating of paper chart is always the theme to the guarantee and improvement of hydrographic chart, in which the quality detection and control is the key to consider. At present, the production of paper chart has already achieved digital mapping with the widespread application of computer technology in the field of marine surveying and mapping. However, it is difficult to ensure the accuracy of the data of paper charts by the traditional quality detection and control methods for paper charts used currently because they have several problems such as much repeated work, low efficiency and a great of waste and so on. Aiming at above problems, a new method of quality detection and control for the production and updating of paper charts based on standard quality database is presented in this paper. This method takes a full account of the digital production technology, and achieves the quality detection and control for paper charts under digital conditions more rapidly and effectively. The prototype system based on the method presented in this paper has been developed, which can be used as a more effective tool than traditional methods to help to detect and control the quality of paper charts.

1. INTRODUCTION

It is well known that the quality of hydrographic chart production and updating is the core and soul of the whole foundational maritime information. The International Hydrographic Organization (IHO) always emphasizes the fast, perfect hydrographic products and achievements of global coverage of reliable hydrographic data (Angrisano, 2001). It is critical to establish a rigorous and efficient system of quality detection and control for hydrographic chart production and updating, which can improve the capability of automatic production and updating of charts, and ensure the quality of charts. With the widespread application of computer and GIS technology in the field of marine surveying and mapping, the production and updating of paper charts has already achieved digital mapping. The forms of hydrographic chart have changed from the single paper chart to the coexistence of paper chart and electronic chart (Zhang, 2006; Sun, 2004). Although digital charts are more and more popular in recent years, the printed charts (that is paper charts) are still very important for many users. The printed chart and electronic chart will coexist for a long time in twenty-first century (Li, 2001). So the quality detection system for paper charts production is still quite important and urgent in digital conditions.

In order to ensure the safety of navigation, the sectors of chart production and publication must update the changed information related to navigation in times in addition to providing accurate paper charts with good currency (Peng, 2003). With the continued expansion of the scale of ports in China, and the rapid development of channel building as well as safety management on the water, the charts update increasingly faster, and the updating cycle becomes shorter and shorter. Though the charts updating is a small work in an overview, the quality of charts updating is quite important because it relates to the safety of marine navigation. Therefore the quality detection and control for paper charts updating is also very significant.

At present, the quality detection and control for paper charts production and updating in China mainly adopts manual means that are done by naked eyes through personal experiences and professional knowledge. After several reviews and several revisions, the final hydrographic charts are published (Sun, 2004). These methods have many problems such as the non comprehensive of quality detection and control, the nonstandard of detection results, much repeated work, low efficiency and a great of waste and so on. Therefore, it is very urgent to develop an effective method to solve the problems of quality detection for paper charts production and updating in digital conditions especially in China.

Aiming at above problems, a new method and strategy of quality detection and control for paper charts production and updating based on standard quality database is presented in this paper. This method not only fully takes into account the chart production and updating process in digital conditions but also realizes more effective quality detection and control for paper charts through the combination of the database technology and knowledge rules thinking. This method can realize semi-automatic detection with artificial assistance and greatly improve the efficiency and accuracy of paper chart quality detection compared to the current use of quality detection methods for paper charts.

2. THE DESIGN, CREATION AND MANAGEMENT OF CHART STANDARD QUALITY DATABASE

2.1 The Definition Chart Standard Quality Database

The chart standard quality database is a database used to store the standard data in order to detect and control paper charts in the process of production and updating in digital conditions. It is the criterion and basis for the detection and control of paper charts. We can detect and control the quality of paper charts through the comparison with the data of detected charts and the data of chart quality standard database.

Not all of the chart elements are suited to be detected and controlled by chart standard quality database, which has more effective efforts to the elements that commonly do not change in the spatial information and attribute information for a long time and have regular errors, and has poor results to the elements that change too frequent. So, the design of standard quality database that can be easily extended and updated should be considered foremost in order to improve the efficiency and accuracy of quality detection based on standard database.

2.2 The Design of Chart Standard Quality Database

2.2.1 The Overall Design of Chart Standard Quality Database: Before the design of standard quality database for hydrographic charts, the classification of chart elements and the characteristics of each element should be considered first in order to make sure which elements can be detected by the strategy of standard quality database. Then we can design the structure of quality standard database based on marine chart knowledge for quality detection and the characters and mapping criterions of suited chart elements.

There are mainly two approaches to design the structure of chart standard quality database. One approach is to summarize the knowledge for chart production and updating, and the other is to analyze the characters of every suited elements. The approach to design the structure of standard quality database is shown as Fig.1.

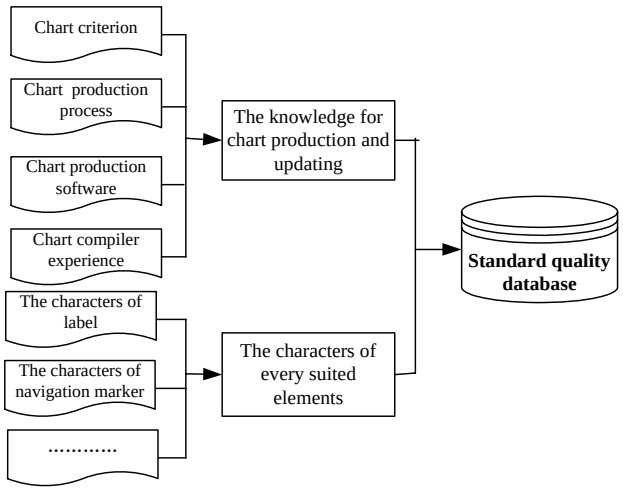

Figure 1.The approach to design standard quality database

Through the approaches for designing the structure of standard quality database, the chart quality standard database can be composed by several parts as follows: basic information standard dataset, knowledge rules standard database, chart element standard database (such as label, navigation marker, tide table and so on), and other assistant standard database, etc. The architecture of chart standard quality database is shown as Fig.2.

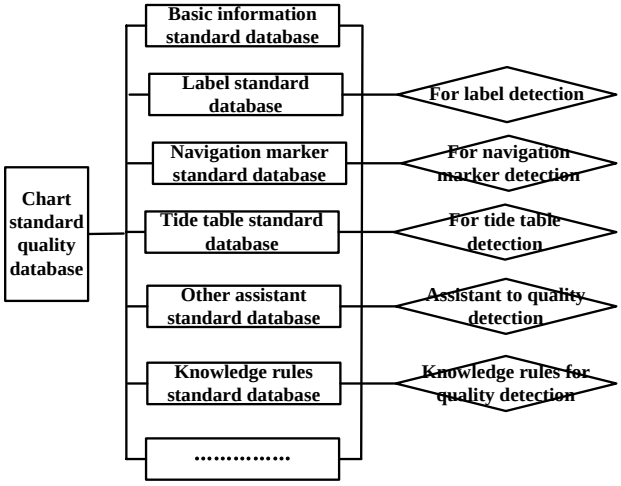

Figure 2.The architecture of chart quality standard database

2.2.2 The Design of Label Standard Quality Database: It is extremely important that the labels are in every map. So are the chart labels. The quality of chart labels can be detected by the label standard database. All of the standard label data, including Chinese labels, English labels and digital labels, are stored into the label standard database which can be used to detect the completeness of label's contents, check the rationality of label's position, judge the validity of label's colour, and reflect the veracity of object's quantity, etc. According to the difference of chart labels, we establish several different tables in the chart label standard database. The classification of labels is shown as Fig.3.

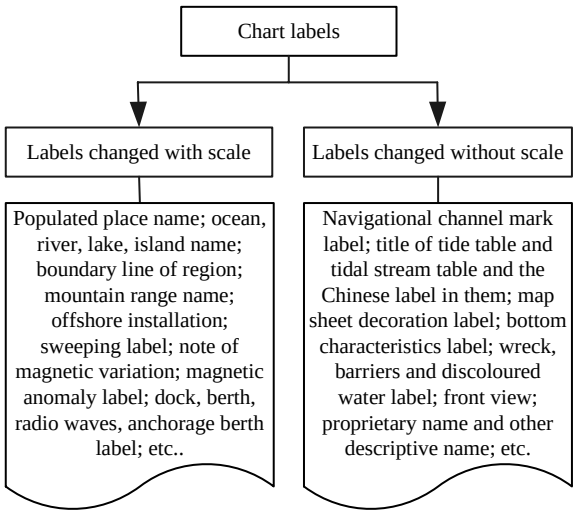

Figure 3.The classification of chart labels

Because of the difference between Chinese labels and English labels, the corresponding methods for quality detection are discrepant. So the standard database of Chinese labels and English labels should be built separately. The labels, which

vary along with the map scale, should be stored to standard database in all of the scales. While the labels that do not vary with the map scale are enough to be recorded in standard database one time. This largely reduces the work load and enhances the efficiency.

2.2.3 The Design of Navigation Marker Standard Quality Database: As an important navigation tool, the navigational channel mark plays an important role in ports and channels in China, which is essential to the security of waterborne transport and maritime operations (Wu, 2006). So the quality of navigation markers is all-important in charts that can be inspected and controlled by the navigation marker standard database.

The navigation marker standard database, including three parts: standard database of navigation marker character code, standard database of navigation marker, and standard database of navigation label character, is used to detect the quality of navigation marker. The navigation marker standard database can check the location of Navigation markers and detect the veracity of navigation marker annotations including height of light, light characteristics, and light range, etc. The structure of navigation marker standard database is described as Fig. 4.

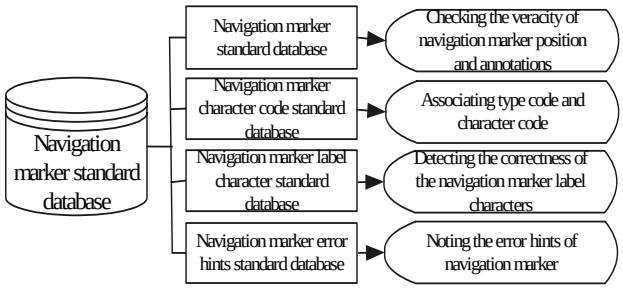

Figure 4.The structure of navigation marker standard database

2.2.4 The Design of Tide Table Standard Quality Database: The tide tables shown in charts provide basic status of tides for the Mariners to roughly calculate the height of tide and the time of flood or ebb of sea areas. The formats of the tide tables are decided by the types of the tide tables, which include three types: tabular statement of diurnal tide, tabular statement of semidiurnal tide, and tabular statement of mixed tide (GB 12319-1998).

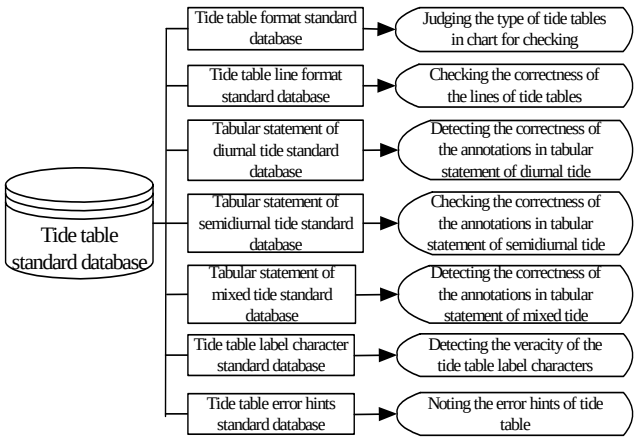

Figure 5.The structure of tide table standard database

The quality of tide tables including the correctness of the tide table lines and the tide table labels can be inspected by the tide table standard database, which includes following tables: tide table format standard database, tide table line format standard database, standard database of tabular statement of diurnal tide, tabular statement of semidiurnal tide standard database, tabular statement of mixed tide standard database, tide table label character standard database. The structure of tide table standard database is shown as Fig. 3.

2.3 The Creation of Chart Standard Quality Database

After the design of chart standard quality database, it is essential to create the standard quality database because if there are no data in the chart standard quality database, the quality detection and control based on standard quality database can not carry out. Since the creation of standard quality database is a quite time-consuming work, the effective and convenient methods must be provided.

There are mainly three methods to create the standard quality database. Relating to the existing production database is one of the methods. The method of map data into standard database is to input the existing map data checked unmistakably to the standard quality database directly with corresponding tools. And the third method is manual means that can be used as a supplement to other methods. Through these three methods, the chart standard quality database can be created exactly and rapidly.

2.4 The Management of Chart Standard Quality Database

2.4.1 The Updating and Maintenance of Standard Quality Database: In order to ensure the accuracy of standard database, the chart standard quality database must be updated in time. The updating and maintenance of standard quality database mainly includes such operations as adding data, deleting data and modifying data, etc.

2.4.2 The Security Control of Standard Quality Database: The purpose of the security control is to prohibit the data in standard quality database from being modified arbitrarily. Only the administrators or the users who have been authorized can update the data of chart standard database. This restriction can enhance the safety and ensure the accuracy of standard quality database.

3. THE DETECTION AND CONTROL MET CHODS FOR PAPER CHART PRODUCTION AND UPDATING BASED ON STANDARD QUALITY DATABASE

After the design and creation of chart standard quality database, a new method of quality detection and control for paper charts based on standard quality database can be devised to detect all the possible quality errors of paper chart production and updating in digital conditions more accurately and efficiently. At the same time, the knowledge rules for quality detection and control should also be discovered to combine with the standard quality database to design the algorithms for quality detection and control in the process of paper chart production and updating.

3.1 The Core Idea of Quality Detection and Control Method Based on Standard Quality Database

The core idea of the quality detection and control method based on quality standard database is that: Firstly, the criterions and production process of paper charts, the properties of each object in charts as well as the relationships between them and expert experience are studied and induced to form the knowledge rules of quality detection and control for paper charts. Secondly, considering the contents of chart quality detection and control, and all the possible types of errors for each suited chart element, corresponding detection and control algorithms are designed through the combination of standard quality database and discovered knowledge rules. At last, based on these algorithms, so-called COM techniques are employed to design flexible chart quality detection modules. Each suited chart element can be detected and controlled by corresponding detection module and standard quality database. The architecture of quality detection and control method based on standard quality database is shown as Fig. 6.

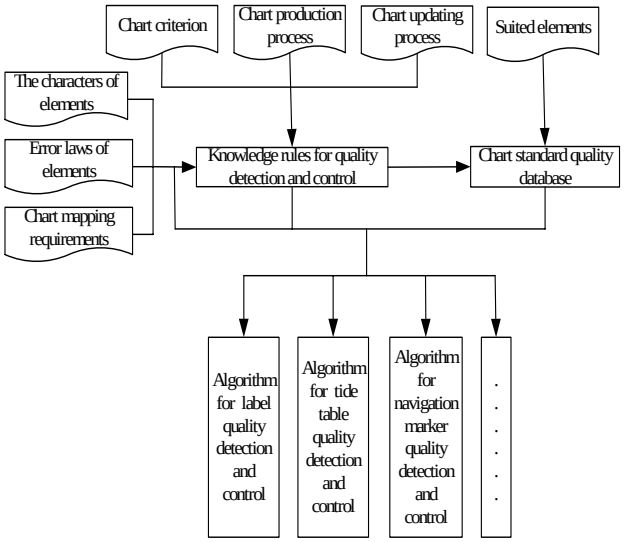

Figure 6.The architecture of quality detection and control method based on standard quality database

In this paper, the quality detection and control of three typical and important chart elements including labels, navigation markers, and tide tables are emphasized. There are several forms to express the results of quality detection and control such as error hint texts, error postil layers (using specific symbols to mark out all the wrong elements, and give clear indication of the wrong types and how to revise), and chart publication. From the detection results, the users can rapidly correct all the errors of paper chart according to the hints of these detection results so that the quality of paper chart production and updating can be controlled very well.

3.2 The Discovery of Knowledge Rules for Quality Detection and Control

In this paper, the purpose of knowledge rules discovery is to design quality detection and control algorithms that can be used to detect and control the quality of paper chart production and updating. Before acquiring these knowledge rules, the most important thing is to have a certain source of knowledge rules. The knowledge rules for quality detection and control mainly source from the following aspects:

- The existing norms and regulations for nautical charting, such as nautical chart symbols and abbreviations, chart compilation outline, nautical charting database building specification, and chart production processes etc.
- Each suited chart element's characteristics and mapping standards as well as the summarization of quality error laws.
- The cartographic requirements and criterions of paper chart updating.
- Expert experience and summarization from solving actual problems in hydrographic chart production and updating.

According to above sources, the knowledge rules can be discovered through specific methods or means. Generally speaking, there are mainly two approaches to discover knowledge rules from these sources for chart quality detection and control. One is statistical approach, and the other is classification approach.

3.3 The Quality Detection and Control Algorithms for Typical Chart Elements

3.3.1 The Label Quality Detection and Control Algorithm: The method of label quality detection and control algorithm is used to detect the rationality of label's position, the completeness of label's contents, the correctness of label's colour, font, font size, shape and interval, etc. The core idea of this algorithm is to gain the knowledge rules of chart labels firstly, then analyze the inspecting contents and all of error types of chart labels, and design the algorithm of chart label quality detection based on label standard database and discovered knowledge rules for label detection and control.

3.3.2 The Navigation Marker Quality Detection and Control Algorithm: The position of navigation marker and the navigation channel mark label, including light characteristics, height of light, light range and the colour of structure can be detected and controlled by the arithmetic of navigation marker quality detection and control. The core idea of this arithmetic is that: firstly, gaining the knowledge rules of chart navigation markers, secondly analyzing the inspecting contents and all of error types of navigation markers, lastly designing the algorithm of navigation marker quality detection and control based on above knowledge rules and navigation marker standard database.

3.3.3 The Tide Table Quality Detection and Control Algorithm: The purpose of studying the method of tide table quality detection algorithm is used to inspect the correctness of tide table line and the labels in tide tables. The core idea of this arithmetic is to first gain the knowledge rules of chart tide tables, analyze the inspecting contents and all of error types of tide tables, and design the algorithm of chart tide table quality detection based on tide table knowledge rules and tide table standard database.

4. THE IMPLEMENTATION OF PROTOTYPE SYSTEM

According to the quality detection and control algorithms based on chart standard quality database and discovered knowledge

rules, prototype system for quality detection and control of paper chart production and updating has been developed, in which the quality detection and control of labels, navigation markers and tide tables are emphasized. Meanwhile, the change detection of different chart editions has achieved in this prototype system.

In general, the prototype system mainly includes creating and maintenance module of quality detection standard database, quality detection and control module (including label detection module, tide table detection module, navigation marker detection module and so on), and different edition change detection module, etc. The framework of paper chart quality detection and control prototype system is shown as Fig. 7.

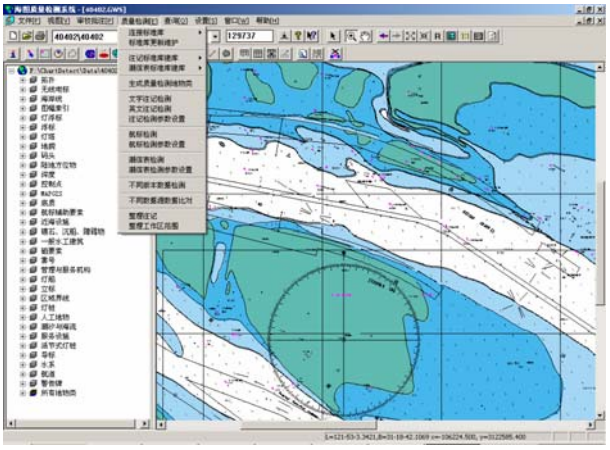

Figure 7.The interface of prototype system

4.1 The Creation and Updating of Chart Standard Quality Database

There are two parts in the operation of chart standard quality database that are creation and updating. The chart standard quality database can be created through the database-building tools in the means of manual assistance. It's quite important to accomplish the creation of standard quality database quickly and precisely. Another important operation is the updating of standard quality database that includes the functions such as adding, deleting, and modifying records and so on. Through the updating, the chart standard quality database can be integrated and up to date.

In order to create and update the standard database conveniently, the key is to define well, easily enlarged database structure and provide creating tools as well as updating tools with good capability. Only in this way, the chart standard quality database can be seen as a real, suitable standard database, and can be created, updated conveniently, rapidly and exactly.

4.2 The Quality Detection and Control for Labels

We can detect incorrect or doubtful labels in every chart by the label standard database and the label detection module. The results of label quality are in the forms of mistake hint texts and wrong postil layers. The users can modify the error labels accordingly. Several samples of label quality detection results are shown in Fig.8. The upper figure shows that the label on the label has incorrect characters. And the nether one describes an English label that has wrong positions. Through the error hints, the users can correct the mistakes rapidly.

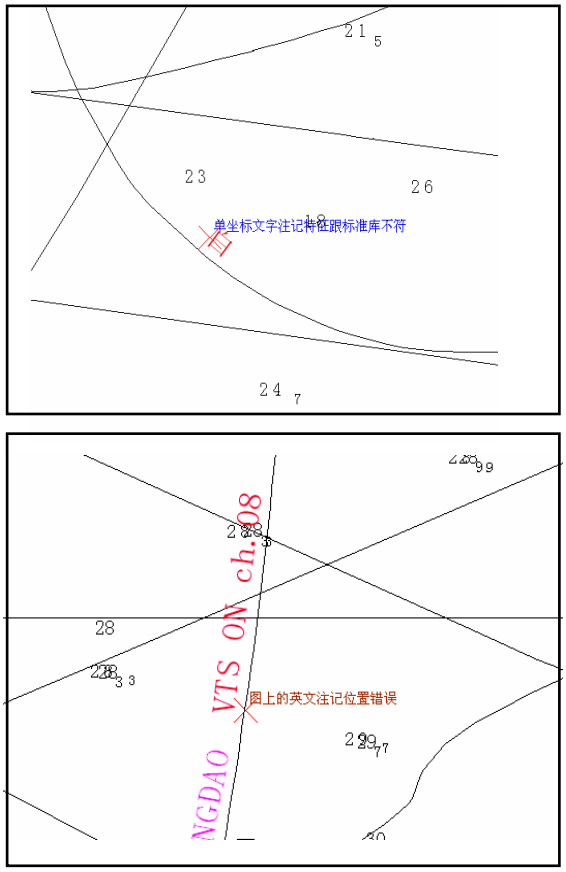

Figure 8.The results of label quality detection

4.3 The Quality Detection and Control for Navigation Marker

According to the navigation marker standard database and the navigation marker detection and control module, the inaccurate or doubtful navigation markers and the labels of them can be detected quickly. Moreover, these detected results are in the forms of mistake hint texts and mistake postil layers, which help chart drawers to modify the error position of navigation markers or the inaccurate labels of navigational channel marks accordingly. The results of the navigation marker quality detection are shown as Fig. 9.

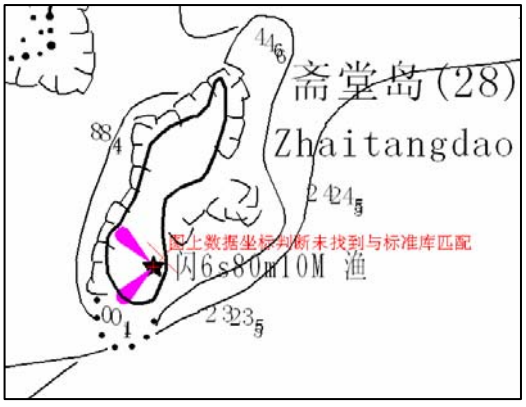

Figure 9.The results of navigation marker quality detection

4.4 The Quality Detection and Control for Tide Table

Taking the tide table standard database as the basis, we can detect the errors of tide tables, including the mistakes of the tide table lines and the labels in them, by the help of the tide table detection and control module. The quality detection results are represented in the forms of mistake hint texts and error postil layers, which are useful for chart drawers to modify the tide table errors accordingly.

4.5 The Change Detection of Different Chart Editions

The change detection for different chart editions is used to detect the difference between every two different chart editions of the same region. It is very useful to detect all the elements changed so that chart makers can track and control all the modifications of chart data in different editions, which is very important to the quality detection and control of paper chart production and updating.

5. CONCLUSION

This paper introduces a new method for quality detection and control of paper chart production and updating based on chart standard quality database and discovered knowledge rules. The accomplished quality detection prototype system has been applied in CMSAB and obtained a good evaluation. Lots of Practices have proved that this method can detect and control the quality paper chart production and updating more effectively compared with other traditional methods used currently. The prototype system realizes the semi-automatic paper chart quality detection and control with artificial assistance, reduces the workload, and greatly improves the accuracy of paper chart quality detection.

While this method is quite suitable to the quality detection and control for chart elements whose space position and properties hardly change, but for those features which frequently change, a new method in another point of view maybe needed to detect and control them. The method presented in this paper is only an exploration to the quality detection and control of paper chart production and updating in digital conditions, a further research is necessary.

ACKNOWLEDGMENTS

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