THE DEVELOPMENT OF A KNOWLEDGE-BASED PROGRAM TO ASSIST GIS USERS IN MAP DESIGN

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Abstract

Maps as output and visualization aids are widely utilised by users of Geographical Information Systems (GIS). They are a means of efficiently communicating information and good design is crucial to their effectiveness. Unfortunately, many hardcopy maps produced from GIS are of disappointing quality as few users have training in cartographic design. In order to improve this situation, a model detailing the stages of operation involved in producing a hardcopy map from a GIS has been developed. Previous attempts to apply expert system techniques to cartographic design have been of limited success as they did not consider the whole design process; a 'whole map' evaluation scheme was thus identified and linked to a period of knowledge acquisition. In this way an 'intelligent assistant' computer program will be produced which will have the additional rôle of cartographic tutor.

1. Introduction

The traditional map as published by a cartographic house is still a vital part of the cartographic scheme. It is produced as hardcopy in response to a perceived commercial benefit; to satisfy a public need; as part of an organisation's legal obligations; at the request of a client or at the instigation of an individual cartographer. The map audience is generally large, with many different requirements of the map. By way of contrast, in an organisation using Geographical Information Systems (GIS), a map will usually be produced in response

to a query made of a spatial database, providing information relating to an analysis. In these cases, maps are more commonly produced on the screen for a more limited audience (often solely for the benefit of the GIS operator). This dichotomy is identified by DiBiase [1] as the private realm and the public realm of the GIS user.

However, not all maps produced from GIS are for such small audiences; a recent survey indicated that more than 60% of GIS users produced some maps for inclusion in reports, suggesting an audience of more than one for the maps [2]. In these cases, map design is of particular importance; when decisions are made based on maps produced from a GIS it is essential that the maps convey the intended message effectively. Unfortunately, few computer users are experts in map design [e.g. 3] and cartographic education seems to be of minor importance to GIS software vendors.

2. The rôle of the GIS user in the production of hardcopy maps.

In response to the problem of cartographically-untrained GIS users and the increased numbers of map authors, the stages of operation involved in cartographic output have been identified (Figure 1). The GIS operator is prompted to use their GIS software in answer to a client request, a perceived audience or a self-motivated need for an analysis. Having decided that a map will be the best form of output, the spatial database is targeted and the relevant files and data layers are selected. Here the user may display the portions of the necessary information on the screen in data (re-) familiarisation; this may result in additional information being used or superfluous data being discarded. Cartographic modelling operations (used here in the very broadest sense) will follow and a 'first draft' is produced on the computer screen and/or as hardcopy.

If a final map is needed for wide circulation, the GIS user then assumes "map mind" and considers the limitations of page size as dictated either by size of the final publication or by available printer type. It is noteworthy that there are rarely projection and scale considerations at this stage; the scale of the map is dictated by the size of the page. Given the limits, the GIS user/map author considers the aspects of cartographic design, each part of a feedback process. Finally, the design is completed and the map is output to hardcopy or transferred to another system for approval, output etc.

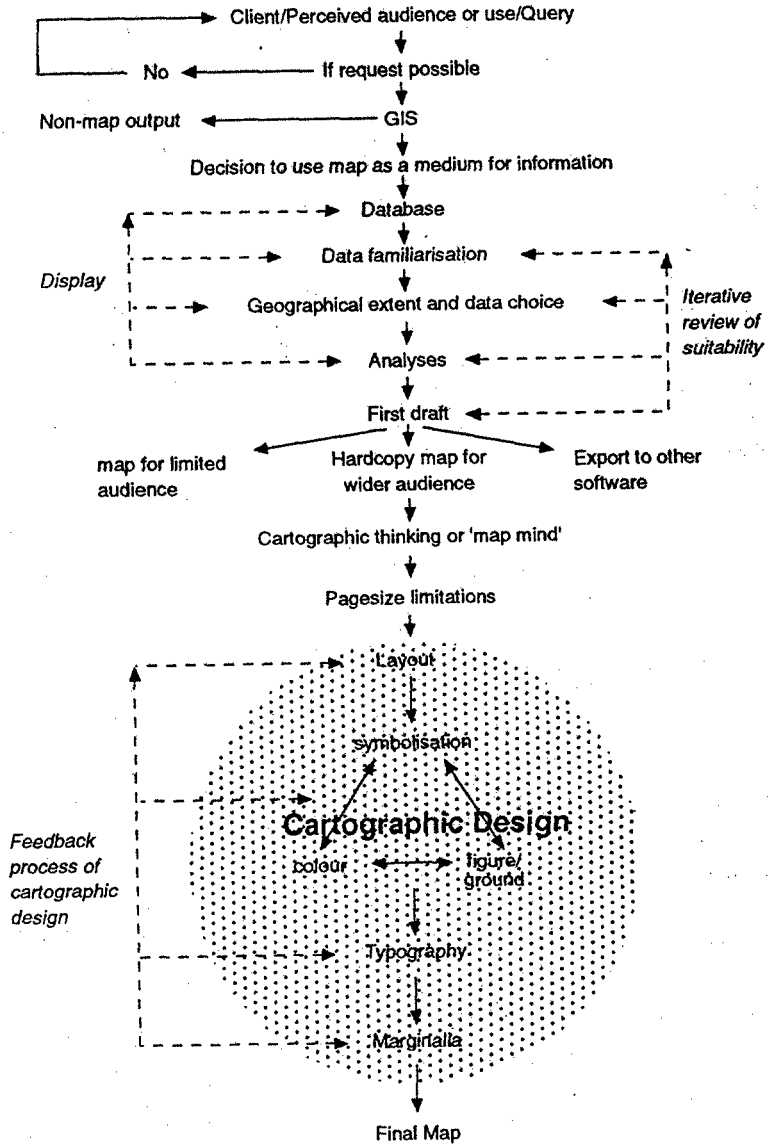

Figure 1. Idealised model of hardcopy map output for multiple users from a GIS.

3. Expert systems

There have been numerous, previous attempts to apply expert system techniques to the cartographic design process. However, most deal only with aspects of map design, they do not take account of the design of the whole map. Since a map is more than the sum of its parts, to achieve a successful design no part can be considered in isolation. To overcome these difficulties, some form of 'whole map' assessment was required. Computer vision-based techniques seemed inappropriate, as did information content analysis, so conventional map evaluation schemes were investigated. Previous attempts have concentrated on particular map types, or have considered the rôle of the user as central. Unfortunately, the majority of these methods "....usually attempted to isolate the effect of one particular factor by taking it out of real map context and testing it in a more controlled situation." [4]. Alternatives were developed which attempted to analyse more realistic map use tasks, but these resulted in few recommendations for improvements in cartographic design.

4. Subjective evaluation and semantic differentials.

Arnheim [5] suggests that the main message from maps is the dynamic "interaction of visual forces"; it is the user's response to the expressive qualities of visual stimulus that begins the communication process. Subjective evaluation of the whole graphic was used by Petchenik [6] using a technique known as semantic differential (SD) testing. These are word pair antonyms (e. g. hot and cold) used to measure attitude in psychological research. The technique was first formalised by Osgood *et al.* [7] and involves the measurement of a phenomena with respect to a range of differences between two antonyms. The evaluator positions their subjective reaction somewhere between the two extremes on an ordinal scale.

5. Knowledge acquisition

In a knowledge-based computer program, the encapsulated expertise forms the core of the system. Following the identification of a suitable domain, there follows a period of knowledge acquisition involving a domain expert and subsequent transfer and

representation of the knowledge. Given the chosen map assessment method, it was decided to ask the cartographic expert to evaluate a series of map case studies and then ask them about their reasons for their evaluation responses. The particular problems of a knowledge-based system for cartographic design indicated that a period of structured interviews was the most suitable approach.

A series of maps were produced from data supplied by the National Rivers Authority (NRA) in response to typical spatial queries based on NRA guidelines. The maps were given to the expert for evaluation and in follow-up interviews, the expert was asked to link their evaluation responses to specific aspects of cartographic design. For example, reasons that a map might appear "very agitated" to the expert include that the data set has too many points, that uncomplimentary colours have been used, or that dashed lines with large gaps have been used. The aim of the approach is to provide the cartographically untrained user with general, low-level map design advice, mimicking the concept of a cartographer sitting at the user's side; the 'amplified intelligence' approach of Wiebel and Buttenfield [8]. Thus, if the user considers their product to be "agitated", the above advice would be offered by the program; the program is both 'intelligent assistant' and cartographic tutor.

6. Conclusion

The formulation of a model for the production of hardcopy maps in a GIS environment enabled the identification of the requirements of the cartographically untrained GIS user. The technique of knowledge acquisition related to whole map evaluation enables the transfer of cartographic expert knowledge applicable to a wide variety of maps. In addition, the program can adopt the rôle of cartographic tutor as well as 'intelligent assistant'. Potentially, it enables the creation of a new vocabulary of cartographic appreciation and evaluation.

References

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