Cartographic Software Capabilities and Data Requirements: Current Status and a Look toward the Future

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In this article, we suggest that a universally accepted cartographic software program does not currently exist and has never existed, but mapping software capabilities are improving, and cartographers should be involved in software developments for map making. We describe the current state of software development and explore what an ideal solution for the future would be. In a related vein, GIS and other data are not generally designed for cartography, but we are learning how they can be, and cartographers should also be involved in the modeling of GIS and other data used for map making.

Software

Cartographers have yet to universally accept a single mapping software program for all their needs. The software that is available to cartographers was largely developed for other primary purposes, but cartographers have discovered ingenious ways of manipulating the software for their mapping purposes.

Modern-day mapping usually requires a combination of software capabilities; most often realized with illustration and geographic information system (GIS) software. GIS is used, at the least, to handle the primary storage for much of the data that are now available. It is also often used to analyze and massage the data to prepare them for mapping. Graphic software capabilities are required to symbolize the data for display on maps, design the page layout, and prepare the map for printing and output. There are advantages and limitations to both these types of softwaare, if they are used exclusive of each other. In this article, we suggest that the ideal cartographic solution is to merge them in a single computing environment that leverages the advantages of both.

Advantages of a GIS-based approach to map making include: a consistent and well defined model for organization and storage of the data, seamless coverage (whereas in the past, the extent of the data was sometimes related to the extent of the map sheets covering the area of interest), multipurpose data (that can serve to create various map and data products), the ability to reflect the real world in a timely manner (through the use of rapid updates), balanced with the ability to present a more stable view of the world (through better data management that controls for multi-person editing and simultaneous updates). One of the limitations of a GIS-based approach is that the software and databases have not traditionally been designed with cartography as a primary focus; therefore, it is often necessary to retrofit the data for mapping purposes and to bail out of the GIS software when more robust graphic design capabilities are required.

Advantages of graphics software packages include a powerful set of tools and effects for human intervention in the software's expression of the data. They also provide control in the outputs for high quality printing and publishing for various media, including the increasing demand for display with digital media.

A GIS-based approach provides the power of a geographic database and the tools for managing and analyzing it. The power of a graphic software package lies in its flexibility and multiple options for graphic refinement of the data display. An ideal software package would provide all these advantages in an environment that is familiar and accommodating to the map maker.

A Computational Approach to Cartography

Today, both graphics and GIS capabilities are available in a computational environment, which is a desirable approach to map making for a number of reasons. The advantages of a computational process for map making include automation, optimization of the workflow, ability to easily vary design, linkages to other software programs, creating and serving maps in a single environment, and distributed processing. Automation is desirable to release cartographers from the drudgery of repetitive tasks and allow them to focus on the decisions in map making that require human review and intervention. Optimization of the cartographic production workflow through automation and computation results in lower costs and less time for a fiscally responsible map-making process. Map making is an iterative process, so the ability to change design choices with little overhead is also desirable in order to keep costs to a minimum and design flexibility to the maximum. Linkages to other software packages, such as *Excel* or *SAS*, allow the various tasks in map making to be performed using the software that best suits the needs of the

cartographer. Maps are increasingly being displayed on computer screens, so designing and distributing digital maps is facilitated by keeping both production and delivery in a computational environment. Distributed processing is desirable when mapping large data sets which are increasingly becoming available, even to the global level.

The Ideal Software Solution

The ideal cartographic software, which does not currently exist, would be a single, intuitive, efficient, consistent and complete package. There are many advantages to having all the map making tasks accomplished in a single environment. Moving data between software systems provides the opportunity for the data to be inadvertently modified, damaged or lost—inconsistencies can result in errors that at best have to be corrected, and at worst may not even be detected. It also takes time and effort to move data between systems—this results in a disruption in the production workflow, leading to inefficiencies that can be time consuming and costly. Depending on the software used, the data can become uncoupled from its underlying GIS database, which results in a loss of parentage and traceability of the data.

The ideal cartographic software would provide robust functionality specifically required by cartographers. It would take advantage of the rigor of a database-driven approach to mapping but allow the flexibility required for cartographic interaction. Although this ideal software could be developed from graphic software by adding the capabilities of GIS, it seems more likely that it would be developed from a GIS by incorporating the required graphics capabilities into the more complex framework that a powerful GIS requires. Indeed, this is beginning to happen with software packages such as *ArcGIS*.

Predictions for 2010 and Beyond

By 2010, we will see GIS software that has been further enhanced for use by cartographers for high-quality map products. The wish list is long, but there are a number of enhancements that cartographers need and will likely receive. The software should be able to store the map and page elements in the database so that they can be managed and manipulated with the same advantages as the data. Labels should be linked to the features they represent so that changes in the database are automatically reflected in the graphic display. Label management should be robust and provide optimal placement solutions, along with exceptional labeling requirements (aligning the text to a curved graticule, various expressions of leader lines, ability to format the font within a label string, tables for unplaced labels, and more). The software should also provide 3D mapping capabilities with high-quality symbols, rapid rendering, and the ability to interact with and, thereby, transform the display (vantage point, data layers shown, etc.) The ideal software would also include controlled outputs for printing and publishing for various media, both digital and analog. Additionally, the software should allow for the presentation of products on demand—an increasingly sought-after function for the distribution of maps.

The software would ideally create graphics based on a multiple representation database. This would also allow multiple map products with different purposes and varied scales to be generated from a single multipurpose database. The ideal database would allow data to be derived for all scales from a single high-resolution database, or a small set of databases at specified resolutions through automation processes that do not require constant human intervention. This is not currently possible and likely will not be by 2010. The limitations are in the requirements for generalization. Although we are seeing more robust generalization algorithms and tools, the need remains for context specific generalization, i.e., algorithms that can recognize that different solutions are needed for different cases within a dataset and between datasets.

An ideal solution for map making in a computational environment would be a database that has enough information embedded in it that it can be symbolized automatically, and software that can be used to enable the data to create “smart maps” that essentially know how to draw themselves from the data. This is not something we foresee for the immediate future, despite the fact that it has been a quest for analytical and other cartographers for decades (see the *AutoCarto* conference series proceedings, for example). Although it is probable that humans will always have to intercede in the software’s expression of the data, the goal is to reduce the amount of intervention and limit it to the complex decision making that is required to artistically and effectively express the nuances in the data in a combined graphic–scientific manner.

Conclusion

Progress is being made towards the development of the ideal cartographic software, and the time is ripe for cartographers to articulate and even demand the functionality that they require for high-quality mapping. The biggest challenge lies in understanding, at a fundamental level, what cartographers do to make maps and translating that into rules that can be implemented in a computing environment. Cartographers should not only be demanding the functionality they require, they should also be articulating their data requirements. In addition, as the software and databases continue to evolve, cartographers need to develop best practices for making high-quality maps with the refined data and software.

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