A KNOWLEDGE—BASED SYSTEM APPROACH TO THEMATIC MAPPING

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ABSTRACT

To design and produce a map   (or an atlas)   is a creative procedure which requires both professional expertise and artistic accomplishment. So it is never an easy task even though we are now in the digital information era, because existing CAC systems cannot satisfy all the requirements of a 'real' design. To solve this problem, it is necessary to make CAC systems 'intelligent' and to make as much profit from GIS system as possible. MAPKEY is such a system developed by the authors, which is based upon GIS systems and integrates Database, Knowledge base and computer graphics.   MAPKEY can cover almost all procedures of thematic map making, such as map type selection,   symbol design,   data grading, color design, four color separation and film output, and provide a color environment, 'What you see is what you get' in its real sense.

In this paper,   the 'inside story' of MAPKEY is revealed and some concents of map design are also discussed.

KEYWORDS

1. INTRODUCTION

Thematic map design is a decision—making pro cess requiring expertise for the representation, the classification and the selection of symbols, legends,colors and typefaces. Thematic mapping or   thematic map   production is a productive process including design,   drawing,   color— separating, plates — making, pre — press proofs and printing.   So it has a very long production period for producing an atlas. 【1】

Map production becomes easier, faster and more efficient due to the development of mechanics and electronics,   but there still exists a lot of problems.

1. 1 THE EXISTING PROBLEMS IN THEMATIC MAPPING

(1). More and more   poor—quality maps are being produced by non—cartographers who use some widespread thematic mapping package. 【2】 【3】

(2). Map design becomes the "bottle neck" problem in the thematic mapping software since it is a creative procedure that general programming technique can harely describe such procedure.

(3). Mapping procedure is very complicated one even if in GIS age, for example, "US ATLAS: 1990 Road Atlas" was competed by 4 groups using 2 kinds of computer and 6 software package. 【4】

1. 2 NEW DEFINITION OF CARTOGRAPHY AND MAP (Board, 1989)

(1) CARTOGRAPHY: The organization and communication of geographically related information in either graphic or digital form. It can include all stages from data acquisition to presentation and use.

(2) MAP: A holistic representation and intellectual abstraction of geographical reality, intended to be communicated for a purpose or purposes, transferring relevant geographical data into an end—product which is visual, digital or tactile.

1. 3 FEATURES OF MODERN THEMATIC MAPPING

(1). GIS and Database maintain the accuracy of original data of map.

(2). New kinds of maps with Multi—form emerge continuously (Dynamic map, CRT map, Electronic map, etc).

(3). It becomes possible for computers to simulate design procedures of experts because of the development of a technique. The concept of map design has changed a lot. Map design is a process transforming map data stored in GIS into "Visual, digital or tactile products" instead of transforming the artworks.

(4). MAP user can enter into design procedure under the guidance of knowledge base

1. 4 THE WORK DONE IN THIS PAPER

In this paper a structure of unified intelligent thematic mapping production software system is developed (Fig. 1)

Unified software system Easy to use, easy to understand	Unified User Interface			
Various facilities needed for map production (Improving transformation efficiency and speed)	Text Processing	Desktop Color Publish	4 color Separating & Correcting	Film Output
The kernel of system control (Emphasizing map design, embodying art style and simulating creative procedure)	Expert System (Knowledge base, Inference)			
Basic graphics and data processing (Maintaining accuracy and improving mapping efficiency)	GIS & CAC		Database Management System	

Fig. 1 *Structure of Intelligent Thematic Mapping Software*

1. 5 FEATURES OF SYSTEM STRUCTURE

(1). The system is based on computer graphics and database.

(2). The knowledge of experts and creative thinking simulation are presented by techniques of expert system.

(3). Text processing, color electronic typesetting and 4 color separation printing are introduced.

(4). A unified user friendly interface which is easy to be used and understood is emphasized.

The 5 existing views in cartography could tend to unification based on the system in this structure and the problem mentioned above could be solved effectively.

2. MAPKEY —— A KNOWLEDGE — BASED SYSTEM FOR THEMATIC MAPPING

Based on the structure describe in Figure. 1, a practical Expert System ——MAPKEY is implemented. 【5】 【6】 【7】
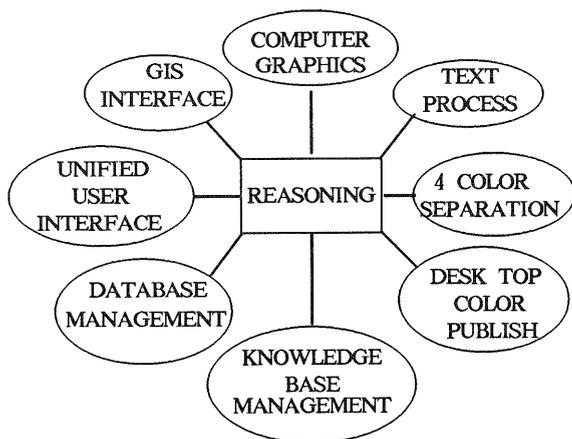
Fig. 2 Main Elements of MAPKEY

2. 1 WHAT CAN MAPKEY DO?

MAPKEY can implement almost all procedures of thematic map making. The following is its main functions:

• Data preparation
• Map type selection
• Data classification
• Symbol design and adjustment
• Legend design
• Color design
• Four color separating
• Film output

2. 2 HOW DOES MAPKEY WORK?

In MAPKEY, the methods of representing and managing knowledge are CONTEXT, FRAME and RULE, etc.

CONTEXT —to describe map content
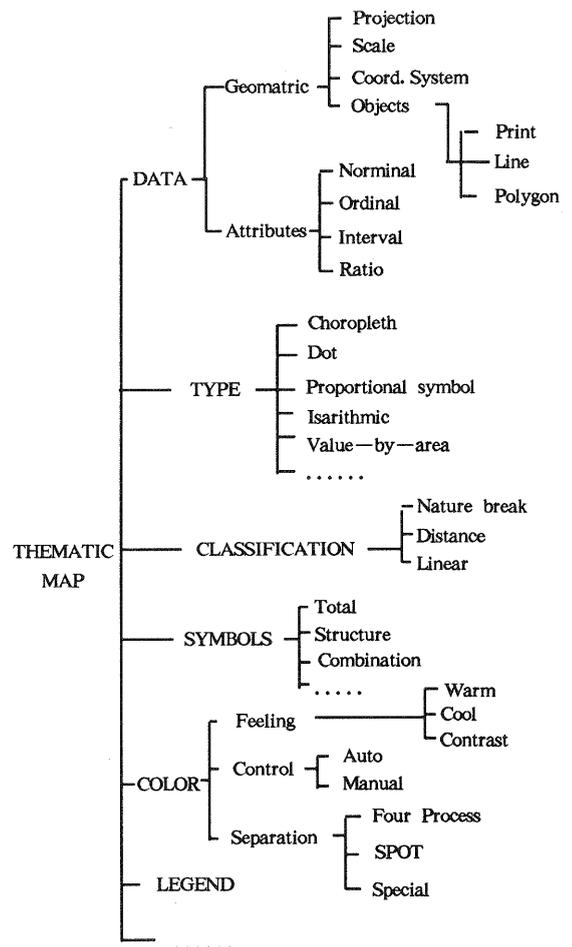
Fig. 3 Thematic Map Context

FRAMES—to presentthe hierarchy of maps and knowledge

MAP TYPE

Choropleth	T
Dot	F
Proportional symbols	T

......

MAP 026

Title	Population
Designer	Huang Rentao
Date	07/29/1991

CONTEXT

......

MAP CLASSIFICATION

Method	Linear
Interval	6
Calculate	Auto
GVF	0.95

MAP SYMBOLS

Symbol type	Total
Shape	Circle
Min R	20
Max R	80

MAP CONTEXT

Map number	026

TYPE
DATA
CLASSIFICATION
SYMBOLS
......

MAP DATA

Geometric
Attributes
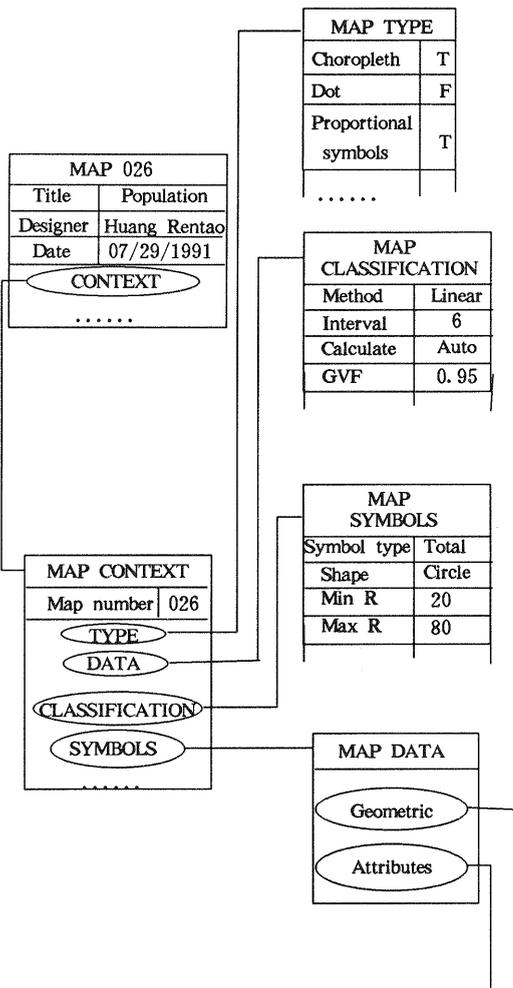
Fig. 4 Simplified Frames in MAPKEY

• To represent the hierarchy of map details
• To express the structured knowledge
• To describe the relationship of map elements

RULES—to express the process of design

FORM:

    IF condition is true

        THEN take actions

• Build the reasoning chain
• Connect frames, database, procedures, graphics and knowledge base

EXAMPLES:

Rule 097:

IF mapdata. property $=$ "total" and

frame—get (mapframe $=$ mapslot) $=$ "symbol"

      THEN symbolsel $=$ TRUE

          DO symbolsel (total)

            symbnum $=$ 1

Rule 082:

IF symbolnum $=$ 1 and accuracy $=$ TRUE

      THEN symbolname $=$ "bar"

INFERENCE — to control the action of knowledge base

• Strategy of "generate and test"
• Forward—chain, Backward—chain and Mixed —chain
• Fuzzy reasoning

The following is the working flow of MAPKEY.

Data collection
Data management
Map's frame set
Map's type detemination
Data classification
Symbol design
Color design
Legend design
Lettering
Four color separation
Film output
Printing

Database
+
Knowledgebase
+
Inference
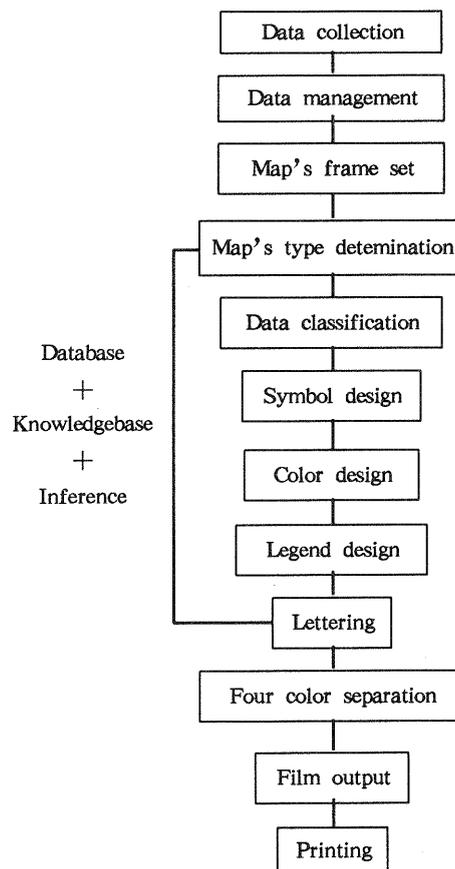
Fig. 5 Working Flow Chart of MAPKEY

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2. 3 ARCHITECTURE OF MAPKEY

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                    ┌──────────────────┐
                    │  USER INTERFACE  │
                    └──────────────────┘
  ┌─────────┐ ┌─────────┐ ┌───────────┐ ┌───────────┐ ┌────────┐
  │ Graphic │ │  Text   │ │  Color    │ │  4 color  │ │  Film  │
  │ Package │ │ Process │ │Typesetting│ │ Separation│ │ Output │
  └─────────┘ └─────────┘ └───────────┘ └───────────┘ └────────┘
              ┌────────────────────────┐
              │    INFERENCE ENGINE    │
              │   (Blackboard System)  │
              └────────────────────────┘
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| Chinese character base | DB1 GEO | DB2 Attr | KB1 Maptype | KB2 Mapsymbol | KB3 Classify | KB4 Color Assign | KB5 Legend |
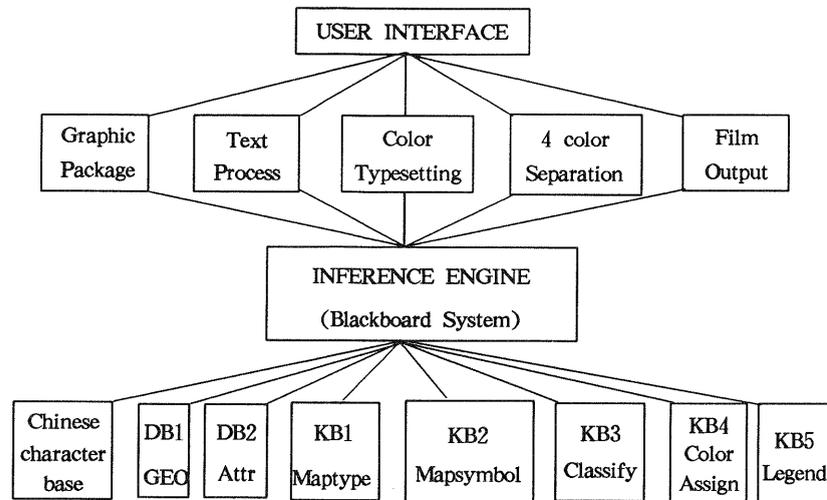
Fig. 6 Architecture of MAPKEY

3. CONCLUSION

(1). MAPKEY is a practical intelligent thematic mapping system which represents the main tendency of modern thematic mapping.

(2). Experience based on MAPKEY has proved that AI combining with mechanic and electronic techniques is a powerful techniques for modern thematic mapping.

(3). The method of Expert system has solved the problem of automatic color assignment (a long—unsolved problem).

(4). Text processing, electronic typesetting and 4 color separation printing can run in a same software system so that it embodes real "what you see is what you get"for color graphics text.

The most important point is that " **Data is only data, knowledge is really power** "

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