THE MISGUIDED EVOLUTION OF FUTURE MAPPING TECHNOLOGY

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ABSTRACT

Efficient fully automated mapping systems are impossible to achieve with current technology. As we move towards a higher degree of automation and sophistication, there exists an underlying assumption that faster and more accurate automated computer mapping systems will be the primary components of future cartographic production. So far the design approaches taken to develop these production tools have not fully considered the human interaction necessary for efficient map production, nor sufficiently addressed the automation problems of map production. In this context the components of a conceptual automated mapping system, aimed at including the human factor to support efficient cartographic production, are explored.

INTRODUCTION

The development of a computer system that will generate maps should be designed with the expected level of computer expertise of the systems' user factored into the design from the beginning. The integration of the human cartographer in the architecture of automated map production systems that exist today, would have made them more productive in less time. Compounding this inherent flaw is a trend to task persons such as electrical engineers, mathematicians and computer scientists with little or no formal training or experience in cartography or imagery analysis to develop functional map production systems. A little knowledge can be a dangerous thing.

I don't intend to rehash the previous discussions of 'man vs machine', or evaluate the same questions concerning what part 'man' should play in the computer mapping process. Instead, I will offer an approach to automated mapping that I consider to be unique and innovative for the discipline of cartography and industry of computer mapping. My approach includes the active involvement of human cartographers throughout all phases of the automated mapping process.

To reach the stated goal of this paper, I will briefly trace the evolutionary path of automated map production systems. Following this background discussion there will be a look at the current state of automated mapping systems and the major flaws inherent in their architecture. Finally, future directions are explored through the presentation of a conceptual automated mapping system for current and future needs.

EMERGENCE AND DEVELOPMENT OF COMPUTER MAPPING TECHNOLOGIES

Tasking computers to generate and manipulate spatial information for mapping purposes is a process that has evolved rapidly since the 1960s. In earlier phases of computer mapping much of the production process was done in batch mode and focused on numerical analysis. Output was in the form of graphical representations such as bar graphs and charts which attempted to portray a particular mapping theme. Automation of cartographic processes and methodologies to portray spatial information in map form were slow and time consuming. Also, final graphical representations of mapped information were crude and simplistic.

In the mid 1960s to early 1970s there emerged an effort to develop new methods and technologies which would offer a more productive alternative to early automated mapping processes. Electronic displays for graphics improved, and minicomputers made mapping systems more economical. Some of the first functional computer mapping systems with an interactive component/capability emerged during the 1970's.

By the early 1970s imagery from orbiting space satellites emerged as a possible major source of information for map generation. Such satellites as the Landsat series beginning in 1972, and space programs such as Skylab, Gemini, and Apollo helped propel the discipline of cartography into a new age of digital awareness.

Despite the problems inherent in the development of computer mapping systems such as map accuracy, scale change, orientation, data sizing, etc., work continued towards development of faster and more automated methods of map generation. As a result, a large part of mapping hardware and software development over the past several years has focussed on 'faster' methods of trying to store, access, manipulate, and process large amounts of digital cartographic information. These developments helped set the stage for the misguided evolution of future developments in cartography by placing less and less emphasis on human cartographic knowledge and skills.

The use of computer graphics to simulate map characteristics and display results on a terminal screen, eventually evolved into an art form of its' own, and along with this new art form came the overlooked and as yet unanswered questions of digital standardization. Questions about digital cartographic issues involving map symbolization, color, size, style, etc., were far more numerous than answers and as varied as the computer graphics organizations themselves.

Fortunately efforts like the Federal Interagency Coordinating Committee on Digital Cartography (FICCDIC), and the National Committee for Digital Cartographic Data Standards (NCDCDS), are attempting to sort out and place in perspective some issues regarding digital cartographic standards. This type of digital standards research holds a great promise for approaching excellence in processing digital data through a cartographic computer system, and turning it into useful map products

CURRENT APPROACHES

In order for some automated mapping organizations to maintain a high productivity, and an economic return on their investments, there is a tendency to have staff specialized on one instrument of the mapping process (BIE 1984).

A similar approach is used in development of mapping software, whereby different cartographic operations are segregated and tasked to a particular software designer to package. Thus we have got the names placement package, the symbology package, the generalization package, and so on. The synthesized skills of a human cartographer are modularized for computer imitation and the resultant mapping system is not unlike a robot-run automobile assembly line. However, with human specialization there is a decrease in knowledge and skills that are exchanged between stages in a map production process (BIE 1984).

Therefore, computer mapping organizations should be considering, to what degree loss of cartographic knowledge and skills are accumulating throughout the computer mapping process, since rarely do the same persons, or persons trained in cartography, develop the assortment of mapping packages that are combined to make one mapping system. And although various packages are tested for functional compatibility, there doesn't appear to be any testing of the viability of the map products it can turn out, which is a test of the effectiveness of any cartographic production system.

As the design of automated map production systems has matured and evolved, a variety of techniques such as artificial intelligence, automatic pattern recognition, and syntactical analysis, currently being used in the mapping industry have been implemented Unfortunately automated mapping techniques conceptualized as a tool to multiply human cartographic capability, are now evolving into tools that are independent of humans. The developers of expert systems such as ACES, which is "an attempt to capture the expertise cartographers use in the labeling process", concluded that much of the map labeling process can be automated, and to them it was clear that many other cartographic tasks could be applicable to artificial intelligence techniques. (Pfefferkorn, Burr, Harrison, Heckman, Oresky, Rothermel, 1984). ACES is a prime example of the potential misuse of technology.

FUTURE DIRECTIONS

Major developments are already under way in areas of knowledge based systems and parallel processing hardware. These directions will likely continue into the future. However, in order to achieve an efficient automated mapping system designed to produce accurate and effective maps, a new direction for computer mapping is needed in which the unique human cartographic capabilities are identified explicitly and then fully integrated into the overall system design. A good place to start in designing an efficient automated mapping system is to maintain and consult cartographic knowledge gained over past centuries, and seriously consider the question/goal of whether a fully automated mapping system is a good idea that represents a true advance in cartographic production. An overview of the conceptual system I am recommending is given in the following paragraphs.

The first step towards design and implementation of this conceptual system, is to require a cartographer to become a major part of the initial design and implementation team. This will ensure that software packages and commands used to generate a map be compatible with accepted cartographic practices (Figure 1).

The next sequence of steps will require a cartographer working with an image analyst, to evaluate hardcopy digitized/scanned material and digital satellite imagery for use as base information, prior to being placed in external storage, or made part of the computer files (Figure 2).

Completing the previous tasks, the manipulation process for further reviewing, correcting, and enhancing cartographic data must be performed by a cartographer In the case where satellite imagery is used as a basis for creating maps, the cartographer would work along side of an image analyst At this level of the map design the image analyst would serve as a consultant in interpreting imagery data with relation to spectral signatures, relief displacement, vertical exaggeration, and multiband comparisons of imagery information which could be used as a spatial information foundation from which the cartographer could build a map.

It is at this level of the system that a cartographer will have most interaction with the system when compiling information for a map. Here the operations of a mapping system fall into two categories, functions that act upon data without change, and functions that act upon data with change. However, a cartographer sitting at a terminal can halt, or change any operations as they occur. It is these functions that will require most development in the future if we are to allow for maximum human interaction (Figure 3, upper left corner).

Once a desired data combination is reached the file is then sent to the 'automatic' part of the mapping process. This step is envisioned as merging multiple planes of information into one plane (Figure 3, lower left corner). After this is done the suggested output product configuration is evaluated by the cartographer for acceptance or rejection. This would ensure that the output product contains appropriate information for use by the intended user (Figure 3, right side).

CONCLUSIONS

The evolution of computer mapping systems has benefitted the practice of cartography by providing better tools for the more rapid display and manipulation of compiled information. Additional work to improve this capability should be continued. However, automated mapping system architecture lacks the basic experienced based knowledge (know-how) necessary to identify, evaluate, and correct badly designed maps produced by automated processing. Currently, only an experienced cartographer can make the final decision, judgments about whether a particular arrangement of symbolized graphic data in map form will effectively communicate to the products' users Therefore, future developments in mapping systems should be centered around using the computer as a cartographers tool. The focus should not be a system as a substitute for heuristic cartographic knowledge gained only through experience; until such time as an efficient methodology for the incorporation of heuristic knowledge is achieved.

It is unfair to blame the computer industry for all of the misguided directions of computer mapping development. After all, if there were enough qualified cartographers to participate in the development of automated mapping systems (and they were allowed to do so) some of the misuse I pointed out would not occur. As (Taylor 1984) states unless cartographers get involved in the 'New Cartography' they will be replaced by computer graphic designers that don't possess the adequate background or knowledge of basic map design techniques.

The future skill level, and training of the cartographer must include experience with a programming language other than BASIC or FORTRAN, and appropriate math skills such as trigonometry and calculus. These skills must be placed upon a firm foundation of the conceptual and communication fundamentals of mapping. The cartographer must also be skilled at some level in image processing, and future skill levels of image analysts must include advanced skills in cartography. Otherwise, as we approach an environment where digital satellite imagery is used as a primary source of information to produce hardcopy maps, Image Analysts could find themselves heading down the same path of non-involvement as Cartographers, when it comes to automated mapping system design.

To achieve this background training and knowledge, more institutions of higher learning are going to have to offer course loads directed at imagery analysis and processing techniques, as well as courses centered on traditional and computerized methods of cartography. Without this breadth of effort to formally educate more people in cartography and imagery analysis, and without changes in the computer mapping industry to allow for more human expert interaction, the misguided evolution of future mapping technology will continue.

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REFERENCES

Brassel Kurt, 1977, A Survey of Cartographic Display Software, International Yearbook of Cartography, pp 60-77

Bie, Stein W., 1984, Organizational Needs For Technological Advancement, Cartographica-AutoCarto Six Selected Papers, Vol. 21, No. 2 & 3, David H. Douglas, ed.

Burr, David J., 1985, ACES: A Cartographic Expert System, Auto-Carto 7 Proceedings, pp 399-404, Falls Church, American Society of Photogrammetry and American Congress on Surveying and Mapping.

Harrison David A., 1985, ACES: A Cartographic Expert System, Auto-Carto 7 Proceedings, pp 399-404, Falls Church, American Society of Photogrammetry and American Congress on Surveying and Mapping.

Heckman Bradford K., 1985, ACES: A Cartographic Expert System, Auto-Carto 7 Proceedings, pp 399-404, Falls Church, American Society of Photogrammetry and American Congress on Surveying and Mapping.

Oresky, C., 1985, ACES: A Cartographic Expert System, Auto-Carto 7 Proceedings, pp 399-404, Falls Church, American Society of Photogrammetry and American Congress on Surveying and Mapping.

Pfefferkorn, Charles E., 1985, ACES: A Cartographic Expert System, Auto-Carto 7 Proceedings, pp 399-404, Falls Church, American Society of Photogrammetry and American Congress on Surveying and Mapping.

Rothermel John G., 1985, ACES: A Cartographic Expert System, Auto-Carto 7 Proceedings, pp 399-404, Falls Church, American Society of Photogrammetry and American Congress on Surveying and Mapping.

Taylor D.R.F., 1984, New Cartography, 12th International Conference, International Cartographic Association, Vol I, pp 455-467, Perth.

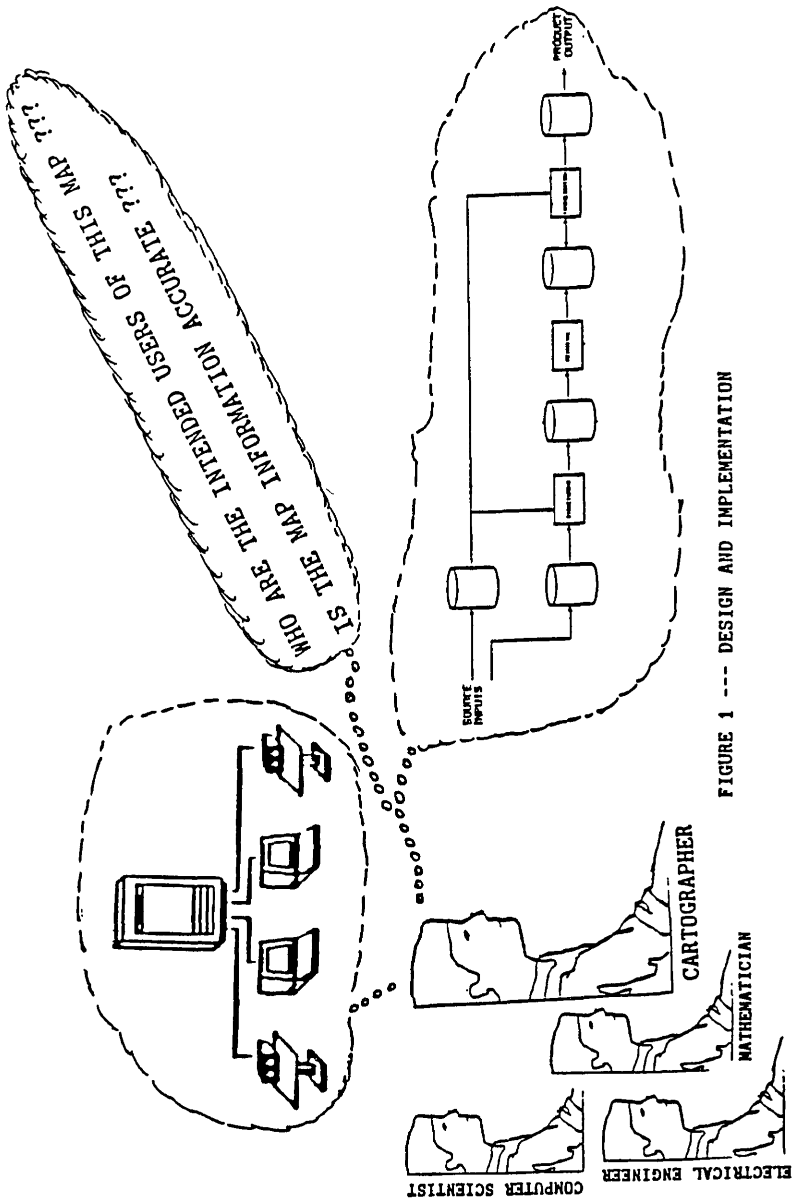

FIGURE 1 --- DESIGN AND IMPLEMENTATION

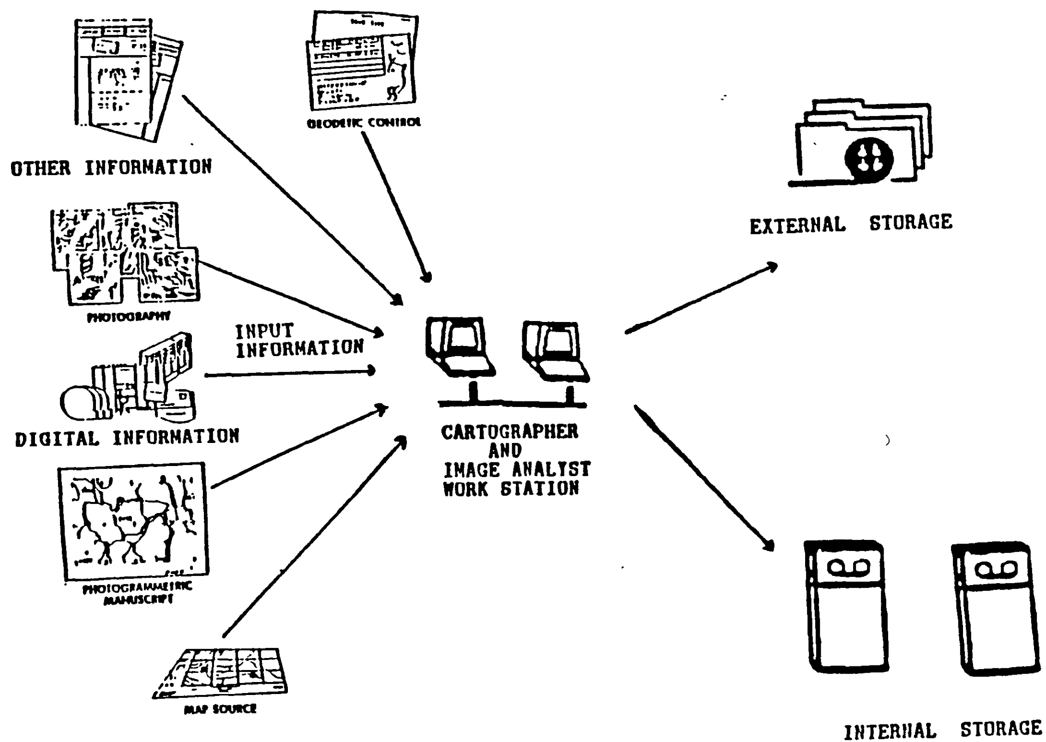

FIGURE 2 --- EVALUATE INCOMING MATERIAL

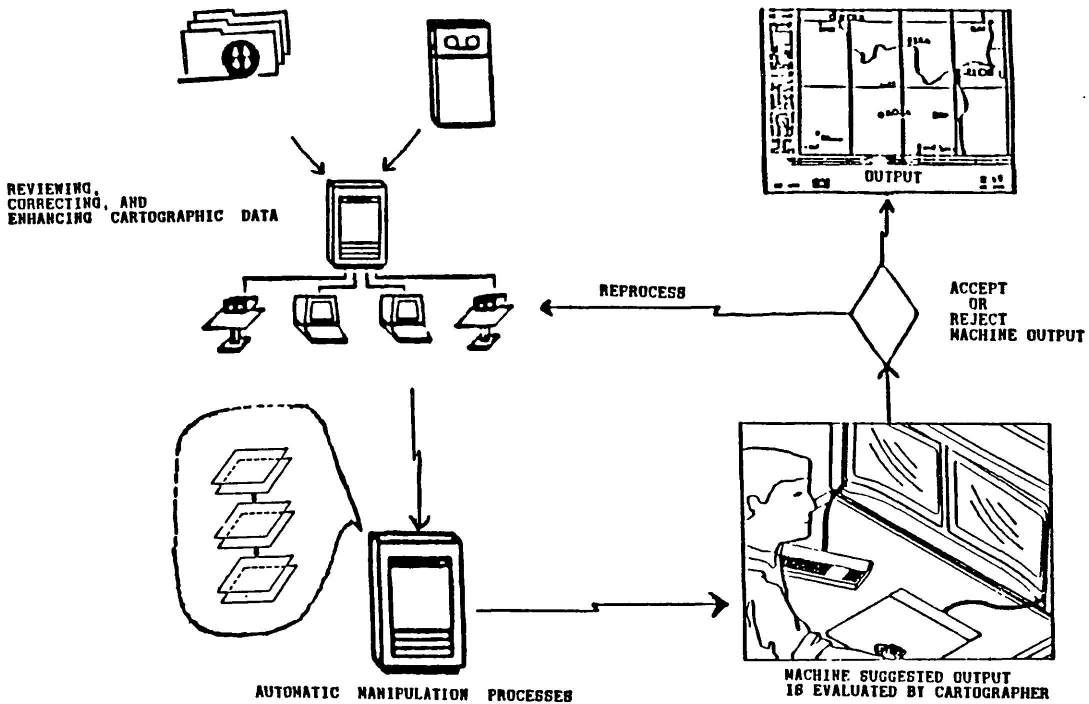

FIGURE 3 --- PROCESSING STEPS