

# Research on Several problems of chart cartographic generalization

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## Abstract

As one of the basic theories and methods of chart cartography, Chart Cartographic Generalization (CCG) has been applying in the whole process of chart compilation, and it is the nuclear problem of chart compilation. If there is no scientific cartographic generalization, it will be impossible to make top-quality chart. Especially with the application and development of Chart Database System and Geographic Information System (GIS), new requirements accommodated with new theory and technology of chart cartographic have been put forward to the research of chart cartographic generalization. This article analyses the present situation of chart cartographic generalization, emphasizes the renewed attitude in condition of modern chart cartographic generalization. It reinforces the study of the regularity of cartographic generalization; the quantity, modernization, mathematics laws of the process; The study of the automatic cartographic generalization with the aid of chart computing data; the system of expert and artificial intelligence in the area of chart cartographic generalization. And it also put forward several views in research of the general approach fitted in modern time, its purpose is for the further exploration and will benefit the theory and practice of chart cartographic generalization.

## Foreword

As one of the basic theories and methods of chart cartography, Chart cartographic generalization is applying in the whole process of chart compilation, and it is the nuclear problem of chart compilation. With the modern science and technology penetrating and applied in map-making field, especially with the application and development of Chart Database System and Geographic Information System (GIS), new requirements accommodated with new theory and technology of chart cartographic have been put forward to the research of chart cartographic generalization. Thus, how to make further study of chart cartographic generalization is one of the fundamental problems that chart-makers have paid urgent attention to.

## History of the study of CCG (chart cartographic generalization)

Since there created the first original map in the world, CCG has been applied and till now it has still been applied. At that times, although map-makers didn't realize the conception of CCG, they had used the method of CCG, and they selected and generalized the symbols of chart. But conception of chart cartographic generalization

wasn't introduced to the mapping science for a long time. In the year 1921,M.Eckert first applied and described the conception of CCG. He points that the essentials of CCG exist at the selection and generalization of chart details, the main factor of CCG lies in the purpose of charts. He also emphasized the necessity of further study towards chart details. But he also considered that the process of CCG was a subjective process, lacked the disciplines, was only determined by the skill of the chart-makers. Till 1960s,chart-making fields in many Europe countries all supported this point of view. After this, the chart-making field of former Soviet had studied the generalization problems deeply and roundly. K.A.Sarlihef and other scientists had published sequentially *The Theory of Chart Making*, *The Complication of Map and Conceptions of Generalization of Scaled Normal Graphic Chart*, etc, based on completing a series of large scale charts. They also gave us a systematic, scientific discussion of CCG's principle , condition and method. They also realized the problem about the quantity of selection standard, which embodied the unite of theory and practice of map-making, and the unite of the methods and the geographic characteristic of chart-making area. And then they developed M.Eckert's attitude towards the "subjective" process having no rules, brought forward the "objective process" having orderliness. This undoubtedly is a big progress. But at that time, the conception of CCG had still been on the stage of describing quantitatively. From then on, the workers of chart-making have begun to study cartographic generalization by using mathematics laws, making CCG more systematic, mature and scientific. In 1960, the former Soviet scientist M.K.Borlochaph has published *Mathematical stat during the course of chart-making*, studied systematically the discipline of positioning of geographical symbols and the determination of some certain chart quantitave index. In 1962, F.topfer, a German, has published thesis for many times, brought forward the formula of square root about selecting objects. In 1972,he published his monograph *Chart Cartographic Generalization*, introduced roundly the application of formula of square root. In our country, in 1960s, there were also some workers labouring in the research of the method of mathematical stat, chart analyses, etc. towards the selection of residential area. They had made some achievements. In 1980s, by introducing methods of Fuzzy Set theory and photograph theory, we have solved primarily the selection of chart objects by a system of rating quota and the quantitation of structure-selecting.

Because of the rapid development and application of computer technology in the 1970s,we have explored a new way of studying and improvement of CCG .The Computer-Aid cartographic generalization has made abundant progress, solved some mathematics laws of CCG. The intellectualized study of Computer-Aid cartographic generalization has caused the recognition of the whole academia. The study of CCG has been changing from "the subjective progress" to "the objective progress", from the "describe quantitatively" to "describe qualitatively", from "handwork" to "automatic CCG", and been continuing to develop. We can believe that with the development of chart producing, the introduction of mathematical method and the application of modern technology in chart-making, there will be a propellant to the study of CCG.

## Present condition of research in CCG

It has only been 70 years since the introduction of the conception of CCG. But the theory and method of CCG has been improved continuously and now has formed a more integrated system, furthermore, CCG has played a more and more instructive role in chart-producing. Because of the trend of modernization and the application and penetration of the mathematics laws, more emphasis has been attached to the mathematics laws applying in CCG. Based on the establish and application of map and chart database, automatic CCG must be led to a higher stage. But we should also see that now there are many problems in CCG. **Firstly**, the study toward the model in CCG hasn't constituted a system. Now , many of the models belong to the quota selection model. For example, the method of mathematical stat, the root model, the diagram calculation model and the regression model, etc. Those methods have only solved the number of selecting-details, but how to select has still been a problem lying ahead. Structural-selecting model is determined by the shape of the object and the distributing density. This model consider not only the qualification of selection, but also consider the objects that should be selected. Compared with the model of quantitatively selecting, it has further advantages. But there are also many inconvenient; **Secondly**, as an integrated process, there are many problems that haven't been or can't be modelized. **Thirdly**, during the course of cartographic generalization, the quantitatively CCG hasn't systematic and rigorous, the quality of CCG is greatly decided by the experience and technology of the CCG worker; **Fourthly**, the present Mathematical Models of Cartographic Generalization are not applied much in the producing process. For example, the selection grade of sea depth will be 4, and the selection grade of river will be 2, but these aren't applied in the course of CCG; **Fifthly**, the study of the mathematical model of CCG haven't been met with the data-based automatic CCG, some calculating methods need to be further studied.

The cause of these phenomena involves many aspects. For one hand, to consider this subjectively, we haven't done well with the relationship of the complicity of the mathematical method and the simplicity of the offering product. That is, the mathematical model of CCG is complicated, while the researchers couldn't present us a product that is simple and easy to be applied. And the product which is applied lacks a widely application. The researchers are usually demonstrated the theory and method's accuracy and feasibility through selecting the statistical stylebooks in the partial area; but the map-producing department need an applied product that is widely practiced; Thirdly, in the practice of chart-producing, there always exist a contradiction between the application of mathematical model and the experience. They did not realize the unity of the two aspects. In fact, all the mathematical models of CCG include the summary of the working experience. For another hand, to see this objectively, there is a obviously mismatch between the trend of the higher technology used in the study of the theory and method of CCG and the present working method of CCG. To some extent, the mathematical models of CCG and some calculating

methods have provided an opportunity to computer-aid CCG. But, the process of CCG is a complicated and creative work, among the process, the experience、knowledge and intelligence of CCG workers all play an important role. Till now, man's thought and reasoning can't be described by mathematical method. Therefore, it is essential to study CCG through mathematical method, but it isn't exclusive to solve automatical CCG, we need to explore a new searching way.

## Several problems of the CCG

Not only the graphic information based CCG or the cartographic data based CCG, there are many problems to be solved.

### Firstly, renew the concept of the CCG based on modern Chart Cartographic

People have different views towards CCG at different stages. As the emergence of modern digital chart , the traditional concept of CCG will be inevitably impacted. Therefore, people have to consider the renewal of CCG concept in the digital environment. Actually, we have made some significative discussion. For instance, the International Cartographic Agency(ICA) has defined CCG as “the selection and simplify of the fragment part according to chart scale and purpose” in the book *The Dictionary of Several Cartographic Technical Terms*; RHIND’s defination of CCG is as follows: because of the development of the change of chart scale and purpose ,through contracting contents of the information on the chart ,CCG is a tool to improve the user’s whole sensitivity of the data”; A Russian scientist regarded “the course of CCG as the transfer of information”. The Generalization can be divided into two parts: Scale generalization and Purpose generalization. The former is called “information contraction with scale”, the later is much more embodied “the information transfer”; R.knoepfli discussed the relationship over CCG and the theory of chart sensitivity, they consider that the course of CCG embodied such concept , i.e. “with the least data transfer while making the user acquire the most information”; Some scholars consider CCG through “the structure of information”, others discuss CCG with the point of view “chart sensitivity”. Our country’s experts in the map-making aera suggest that through the combination of the alternating compilation function of chart database、the function of searches and the function of CCG ,to solve the problem of the CCG.

Now there are still some problems waiting to be solved.

### Secondly, strengthen the research of the ruling CCG and the quantitative , modeling and calculating study.

There have been various opinions toward the cognition of the discipline of CCG. Some consider that CCG is a subjective course, and there is no law in it, only is decided by the chart worker’s technology and experience. This opinion is unilateral. In fact, the spatial distribution of chart materials and the relationship of each other have some initial discipline. Of course, there are also disciplines in CCG. Many disciplines have been discovered and summarized. With the development of the modern technology in chart-making, it is much

more urgent to recognize and explore the objective disciplines of CCG. We should make further study improve the experts' experience and intelligence of CCG , find the initial rule .For instance, the purpose of the chart、scale and the features of the mapping area that embodied the logical relationship and material expression, some concrete rules using in different chart area,--all of the above should be well studied and summarized. The critical problem of CCG on discipline is to quantitative、model、calculating. At present, in the regulation and outline of chart cartographic and compiling, the concept and method have still limited in the qualitative description, lacking a definite standard. For example, in the generalization of such line object as the coastal and river elements, they need to maintain a contrast in different areas. This is inevitably true. But how to master a quantitative standard ? And what extent can be fit? Such problems all need a definite, suitable standard. Or, in the definite generalization practice, the workers themselves couldn't attain a unite, harmonious criterion, and that will not do good to the automatic CCG. There are many phenomena ,many elements that can be described by mathematical model based on analysis,simplifying and abstraction. At present, the mathematical models of CCG mainly involve mathematical models of characteristic distribution: they usually involve the model of the decreasing exponent distribution (e.g. the distribution of length of the curve coast、the length of river) and the model of normal school (e.g. the distribution of height of various relief). There are also models of materials-selecting (e.g. root model、the regression model、the equal ratio etc.). Some course of CCG may be arithmetical models. All of these will improve the scientific of CCG by hand and accelerate the realizing of Computer-Aid CCG. That will be significant.

*Thirdly, strengthen the study of automatical CCG sustained by database*

Automatical CCG is one of the main reasons that restrict the automatization of CCG programming, it is paid much attention to. The development of the modern CCG technology is towards “ the computerize of CCG process, the databasize of the chart data”. The former is determined by the chart data. The later provide the basic data to the computer-aid CCG, and the various functions and the perfect inter-graphical complication functions, have created conditions to realize computer-aid CCG. Though we have achieved many products, but the present various databases built, mainly belonging to the systematic charts having certain scale and database. When we need charts or database or the output graph that having reducing rate, there will be some illogical in the capacity of chart limit 、the graphical expression extent and the treatment of the materials' relationship because of the restriction of the functions of CCG. So, we should strengthen the study towards the automatical CCG aided by the chart database. That will quicken the process of automatical CCG.

*Forthly, exploring new method of CCG that is suit to this information age*

Our world has entered a new age—information age. With the development of GIS technology in the information highway and all kinds of scientific theories and

methods, we are confronted with the new challenge in the management of chart cartographical information and we also bring forward new theory and ability. At present, there has been some certain achievement in the new technology of CCG based on the theory of manual nerve center internet、divided dimension theory、small-wave theory. The nerve internet is a mathematical model that abstract、simplify and simulate the fundamental characters of human brain based on modern achievement of nerval science. And this model is fit for parallel treatment. The training course actually involve the collection and expression of manual CCG, this is inevitably provided a new consideration ; Divided shaping is some complicated geometrical objects that have familiar structure, the nuclear problem is the self-familiarity, the character quantity is the divided dimension ,the unique trait is that it has no scale in the character. The determination of the divided dimension may have many definitions and calculating methods. Some generalization objects may be solved by calculating divided dimension and may be quantitative the structure of it. Because there are many statistical self-familiarity, the divided dimension is suitable to automatical CCG. It can provide quantitative index to the shape and the complexity extend and therefore providing simplified mathematical model. This is very significant to the research of CCG. Furthermore, in the GIS environment ,the method of CCG , the research of the internet automatic CCG system and tool mainly based on the customer computer-service equipment model、and the exploitation of various database analyses and searches software that fitted to the need of chart clients – all of these will play an important role in the study of CCG.

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