前方後円墳データベースREDATO

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Abstract

A research support system complex REDATO is implemented for handling a variety of problems related to the Japanese ancient tombs. REDATO consists of the three systems SIS (Symbolic Information System), GIS (Geographical Information System) and PIS (Pictorial Information System) which deal with the databases SID, GID and PID, respectively. SIS is nothing but the so-called DBMS which manages the relational database SID. GIS performs interactive graphic processing for the geographical aspect of the tombs distributed all over the Japanese islands. GIS acts in cooperation with SIS, providing various archaeological distribution maps of the tombs in specified regions. PIS handles pictorial informations of shapes of the tomb mounds in terms of the contour maps. Logical zooming, pictorial query and the other interactive graphics are also performed by PIS.

Keywords

Research support system, Archaeology, Database, Geography, Computer.

1. Introduction

Many kinds of support systems [1-8] have been developed in various fields, which are mostly implemented on the basis of their own special databases. Although less popular than the ordinary document databases such as INSPEC, the support systems would be very powerful not only for solving a special problem but also for doing a scientific research in every field. There would appear to be many problems in archaeology such that support systems would act well as powerful research tools.

Between the 4th and 6th centuries AD, a large number of huge ancient tomb mounds, termed the Keyhole tombs, were built all over Japan. Even today more than three thousands of the Keyhole tombs still remain in spite of excessive urbanization in modern Japan. The Keyhole tombs have been playing the most important role in understanding the so-called "ancient tomb period", in which the Japanese regime would start. Information of a keyhole tomb involes (i) structure of the burial chamber or formality of the burial, (ii) styles and qualities of the terra-cotta figures, potteries or other remains, (iii) location and outlook of the banked mound, mostly capped with stone blocks, and sometimes surrounded by ditches, (iv) shape, dimensions and volume of the mound, and (v) the other knowledges acquired from survey or excavation.

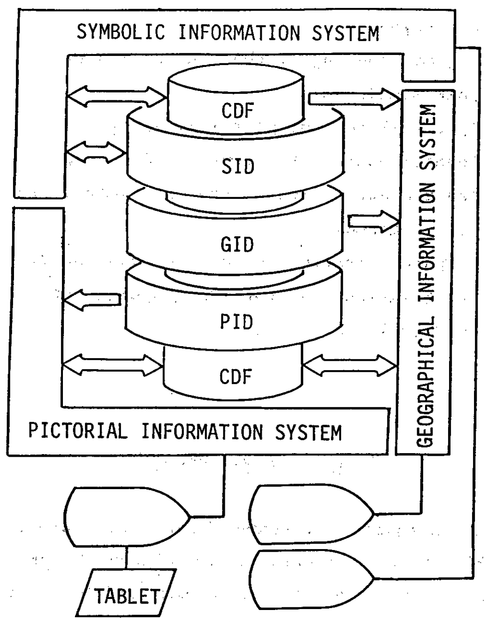

Figure 1. Global system structure.

This paper presents a research support system complex REDATO for handling a variety of aspects of the Keyhole tombs [9]. REDATO has been implemented based on the following three types of databases:

Symbolic Information Database (SID)
Geographical Information Database (GID)
Pictorial Information Database (PID)

As illustrated in Figure 1, SID, GID and PID are managed by the three systems SIS (Symbolic information system), GIS (Geographical information system) and PIS (Pictorial information system), respectively. SIS is, basically, equivalent to the so-called database management system (DBMS) and plays a key role in the REDATO's performance. Cooperation of SIS, GIS and PIS of REDATO creates the following capabilities:

(1) Conversational retrieval in relational query language.
(2) Generation of distribution maps of the Keyhole tombs retrieved under various conditions.
(3) Logical zooming of the contour map of a tomb mound.
(4) Retrieval for the pictorial query; identification of a tomb based on the feature extraction of the outermost contour of the mound.
(5) Graphical restoration of the tomb mound.
(6) Other various interactive graphics and retrieval functions.

2. Computer Environment

The hardware environment for implementation of REDATO is illustrated in Figure 2. Main specifications of the computer FACOM M-150F (Fujitsu Ltd.) include 160 nano seconds memory cycle time, 4MB CPU memory and 400 x 4 disk memory devices. One character display unit and

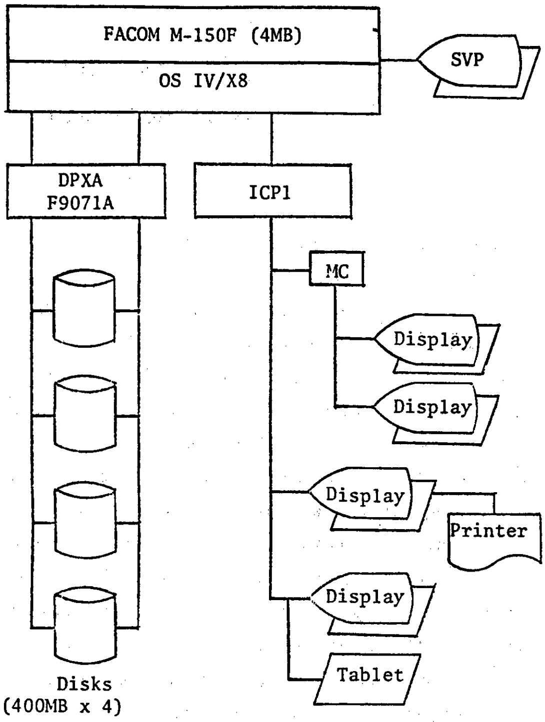

Figure 2. Computer environment.

two graphic display units are available for an end user of REDATO, which are interactive I/O devices of SIS, GIS and PIS, respectively. The operating system of the computer M150-F is OS IV/X8, under which REDATO runs.

3. Systems

3.1 A view of REDATO

As seen in the title, REDATO is also regarded as a special type of database for a limitted number of the archaeologists who work at problems around the Keyhole tombs. As shown in Figure 1, REDATO consists of the three systems SIS, GIS and PIS which are basically independent from each other, while they are loosely coupled in terms of data transmission through the common data file (CDF). SIS analizes the inquiry language (INQL) and the

Table name	Attributes	Values
古墳表	コフンバンゴウ	古墳番号
	ケンバンゴウ	文字47　ホッカイドウ，アオモリケン，イワテケン，ミヤギケン，アキタケン，ヤマガタケン，フクシマケン，イバラギケン，トチギケン グンマケン。サイタマケン，チバケン，トウキョウト，カナガワケン，ニイガタケン，トヤマケン，イシカワケン，フクイケン，ヤマナシケン ナガノケン，ギフケン，シズオカケン，アイチケン，ミエケン，シガケン，キョウトフ，オオサカフ，ヒョウゴケン，ナラケン，ワカヤマケン，トットリケン，シマネケン，オカヤマケン，ヒロシマケン，ヤマグチケン，トクシマケン，カガワケン，エヒメケン コウチケン，フクオカケン，サガケン，ナガサキケン，クマモトケン，オオイタケン，ミヤザキケン，カゴシマケン，オキナワケン
	コフンメイ	古墳名
	ショザイチ	———
	ショザイチ_シチョウソン	コード（都道府県・市区町コード，昭和55年度／自治省編　参考）

Table 1. A part of the "Kofun" table.

working schema manipulation language (WSML), and executes the consequent retrievals from SID. SIS also executes the user's command to transmit the retrieved data set to GIS through CDF. INQL and WSML are relational; every query statement is to be written in terms of relational operators such as JOIN, AND, OR, SUB, PROJ and the other several symbols.

GIS performs the various graphic operations, interacting with GID and CDF; GIS generates archaeological distribution maps under different conditions and deals with all the geographical aspects of the tombs. PIS performs decoding of the encoded data in PID, feature extraction for the pictorial query and the pictorial retrieval processing.

3.2 Data Structure

The raw data describing a Keyhole tomb can be classified into three types; i.e., the symbolic, geographic and pictorial types of data that correspond to SID, GID and PID, respectively. The logical structure between the three databases is illustrated in Figure 3. The symbolic type of data include all the descriptive character strings such as names, locations, burial things and so on. The conceptual schema for the symbolic type of data

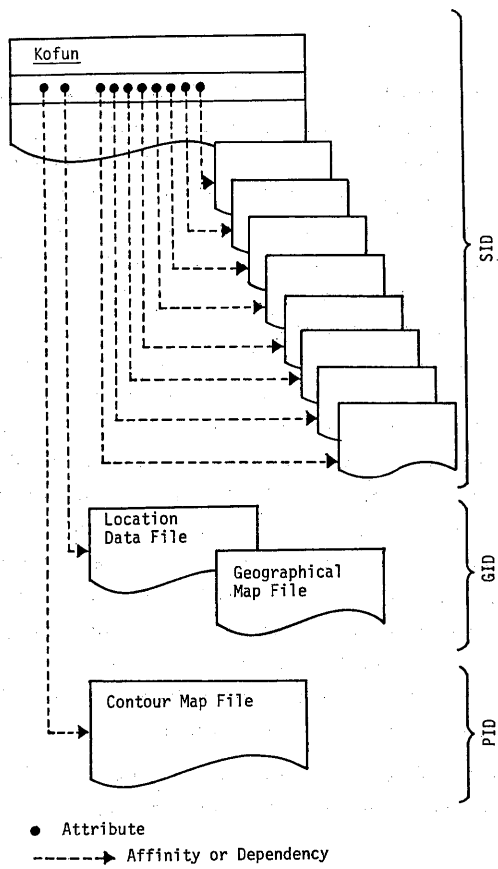

Figure 3. The logical data structure of REDATO.

```
27- 61  NAKATSUYAMA
  0.593  0.490  0.519  0.587  134  286.0  286.9   60.6  0
  3 92  8 95 14 98 18 95 25 97 29100 35 30 35 95  0  0  0  0  0  0  0  0  0  0
888888888888888787887878787878787787776776767776666667666667666666666666666566665
666565655455555555454554544544544544444434444434444443443443434544454454444544444334
44444445444544544544544545554545445445445444544444544432222222222222222322222222
22222222222222222322222222222222223222222222222221222232222222222888888888887878887
888788887888878888878888887888888781881881881888888888888788111811818181881888888888
7888878787788788787877776766767677676666666676665665665666665656556555645555554554
44544454444444444444444444344334333343434454545454544444444454454444555444544454454
44544564545454454454444222222222322222222222232222232222222222232222222222222222222
212232222222222222888888888878888788788887888888887887888888888788888888787887888811
11188811118188188181881888888878777787878787776767767667666666666666566666565656556
56555454544544444544454444443443434343434343333235454454544544544545554444544545545544
545444454454444555654544544232222222322222222232222222222222222222223222223222222212
1222232221288888787888888878887888788887888888878878887888878888881888818111111811
811881881888881888888888887866677777777767667666666666665665656555554545454444444
44444344434334333234344544454545444444445445454444544444545445456645445445454544443
222322222322322222222222222222322222222222222222222888878888788887878888878887888887
8887867888788878888888888888811221121111811818188188888888878777776776767667656665
6656565554554544444444443444343342333334444454444544444544454454454545544444444454545454
54445444544444232222223222222222222222222222222221888888788888888788788878888788788888
7888887888878888188818111211121818818818878787776767666666656656545454544444444434
3333332322222121128111818188188888887888788787666766666666565545455444444444222322
22222222222222222888888887767666765655545444434333222222212812000000000000000000
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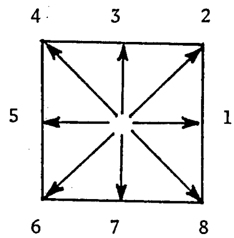
Name and quantitative values including feature vector

Freeman's chain code

(a)



(b)

Figure 4. Data structure of PIS. (a) An example of a record for a tomb mound. (b) Eight primitives for the Freeman's chain coding.

is defined based on the Codd's relational model [10]: SID contains the eight tables of which attributes have totaled up to 47. Among them, the "Kofun" table in SID plays a key role in managing the three databases. All the attributes and their values are defined and handled by the use of Japanese phonetic characters as partially shown in Table 1.

GID stores the set of line primitives to draw every sub-area of the Japanese islands, including borders and rivers, and the set of geographical locations of the tomb mounds. PID stores the encoded strings of the contours of the tomb mounds; the Freeman's chain coding [11] has been introduced to define the strings. PID also stores the symbolic feature vector with five elements for every tomb mound, which is automatically converted from the raw pictorial data in its coding process. All the feature vectors are referred to when a pictorial query takes place. Figure 4 shows the data structure for a tomb mound.

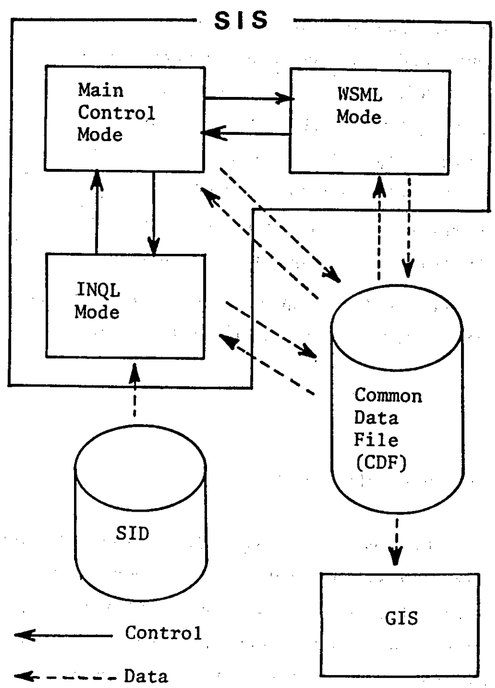


Figure 5. Mode transition of SIS.

3.3 INQL and WSML

Every retrieval from SID is performed by the combined use of INQL and WSML that are interpreted and executed through the mode transition process depicted in Figure 5. Query formulation in INQL is the process by the REDATO's user in order to communicate through SIS with SID. Data sets retrieved by query statements in INQL are temporarily stored in CDF as the woking schemas that can be manipulated by WSML. INQL is set-mathematics oriented. The INQL query expressions include the followings:

(i) (aRv).PROJ.b?

(ii) ((aRv).PROJ.b).S.((a'Rv').PROJ.b')?

Where .PROJ. is the projection operator and the other notations are defined as follows:

Comparative operator

$R \in \{ :, \neg=, <, <=, >, >= \}$

Set operator

$S \in \{ .AND., .OR., .SUB. \}$

Attribute a, a', b, b'

Value v, v' (real number elsewhere R = :)

Actually, all the attributes and values in (i) and (ii) are defined in Japanese. The following examples are the English translations of query statements:

(REMAIN:SWORD).PROJ.TOMB-NAME?

((REMAIN:TERRACOTTA-FIGURE).PROJ.TOMB-NAME) .AND.((LENGTH > 200).PROJ.TOMB-NAME)?

Data sets retrieved by the INQL query statements can be stored using the SAVE command as working schemas. Each schema is labeled with the data set name that the user can

HY03	
0016	27061
0047	27063
1456	27086
0009	27092
0025	27113
0017	27120
0003	27129

HY01	
0002	ｹｲﾀｲ_ﾃﾝﾉｳﾘｮｳ(ﾁｬｳｽﾔﾏ)
1431	ｵｵﾂﾞｶ
1432	ﾂﾄﾞｳｼﾛﾔﾏ
0001	ｲﾝｷﾞｮｳ_ﾃﾝﾉｳﾘｮｳ
0016	ﾅｶﾂﾔﾏ
0047	ﾁｭｱｲ_ﾃﾝﾉｳﾘｮｳ
1456	ｵｵﾂﾞｶﾔﾏ
0059	ﾊｶﾔﾏ
0009	ｵｳｼﾞﾝ_ﾃﾝﾉｳﾘｮｳ
0025	ﾆﾝﾄｸ_ﾃﾝﾉｳﾘｮｳ
0017	ﾘﾁｭｳ_ﾃﾝﾉｳﾘｮｳ
0003	ﾆｻﾝｻﾞｲ

JOIN

TUPLE(S)		
0016	27061	ﾅｶﾂﾔﾏ
0047	27063	ﾁｭｳｱｲ_ﾃﾝﾉｳﾘｮｳ
1456	27086	ｵｵﾂﾞｶﾔﾏ
0009	27092	ｵｳｼﾞﾝ_ﾃﾝﾉｳﾘｮｳ
0025	27113	ﾆﾝﾄｸ_ﾃﾝﾉｳﾘｮｳ
0017	27120	ﾘﾁｭｳ_ﾃﾝﾉｳﾘｮｳ
0003	27129	ﾆｻﾝｻﾞｲ

Figure 6. Creation of a new schema by the .JOIN. operator.

define. Using WSML, working schemas created by INQL queries can be manipulated; new schemas can also be created from existing working schemas. The WSML operators include .JOIN., .AND., .OR. and .SUB., and the WSML query statements are written, for example, as follows:

```
x.AND.y

(x.OR.y).JOIN.z

x.AND.y.JOIN.z
```

Where x, y and z are the data set names defined for existing working schemas.

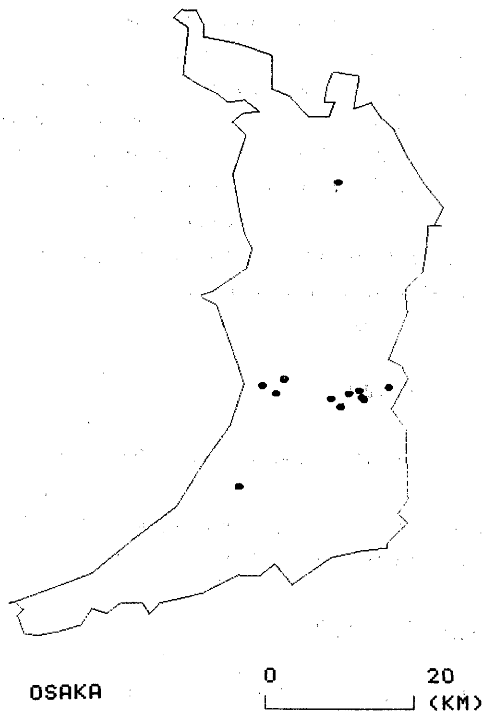
Figure 6 illusrates the creation of a new schema by the following WSML statement:

```
HY03.JOIN.HY01
```

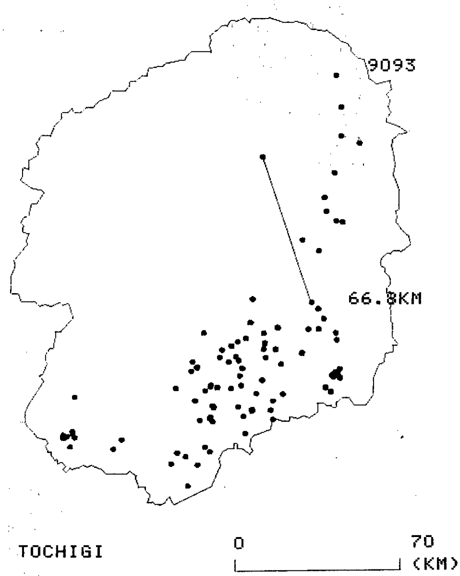
Two schemas "HY03" and "HY01" are joined and, then, a new schema is created.

3.4 GIS and PIS

The geographical information system (GIS) performs not only the graphics cooperating with SIS but also its own interactive graphics including distribution map processings, the cursor oriented graphic query processing and so on. The interactive graphics can be operated using the hierarchical commands provided by GIS. Figure 7 illustrates two examples of the screen images depicted by GIS; (a) is a distribution map given by cooperation of GIS and PIS, and (b) is an example of measurement of the distance between the two tombs specified by the cursor.



(a)



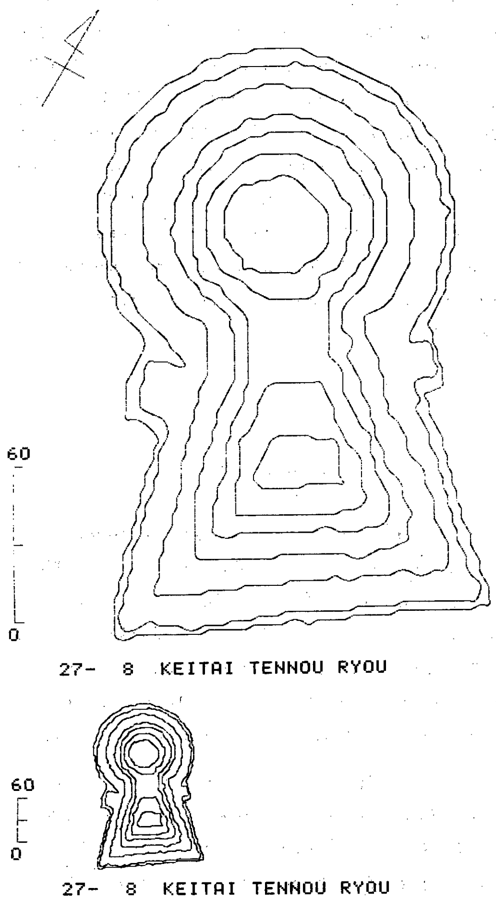
(b)

Figure 7. Screen images of GIS. (a) A distribution map created by GIS. This example is generated, satisfying a condition such that "the tombs are located in Osaka Prefecture and are greater than 200m in length". (b) Measurement of the distance between the two tombs specified by the cursor. "9093" is the retrieved key index of the tomb which is manually specified using cursor.

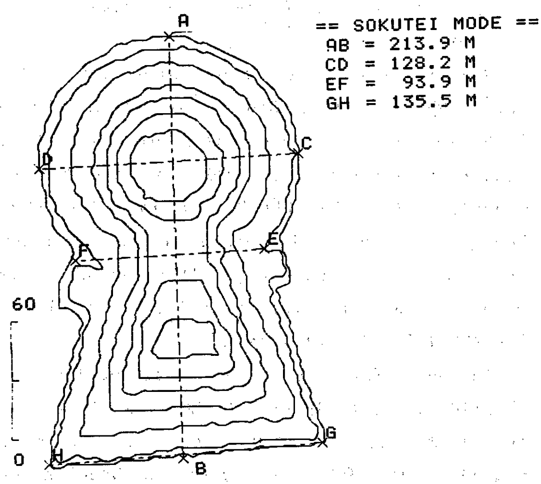
The pictorial information system (PIS) provides various interactive graphics related to the pictorial aspects of the tomb mounds. Technically, PIS performs decoding operations of the coded strings stored in PID, feature extraction from the outermost contour of a tomb mound to be identified and the other picture processings needed. Among others, the pictorial query processing is one of the most specific performances of PIS; a pictorial query is accepted as a sequence of discrete points on the outermost contour of an unidentified tomb mound. Entry of the sequence is carried out using the tablet terminal of the FACOM M-150F computer system. PIS compares the feature vector extracted from the input sequence with all the feature vectors of the known tombs stored in PID and, then, identifies the unknown tomb in terms of the assumed dissimilarity measure. Figure 8 presents examples of the PIS graphics.

4. <u>An Example of the Retrieval Process</u>

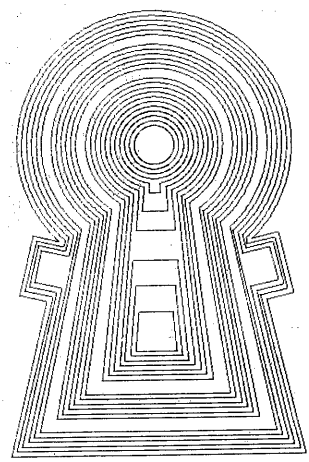
To illustrate what REDATO does, the following example of a retrieval process is presented: At the first step, the locations of the 170 tomb mounds in Osaka Prefecture are



(a)



(b)



(c)

<u>Figure 8</u>. PIS graphics. (a) Logical zooming. (b) Graphic measurement using the cursor. Distance between the two points specified using the cursor is computed and displayed. (c) Graphical restoration of a tomb mound. The left is the contour map of an existing tomb mound and the right its restored contours.

```
K> RETRIEV ØR END?: R

INQL>
*:  (ｹﾝﾊﾞﾝｺﾞｳ:ｵｵｻｶﾌ).PRØJ.ｻﾞﾋｮｳ?

                    MATCHING VALUE: 27
               170  FØUND REST.
               170  FØUND PRØJ.

 170  CØMPØNENT(S) FØUND.

K> ØUTPUT,SAVE,RETRIEV,GRAPH ØR END?: S

WSML>
DEFINE SET NAME:  ØSAKA

 ' ØSAKA ' SAVED.

WSML> ØUTPUT,LIST,SET_ØPERAT,GRAPH ØR END?:  E

K> CONTINUE_RETRIEV ØR END?: C

INQL>
*:  (ﾌﾝｷｭｳﾁｮｳ)=200).PRØJ.ｺﾌﾝﾒｲ?

                    MATCHING VALUE:          200
               33   FØUND REST.
               33   FØUND PRØJ.

  33  CØMPØNENT(S) FØUND.

K> ØUTPUT,SAVE,RETRIEV,GRAPH ØR END?: S

WSML>
DEFINE SET NAME:  GT200

 ' GT200 ' SAVED.

WSML> ØUTPUT,LIST,SET_ØPERAT,GRAPH ØR END?:  S

$:  GT200.JØIN.ØSAKA

               13  TUPLE(S) FØUND JØIN.

  13  TUPLE(S) FØUND.

$: ØUTPUT,SAVE,GRAPH ØR ELSE?:  Ø

+----------------------------------------------------+
|                      TUPLE(S)                      |
+----------------------------------------------------+
|  ｹｲﾀｲ_ﾃﾝﾉｳﾘｮｳ(ﾁｬｳｽﾔﾏ)     034 49 54 135 34 55     |
|  ｵｵﾂﾞｶ                    034 33 50 135 34 16     |
|  ﾂﾄﾞｳｼﾛﾔﾏ                 034 33 14 135 35 08     |
|  ｲﾝｷﾞｮｳ_ﾃﾝﾉｳﾘｮｳ           034 33 46 135 37 10     |
|  ﾅｶﾂﾔﾏ                    034 33 56 135 36 58     |
|  ﾁｭｳｱｲ_ﾃﾝﾉｳﾘｮｳ            034 34 13 135 35 49     !
|  ｵｵﾂﾞｶﾔﾏ                  034 33 50 135 34 16     |
|  ﾊｶﾔﾏ                     034 34 42 135 39 21     |
|  ｵｳｼﾞﾝ_ﾃﾝﾉｳﾘｮｳ            034 34 26 135 36 45     |
|  ﾆﾝﾄｸ_ﾃﾝﾉｳﾘｮｳ             034 34 15 135 29 29     |
|  ﾘﾁｭｳ_ﾃﾝﾉｳﾘｮｳ             034 34 51 135 28 17     |
|  ﾆｻﾝｻﾞｲ                   034 35 19 135 30 10     |
|  ﾏﾕﾔﾏ                     034 27 24 135 26 11     |
+----------------------------------------------------+

WSML> SAVE.GRAPH ØR ELSE?:  S

DEFINE SET NAME:  ØGT200

 ' ØGT200 ' SAVED.

WSML> ØUTPUT,LIST,SET_ØPERAT,GRAPH ØR END?:  G

SET NAME?:  ØGT200

GRAPH>

WSML> ØUTPUT,LIST,SET_ØPERAT,GRAPH ØR END?:  E

K> CØNTINUE_RETRIEV ØR END?: E
```

retrieved and stored as the working schema "OSAKA". Similarly, the names of the 33 tombs greater than 200m in length stored as "GT200". Next, the two schemas "OSAKA" and "GT200" are joined into a new schema "OGT200" consisting of 13 tuples as seen in the example. Finally, the data set "OGT200" is transmitted to CDF; GIS receives "OGT200" and generates the distribution map image as previously presented by Figure 7(a). Where, in this example, PIS is not employed.

5. Conclusion

As far as the author's survey is concerned, no research support system other than REDATO has been developed so far in Japanese archaeology. The author feels that implementation of any other research support system for archaeology will be possible in the similar way of REDATO. As a matter of course, density and reliability of the data items in each database play key roles in the total performance of REDATO. Unfortunately, the present situation is not satisfactory: It is impossible without the continued data acquisition and correction to make REDATO reach completion.

From the view-point of system design, there would appear to be a room in the present REDATO to be improved or to be completed. One future task is to introduce the image database and its managing system to REDATO. As is well-known, photographs are so frequently found among the raw data in archaeology that image data managing functions are basically required for the REDATO's kind of system.

Another task is the introduction of artificial intelligence techniques including the knowledge-base and automatic inference engines. In order to support archaeological researches more positively, the system should manage not only data items but also archaeological knowledges, contextual relations between data items, and performs not only retrievals from a database but also various inferences based on the knowledge-base.

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References

[1] J.A.E.E.Van Nuen and J.F.Benders, A decision support system for location and allocation problems in a brewery, Informatie, vol.23, 11, 693-703, Nov. 1981.

[2] D.R.Perley, Application of new simulation technology to a database for emergency planning in Canada, Proc. of the 1981 Summer Computer Simulation Conference, Washington, D.C., 628-630, July 1981.

[3] S.W.Chan, OCTL: A database design for an educational decision support system, IIFP(Conference), Paris, 159-163, 1978.

[4] E.J.Chanza and L.E.Fortune, GTD-5 Eax software management support system, GTE Autom. Electr. World-Wide Commun. J., vol.19, 3, 90-96, May-June 1981.

[5] J.J.Donovan and H.D.Jacoby, Virtual machine communication for the implementation of decision support systems, IEEE trans. Software Eng., vol. SE-3, 5, 333-342, Sept. 1977.

[6] N.Duong, R.M.Li and D.B.Simons, An interactive planning model for river basin management, Proc. of the 2nd Lawrence Symposium on Systems and Decision Sciences, 158-164, Oct. 1978.

[7] H.Matsuka and K.Sugimoto, Regional planning support system, J. of Inf. Proc. of Japan, vol.23, 9, 818-827, Sept. 1982 (in Japanese).

[8] K.Wadatsumi, S.Matsumoto and T.Fukuma, GEODAS: Geo-database system-development of infrastructure for interdisiplinary sciences, J. of Inf. Proc. of Japan, vol.21, 12, 1250-1258, Dec. 1980 (in Japanese).

[9] K.Ozawa, REDATO: A research support system complex with the databases of Japanese ancient tombs based on the relational data model, Proc. IGARSS'83, IEEE, 31-36, Aug. 1983.

[10] E.F.Codd, A relational model of data for large shared data banks, CACM, vol.13, 6, 377-387, June 1970.

[11] K.S.Fu, Digital Pattern Recognition, Springer-Verlag, 105-106, 1976.