CHALLENGES AHEAD FOR THE MAPPING PROFESSION

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ABSTRACT

Cartography is in a stage of revolutions. The multi-purpose maps of yesterday, essentially descriptive, static and deterministic are now conceptually challenged by new map products which are extremely volatile, single purpose and probabilistic. The realm of cartographic activities has expanded towards the portrayal of highly abstract geographical spaces. The traditional function of maps as spatial storage device is on the decline, whereas their communication function and analytical power are increasingly emphasized.
Parallely, the multiplication of 'do-it-yourself' micro-computer mapping kits, the emergence of cartographic expert systems and the incorporation of mapping activities within the wider realm of technologies for geo-information production are challenging the integrity of the cartographic discipline.
An attempt is made to investigate the origin of these recent developments and to speculate on the practical and theoretical implications for the mapping profession.

INTRODUCTION

Maps are tools to acquire, analyze and communicate spatial knowledge. Their history is closely related to the history of man who always felt the need to increase his knowledge of the surrounding spaces in order to better exploit the resources required for his survival. For a major part of this history, maps have been used as spatial records of planimetric and, more recently, topographic information. Maps were mostly viewed as symbolic representations of the visible space, with various degrees of abstraction. The map products were essentially descriptive, static and deterministic. Map querries were geometrical and related to place locations, distances, orientations, areas and elevations.

With the advent of computer, remote sensing and geographic information systems, the nature of maps has undergone a dramatic change, however. Most of the maps of today are thematic maps, which emphasize the attributes of places rather than their location. They often give a probabilistic view of physico-socio-economical phenomena that are not thoroughly commensurable. They portray a temporary view of a world which is changing faster than it takes to produce them. Finally, their look is more than ever influenced by the use of highly versatile sophisticated graphics which may enhance or destroy their power of communication.

It would be erroneous to think that these new developments were strictly a result of the computer revolution. Computer technology only provided the means for such transformations to occur. In the history of science, problems often appear to come along with their solution. In this case, computers were used to bring about a new cartography capable of providing solutions to the problems of managing large amounts of thematic and topographic data. Following are examples of the new challenges faced by the cartographic profession.

INFORMATION EXPLOSION

We live in an information society. In the United States it has been estimated that more than fifty percent of the Gross National Product stems from information-related areas and less than fifty percent from manufacturing. Furthermore, it has been estimated by different investigations that annually, somewhere between 9×10^{11} and 2×10^{12} images are printed world-wide. This means about one picture per day per capita. Hence, the trend towards non-verbal communication is strong and is increasing. Part of those images are used to communicate scientific information and appear in the form of statistical graphics and maps. Specifically, there is a need to portray an increased amount of spatially referenced data which has expanded beyond the narrow limits of the portrayal of the surface of the Earth. We are at a time of new explorers who do not travel across the oceans and continents, but who explore and collect data about the fabric of our physical and socio-economical environment. They are busy stacking up information related to the subsurface of the earth, the atmosphere, the geography of populations and socio-economical activities. The value of this information increases with the worldwide increased human pressure on the environment, the disruption of the earth ecosystem, the urban growth and the threats of destruction of our resource base. This information, however, needs to be organized, analyzed, and interpreted in order to be used by the planner, the resource manager, or the politician. An essential part of this "digestion" process is done through visual analysis of spatial data depicted in the form of maps. In this respect, the cartographic profession faces two challenges:

1) how to respond economically and efficiently to those map needs at a rate which <u>usefully</u> follows the extraordinary growth of digital data bases, and
2) how to provide an optimal answer to the problems of rapid updating at a time where the life cycle of environmental and socio-economical data is often shorter than the map production cycle.

DEMOCRATIZATION OF THE DECISION MAKING PROCESS

The principle of delegation of power and decision in democratic societies can only be implemented if there is a liberal access to information. In turn, this requires a distributed network of information sources and communication which are available at the various levels of government. Modern technology provides the means for data communication through satellites, telephone lines, cabling and fiber optics. Furthermore, micro-computer based geographic information and mapping systems now give the possibility to analyze the data and produce the maps at the lowest level of authority where the interaction between the mapper and the user can take place most efficiently.

A challenge for the surveying and cartographic profession is to provide the guidelines which are required for efficient data exchange and communication. Another challenge is the delegation of responsability for data maintenance. Traditionally, national mapping agencies have been responsable for the creation and maintenance of national mapping programmes. Provincial and municipal authorities are now custodian of their own maps as well. Should they be left alone in insuring the updating and maintenance of their own data? Do they have the financial means to do so? One must find a formula which insures a firm control at the national level for data integrity and maintenance with the necessary degelation of power and accountability at the local level as well.

Another aspect of the democratization process is the increased liability of local governments for the management of their own resources. The saying goes "local problems are best solved locally." The recent spread of geographical information systems at the municipality level illustrates this trend. The distinct function of maps in the GIS tool box is of particular significance for cartography. For the first time in the long history of mapping is the map <u>systematically</u> recognized as a procedural tool for the simulation, modelling and interpretation of spatial processes. Some investigators have gone so far as suggesting the emergence of a new map era: the algebra of maps or parametric mapping. Maps are variables represented as organized sets of numbers and, like in traditional algebra, can be added, subtracted, exponentiated and logically sequenced to form equations. The spatial coincidence and juxtapositioning of values among and within maps create new operators, such as proximity, spatial coincidence, and optimal paths (Berry, 1987). GIS technology has revolutionized the way we handle or use maps. Along with other professionals, cartographers have shifted their dependence from pure graphics to an increasing dependence upon digital databases and spatial theories. Part of the cartographic community may have some difficulties in accepting those changes, particularly for those cartographers who view themselves essentially as symbolic designers or graphic communicators. But this revolution merely goes back to the traditional geometrical roots of cartography with the added power of matrix algebra and spatial statistics.

The use of maps as spatial operators in the decision making process is not without problems, however. Many spatial relationships cannot be adequately quantified. A theory for spatial statistics is only emerging, and one does not know adequately the effect of spatial uncertainty in the manipulation and the combination of maps.

INCREASED ABSTRACTION OF SOCIAL/ECONOMICAL COMMUNICATIONS AND MOVEMENTS

Cartographers are used to deal with non-Euclidean geometries to resolve the equation of the spherical surface onto a plane. The mapping of socio-economical spaces is much more elusive than the mapping of the earth surface, however, and goes outside of the Gaussian or Riemanian classical differential geometries. The notion of distance between people and places is very much depending on the means of transportation or communication and is rarely consistent with the measure of geographical distance. Time distances, cost distances or physchological distances are often prevailing over geographical distances and require to be mapped in order to understand and predict people's behaviour. There has been much study but little success in the cartography of socio-economical distances, for the obvious reason that the traditional map format which implies a continuous metric space is not well fitted to the metric inconsistencies and discontinuities in the numbers of hours, dollars or kilowatts that separate people and determine people's interactions.

Cartographers face here a new challenge which is more than just an intellectual curiosity:our ability to understand, control and monitor the multilayers of space which make up the fabric of human relationships will depend on the means of analysis and interpretation which are made available to the planner and the decision maker. New forms of data portrayal will have to be invented for this purpose. Geometrical, topological and thematic relationships between spatial elements will have to be encoded and structured in such a way as to allow for easy and fast spatial querries, spatial analysis and conceptual generalization based on context rather than single geographical objects.

It is interesting to note that the advent of digital cartography, for the most part, has done little to promote new cartographic products. Most efforts in the development of cartographic software have been directed toward the emulation of manuel cartographic products of high graphic standards (Goodchild, 1988). That is, we still think of a spatial representation as something pressed flat on the finite dimension of a piece of paper or the screen of a graphic station. We still think of a map as a visual product where graphic appearance holds priority over content in data quality and resolution. A challenge for the cartographer will be to extend his activities towards the manipulation of the invisible part of the landscape model, where data are unclassified and ungeneralized, where lines are fuzzy and areas heterogenous, within the framework of a multidimensional space including time. A stronger involvement of cartographers in "pre-cartography" will emancipate cartographic thinking as dictated by a platonic view of a world made of ideal forms and help design cartographic products where "what you get you cannot see".

Recent developments that will contribute to that emancipation are the introduction of raster technology (in which the physical domain is reduced to atomic objects), hierarchical data structures leading towards multiresolution representation and the advent of dynamic three-dimensional stereo perspectives on a Tektronix screen which allows the eye to look "behind" the scene.

WIDE ACCESS OF TURNKEY CARTOGRAPHY WITHOUT CONCOMITANT SPREAD OF CARTOGRAPHIC KNOWLEDGE

A new phenomenon has emerged recently which may be potentially disruptive to the all evolution of cartographic science: the multiplication of commercial micro-based computer packages which allow the user to make his own images without the costly help of a cartographic expert. The reduction in cost of computer hardware for the production of graphics and the recent development of mini-based computer cartography software are the main reasons for this upsurge. On the one hand one may welcome such development, as it will enhance the role of maps in the analysis and communication of spatial information by extending the use of cartographic products to a wider circle of society which normally could not afford them. Such development also reinforces the present trend toward customized cartography where maps are produced for a few individuals in order to respond to specific queries, at a time when the social role of general purpose topographic map series appears to be on the decline. Customized maps are typically very specialized and have very short life cycles. They are more like working maps which are thrown away once the problem at hand has been resolved. Hence, they must not be very expensive, they must be quickly designed and strictly limited in scope.

The emergence of micro-based computer packages apparently provides a technological response to those requirements. The user can now produce his own specialized map quickly and cheaply. Hence the traditional separation between map makers and map users is disappearing. One may expect that the quality of maps and the evolution of cartography as a tool for spatial analysis and communication will be greatly affected by this new generation of self-made map makers who have had no cartographic training but who have the tools to make maps through simple turnkey devices. As a result, one could think that cartographers will loose control of the evolution of their own discipline. Several indications point towards this direction. Cartographers have had so far little input or control in the production of micro-computer cartographic software, whose main developers are coming from the computing science disciplines. The user of those packages usually has no interest in cartographic principles and is only interested in learning the operating system which will allow him to produce the map which we believe will best fulfil his needs or interests. There are practical and philosophical implications related to this new development.

The basic models of cartographic communication, developed in the seventies when the production of maps was still monopolized by cartographers, will have to be changed. The user is not only the receiver, but the transmitter as well. The social and cultural biases of the user's mind will occur upstream in the map communication process. One might further argue that noise will be reduced, since one (the cartographer) does not talk to somebody else (the map reader) but rather talk to himself.

The danger, of course, is the loss of the so-called "neutrality" of the expert cartographer who was striving for scientific integrity. An additional problem is the lack of cartographical skills. I am not referring here to the ability to draw lines and symbols, but to the various domains of knowledge which are required for designing a map, including a basic understanding of geography, spatial processes and graphicacy. Our secondary school curriculums usually give little training in those areas. Hence, the user will be provided with a tool which he probably does not know how to use. Since one cannot undertake the cartographic training of the thousands of potential users who are going to improvise map making, we will have to research the possibilities of implementing 'intelligent' front ends to the cartographic execution programs, preferably in collaboration with the commercial vendors. This front end may take the form of a cartographic expert system which emulates the expertise of a human cartographer and provides guidance to the naive user. Knowledge engineering of cartographic expertise in order to build the knowledge base of such systems will not be easy. It forces cartographers to analyze and to formalize the decision process which leads to the making of a map. Hence academic cartography will be forced out of the textbook to be confronted against judgemental rules which must be agreed upon by everyone. There is some doubt as to whether or not a consensus can be reached about the procedural aspects of map design, which is essentially a subjective, nonrepetitive and hollistic process. It seems that only the simplest aspects of graphic semiology can be agreed upon, such as the adequation between measurement scale and graphic variable, for which we do not really need an expert system! Perhaps developing "negative" ("idiot proofing") systems to discourage dangerous practices is a more realistic undertaking than prescribing mapping choices, since it seems easier to agree on what should not be done. The idea of idiot proofing systems for GIS applications has already been suggested by David Rhind (1988).

CONCLUSION

One can observe several trends in the recent development of cartography, both in response of the global demands for spatial information as well in promoting new needs for information by increasing the public awareness that spatial information may be obtained and can be used for planning and policy making purposes:

1) At a time when the social and economical relevance of the traditional large scale, multipurpose analogue mapping series is increasingly hard to justify, thematic map products, in analogue or digital forms, are rapidly expanding. The simultaneous growth of remote sensing and GIS technologies and the extraordinary development of national and regional census agencies are partly responsable for this expansion.
2) The life cycle of maps is becoming increasingly shorter. Up-to-date maps are required to portray the rapid changes in economic development, resources, environmental pollution and urbanization.
3) The traditional function of maps as spatial storage device is on the decline, whereas their analytical and communicative functions are now stimulated in another form through the introduction of GIS technology and high quality computer graphics packages.
4) New forms of spatial representations are being investigated to depict non-metric spaces, subsurfaces, the time dimension and the fuzziness of spatial objects.
5) GIS technology has revolutionized the way we use maps. Maps are now systematically used as spatial operators to analyze and experiment the interaction between the various layers of physical and human geography.
6) Maps are increasingly produced for one purpose for one single user. This trend towards customized mapping was made possible through the combination of computer-assisted cartography, computer graphics, remote sensing and GIS technologies.
7) The traditional separation between map makers and map users is disappearing, with the map client being able to produce his own maps on demand with a computer cartographic package. Hence, the models of cartographic communication developed in the last twenty years are now somewhat irrelevant. The major issue is whether the user can communicate to himself via the map channel which he creates.

There has been too little time to appreciate the effect of these recent trends on the theoretical fabric of the cartographic discipline. Where will cartography be ten years from now? With the GIS and remote sensing revolutions, maps appear to be losing pre-eminence. They are increasingly viewed as by-products of technologies for geographic information extraction, modelling and interpretation. Some even doubt "whether an entire discipline will still exist to make and study [maps]...; most likely expertise for creating maps will reside within the tool-creating enterprise that is increasingly being referred to as "spatial data handling" (Petchenik, 1988). Others fear that "automated mapping techniques which could be used as a tool to multiply human cartographic capability, may evolve increasingly into tools which are independent of humans" (Gallant, 1987). This statement refers to the (unrealistic) prospect of full-fledged cartographic expert systems. The present trend towards "do-it-yourself" customized maps on demand may appear threatening to the professional cartographer, but so did photogrammetry for the land surveyor. As professions are being challenged, they are forced to critically review their activities, expand their skills and explore new areas of endeavour. The remarkable development in recent years is the increasing awareness of a communality of goals between surveyors, photogrammeters, cartographers, geographers and other spatial scientists towards the production of geo-information. The joining of forces appears to be an obvious answer to the challenge of survival, as each discipline is individually incapable to cover the scope of technology and knowledge which is now required for the production of geo-information.

The research agenda for automated cartography in the 1990s, therefore, will have to include many disciplines. Fundamental questions, such as the following, will have to be answered: (1) What kind of information can be imparted to cartographic expert systems? (2) What are the criteria and priorities for developing cartographic software in a desk top publishing environment? (3) How can we handle the time dimension in our cartographic displays? And (4) How can we operationalize the process of automated map generalization in a hollistic fashion? A comprehensive research model that will integrate the many technologies involved in the production of geo-information is required. Such a model would act as a clearing house for knowledge, and it would eliminate duplication of ad hoc research initiatives undertaken on either side of discipline boundaries. The identity of the cartographic discipline may become increasingly fuzzy in the process of this evolution, but the role of maps as modelling tools will become potentially more valuable.

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