A STUDY OF FACILITY MANAGEMENT SYSTEM IN THE COMPUTER AIDED DESIGN USING 3 DIMENSIONAL DATA BASE

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ABSTRACT:

This paper presents a new development of Facility Management System as applied to CAD (Computer Aided Design) using 3D (3 Dimensional) Data Base supported by a R.D.B (Relational Data Base) system in the environment of digital mapping. This system consists of MAPCAD (a digital mapping system developed by PASCO) and an architectural CAD system, both based on AutoCAD graphic platform. The relational data base system being utilized is R:BASE. In this paper, the authors describe the concepts of 3D drawing description and the linkage of relational data base (i.e. R:BASE) to this 3D drawing data via AutoCAD attributes. Although the present data base system is PC-based system, it will be further extended as Facility Management 3D- Data Base System on Engineering Work Stations. Then this system will be applied in various urban planning activities such as in amenity planning, ecological planning, economical planning and landscape design, etc..

KEY WORDS: Facility Management (FM), MAPCAD , AutoCAD, R:BASE, Geo/SQL.

1. Introduction

With the establishment of digital mapping method, geographic information have been reorganized and discussions are made on utilization of these data in various ways. Utilization of such geographic information in facility management (FM) becomes more and more important and expected to grow with leaps and bounds. The data mainly of land use among digital mapping data created in digital mapping processes have been used with reference to other information. This is called a geographic information system. On the other hand a facility management database utilizes digital mapping information together with some other data to manage a facility.Classification codes for geographic features created for a large-scale digital mapping process contributes largely to this facility management data. Basically measurement data are 3D data and facilities management data which have been handled as 2D data on a conventional map can be handled as 3D data with the system consequently enabling 3D facility management.
This report describes how to construct facility management data by utilizing geographic information.

2. An approach to facility management database

Photogrammetric measurement using aerial photographs is an effective method to create geographic feature data of an area. Because it can significantly reduce the labor conventionally required for entering geographic data of an outdoor object at the survey site and provide capability of conducting delicate operations of such data in a room. In addition further progress in digital mapping systems enables real time CAD editing providing a more efficient data processing system.

We have developed a MAPCAD system applicable to the Japanese unique digital mapping process by using a DAT/EM system combining a digitizer with AutoCAD.(Photo 2.1) Further a computer graphics (CG) plane surveying system combining a total station with an AutoCAD has enabled the system to fetch field survey data into AutoCAD data at the survey site in real time mode. (Photo 2.2) AutoCAD Data can be created as desired using digital mapping data and facility management data can be constructed by using AutoCAD. Geographic feature data are acquired by adding height data to the data created by using the POLYLINE structure of AutoCAD. Also 3DPOLY data comprising three dimensional coordinates of each vertex and symbols are used. Data items to be created cover not only buildings, road facilities, environmental facilities, but also underground constructions, buried objects and various boundaries. These data are managed in layered structure which makes it easy to retrieve or collect data in each layer. Further buildings are expressed in three-dimensional building squares to check the landscape.

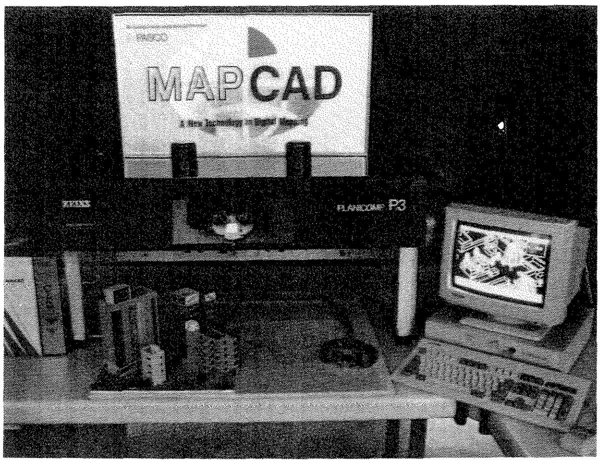


Photo 2.1: Digital Mapping System (DAT/EM system)

Photo 2.2: CG Plane Surveying System

3. Three-dimensional facility management system configuration

3.1 System features

A 3D facility management system is designed to maintain and manage facilities including buildings, railways, roads, water-works and sewerage, electricity and gas. It is a system supporting daily routine works to manage these facilities. Practically it has the following features.

1) Systematization of systems supporting facility management

2) Sharing and integration of information

3) Organizing data maintenance procedures

1) Systematization means speedy and scientific backup of a facility data to assist a long-term city planning which covers the construction plan,construction management, and maintenance and management of the facility. A three-dimensional database is used for intensive use of land in an urban area including underground construction and high-rise building developments. It also can be used to maintain and protect various environments including landscape. The system can also support municipal administration and services.

2) Sharing and integration of information means simplification of facility management map and record updating processes by combining existing file data (text database) and base maps (2D space database). This is to organize digital mapping data (3D data obtained by field survey) as the base map and to supply such common data to other systems.

3) Organizing data maintenance procedures means development of a system and organization with which a desirable data can be input or updated any time.

3.2 Problems on Conventional Geographic Information System

Conventional geographic information systems have been used in various fields including city planning. It is started to be applied to facility management systems. However they do not perform satisfactorily as yet due to the problems outlined below.

1) Maintenance of geographic information and/or database within the system is difficult.

2) Tremendous cost is required to input accumulated information that has not been digitized yet.

3) The system does not support daily routine jobs.

4) Customization is difficult.

5) Data accuracy is not clearly standardized.

6) Handling three-dimensional data is impossible or extremely limited.

3.3 System Development Direction

Considering current circumstances the system is to be improved to implement these functions under current system operation. In other words procedures to ensure daily maintenance of data as well as implementation of supporting functions of the system are required to be provided. For example provision of flexibility for data input functions including updating of digital mapping data on a CAD system, digitization of existing maps using a scanner and visual modification of database is important. In addition improvement of simulation function using statistics and retrieved and/or collected data is required. Further special customized functions including analysis by time such as past, current and future should be implemented. Considering all points described above the target system should

1) enable to input and update current data easily.

2) support daily routine works.

3) be available in extending various functions.

4) utilize currently existing system to the most.

3.4 Outline of System

Figure 3.4.1 provides conceptional drawing of the system functions and descriptions below provides outline of the system.

- Digital mapping data (three-dimensional database) are used as base data.

- Various rearranged maps by theme and existing maps are accumulated in the administrative information together with digital mapping data.

- These data are classified and rearranged by a computer and stored in a source file which is created based on a CAD file.

- Data on various forms and ledgers are stored in relational database as attribute information.

- Graphics data and attribute information can be added, corrected or updated in real time in a CAD or database system.

- Administrative and attribute information can be referred to each other by issuing such a request from the operator.

- The system supports various planning works including creation of various documents.

- These are used as the system document whose data are to be added, corrected, or updated.

3.5 System Configuration

Select or employ the hardware and software to establish the system satisfying the following requirements so as to provide the functions provided in section 3.4.

- The system is efficient in performing digital mapping processes.

- A standard relational database is employed.

- A general purpose geographic information system is employed as the standard system.

- Standard data format is employed.

- The system utilizes a scanner.

Further hardware and software are configured so that the system can be expanded in the future. An example of system configuration is shown in Figure 3.5.1.

4. Application Example

4.1 Creation of Central Governmental Office Geographic Information database

Management of governmental office facilities have been based on the existing building-use map made by Building Repairing Department, the Secretariat, the Ministry of Construction. However, in accordance with increase of management items, conventional management procedures were required to be reviewed. Then a total management system of facility data of the central governmental office was considered, where a mapping information database built with AutoCAD is used as the core to construct a database of the office facilities and the facilities were designed tobe managed by using the system. (Photos 4.1.1 and 4.1.2)

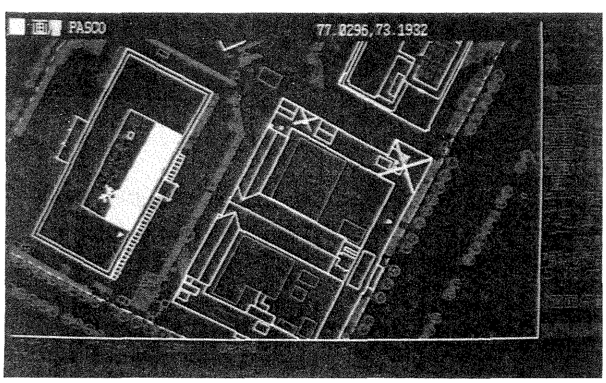


Photo 4.1.1 Central Governmental Office Mapping Data

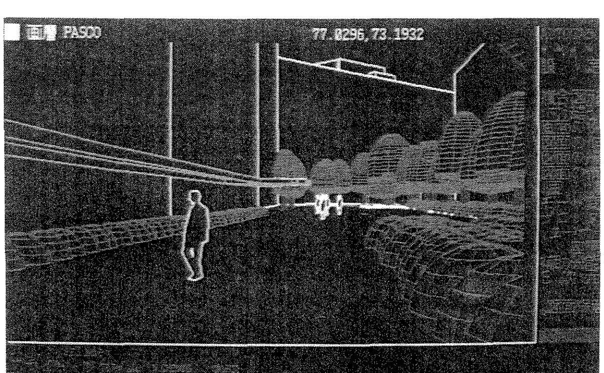


Photo 4.1.2 Three-dimensional Data Used for Consideration of Landscape/scenery

In implementation, CAD based on the AutoCAD was used to design a new building and a relational database was configured by using personal computers to handle geographic information data as AutoCAD data. In other words mapping information is contained in AutoCAD data and the attribute information is managed by R:BASE provided for the relational database.

As the office locates in the central part of a metropolitan city expressing the buildings in terms of three-dimensional mapping data was required. Therefore the data structure shown below was designed.

A building is expressed in a three-dimensional building square by acquiring the profile data of the top floor of the building. Further height data for the top ground and underground floors are acquired to construct a three-layer structure. Also other planimetric feature data in the three-layer structure are acquired. (Figure 4.1.1)

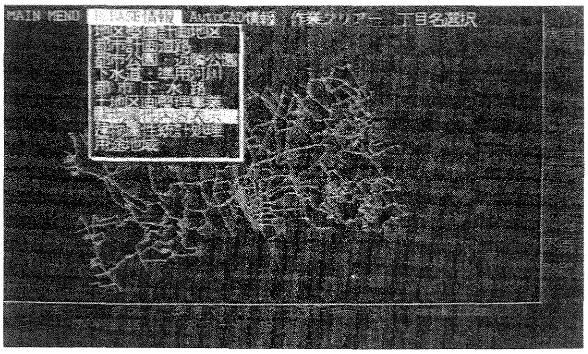
Further, name,height of floors,and ID numbers of buildings are stored in the AutoCAD data as mapping attributes. Then the attribute information in R:BASE is retrieved using these mapping attributes. (Figure 4.1.2)

4.2 Pilot System Supporting Oomiya City Planning

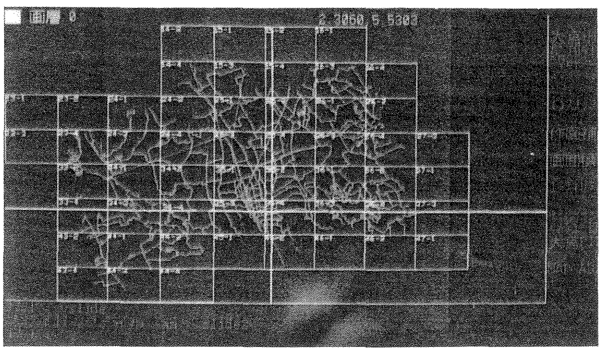
Oomiya-city in Saitama Prefecture created a map with a scale of 1/2500 for the whole city area of 90 km^2 in 1991. This project was undertaken by PASCO. PASCO created a digital geographic data by integrating files including digitized mapping data and standard data into one AutoCAD-based file using a digital mapping system MAPCAD, consequently providing more efficient use of the data.Together with this project Oomiya city has requested to create reports on utilization of digital mapping data and construction of a pilot system supporting city planning works. In this section outline of the pilot system is described.

The pilot system is constructed using AutoCAD MAPCAD 20 and R:BASE on a personal computer. The configuration is as shown in Figure 3.5.1. The items contained in the database are shown in Table 4.2.1. The pilot system has introduced the data retrieval and collecting functions for the items in the database via the menu of AutoCAD by reorganizing geographic information editing functions of MAPCAD 20.

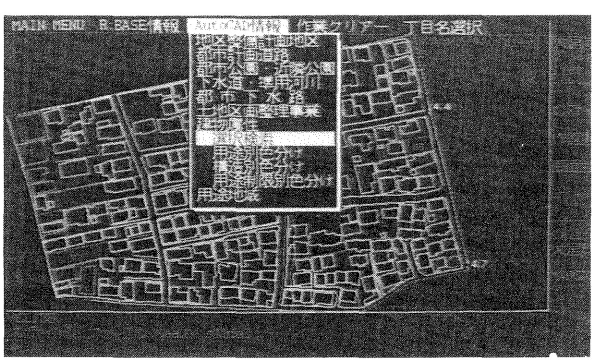
An example of the functions is as follows. When the retrieval of construction attribute is selected on the R:BASE information menu of the AutoCAD, the index map of the whole city is displayed.(Photos 4.2.1) Then the user has to specify the mapping data file of the area.(Photos 4.2.2) If the name of the area is known mapping data file can be retrieved by the name of the area. When the mapping data is displayed, the user has to specify the building that would be viewed on the AutoCAD.(Figure 4.2.3) Then the attribute table in R:BASE is displayed and the attribute data required are retrieved and printed out. Thus retrieval from the AutoCAD environment to the R:BASE environment is enabled. Further retrieving a mapping data from R:BASE to AutoCAD is also enabled. In other words, multiple items including name of area, building use, floor ceiling heights, area capacity and plan for area use can be retrieved on the building attribute retrieve menu of R:BASE. The system is designed to hatch the specified mapping data automatically. (Photos 4.2.4) Retrieval of an item between AutoCAD and R:BASE is made possible now.



Photos 4.2.1 Initial map



Photos 4.2.2 Index map



Photos 4.2.3 The displayed mapping data

Photos 4.2.4 The specified mapping data

4.3 Kyoto Model

The study area has been selected around Kyoto University with an area of about 3 sq.km.The objective is two-fold. One is to assess the suitabilty of the proposed system in the University's space and facilities mangement process dealing with the future space needs of the University. Another is to utilize the same data set as 3-D database for simulation models which will reflect the landscape relationships among buildings (new/old),prominent land-marks and the topographical mountain ranges of the historical capital of Japan.

Aerial photography of the study area was taken from 2-seater Robison R-22 Beta helicopter using Hasselblad MKW hand_held camera. Stereo-models were formed in ADAM MPS-2 portable analytical plotter and conventional 3_D map compilation was carried out with MAPCAD 30 digital mapping system.

The proposed system is configured with MAPCAD digital mapping system,R:BASE (relational data base) and GeoSQL which is the PC AutoCAD-based FM/GIS software developed by Generation 5 Technology. Being a typical digital mapping system,the limiting nature of CAD data structure is inherent in MAPCAD, i.e. CAD data structures are designed without explicit topology, omitting certain references to connectivity, thus not well suited for efficient data analysis. Although it is possible to perform data analysis on a specific level by layering and/or attribute manipulation as described in the previous applications, practical implementation of such approach is rather limited, suitable only for a small infrastructure that could be maintained in a single AutoCAD drawing file without cross-referencing the data levels.

With GeoSQL this bottleneck can be overcome by replacing the CAD data with a suitable spatial data base supported by peripheral softwares to establish the linkage with attribute data base. GeoSQL comprises two data bases: a relational database which supports S(tructured) Q(uery) L(anguage) for storing attribute information, i.e. R:BASE in this case, and the GeoSQL spatial database which is structurally topological as well as internally tile-indexed for storing graphic information. These two databases are linked together to be looked like one and AutoCAD is used merely as a graphic window to these databases. The CAD drawing compiled via MAPCAD is of temporary nature, being used only for data input to that GeoSQL spatial data base. After that, AutoCAD drawing file(s) are no longer necessary for further data analysis and display. (Figure 4.3.1)

Implementation of MAPCAD generated data in GeoSQL involves following basic steps:

Creating databases: Two R:BASE tables are created, one for campus buildings and the another one for trees inside the campus. The BUILDING (R:BASE) table consists of such columns as building number, elevation, height, building type, usage, date of construction, present status, last date of maintenence, etc. The TREE (R:BASE table consists of such columns as tree number, tree type, tree size, elevation, tree age,etc. Roads are used only as graphic primitives,i.e. only as the background drawing for graphic display without associating with any attributes.

Defining Geoviews: By defining Geoview,all the pertinent system parameters such as databases involved, type of relationship (i.e. simple, linked, dynamic) between the GeoSQL spatial database and R:BASE attribute database, and R:BASE table column(s) including the one used for unique ID(entifier) are all set for a particular application. Different Geoviews can be defined from a given data set. Each Geoview is given a name and further data analysis is made by referencing only to that Geoview name. In the present case, simple Geoview types are used, i.e. single R:BASE table is linked to single GeoSQL spatial database subject. Two Geoviews are defined and named , one for campus buildings with building number as unique ID and the another one for trees with tree number as unique ID.

Tagging the map entities: Tagging associates each record of information in R:BASE table with its corresponding object in AutoCAD drawing. Tagging has to be done first by defining a tag with the contents depending upon whether the attribute (column) values should be read from or should be written back to an existing R:BASE table during the tagging process. Object type(i.e. point, line, polygon), Geoview name, associated R:BASE table column(s) are also included in tag definition and unique ID column is automatically selected by referring to given Geoview name. In the present case, unique ID is building number for tagging the buildings and tree number for tagging the trees. Since other data are already existed in R:BASE tables, the tag definition used in this case contains only one unique ID column for each tag. For tagging the buildings, integrity of CAD drawing data is first checked by using a GeoSQL built-in facility. This facility allows error checks and , to some extent, automatic corrections for overshootings, undershootings, dead ends, and concidence lines, etc.. Then the polygon entities (buildings) are tagged by picking relevant interior points while the point entities (trees) are tagged by the point-locations themselves.

Inserting into GeoSQL spatial database: After establishing the relationship between R:BASE records with their corresponding X, Y locations in AutoCAD, these graphic primitives are inserted into GeoSQL spatial database by GeoSQL INSERT command. In this process, the attribute insertion points are extracted, stored in GeoSQL spatial database each with system-assigned OBJ#, and that OBJ# is written into OBJ# column in the R:BASE table. For polygons, additional step is required to determine, extract and insert all the line-work that makes up the polygon object for each interior point. In essence, INSERT establishes the topology, sets-up the spatial database from CAD graphic primitives,and links these spatial objects to their corresponding attribute records of R:BASE through the OBJ#.

Data retrieval: Various outputs tailored to suit the individual needs of different applications can be derived by using GeoSQL Query command. QUERY adopts the SQL command syntax with the following options: SELECT (primitives, points, lines, polygons, attribute columns), FROM (Geoview names), WHERE (geographic condition, attribute condition), AS (AutoCAD drawing, text layout), FORMAT (text and object formatting by AutoCAD graphic options). In the present case, preset queries are made so that, whenever retrieved back in AutoCAD graphic display under various attribute and geographic aeral conditions, buildings are formatted by the corresponding elevations and heights and the trees are formatted by tree elevations, tree sizes and corresponding tree symbols.
By this way, queries can be made according to the needs of University's Facility Management and these queries can be retrieved back as text reports or as 3-D simulation models interactively in AutoCAD graphic environment. (Photo 4.3.1).

Since all the CAD drawings are being replaced by single spatial database which is topological as well as tiled, fast queries can be processed via tile-wise filtered search, slivers and slices can be avoided by explicit topology and the entities common to seperate CAD drawings can be handled without sewing the drawing patches.

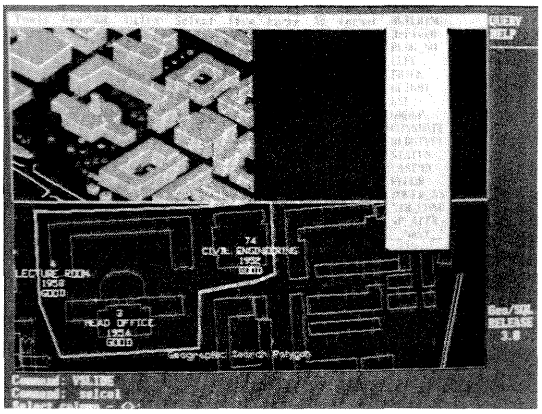


Photo 4.3.1 University's Facility Management(Graphic)

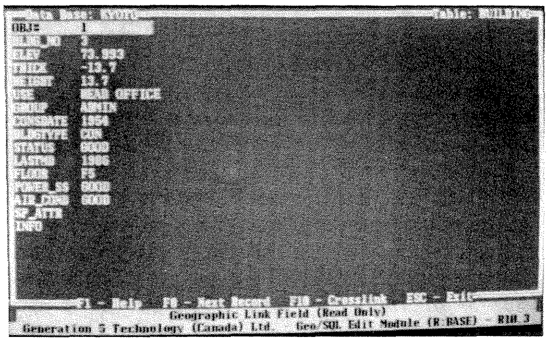


Photo 4.3.2 University's Facility Management(Text)

5. Conclusion

We have built up a facility management system using geographic information data created through digital mapping processes. Now we are confident that a system connecting AutoCAD and R:BASE is a capable one and we are going to study its applications further.

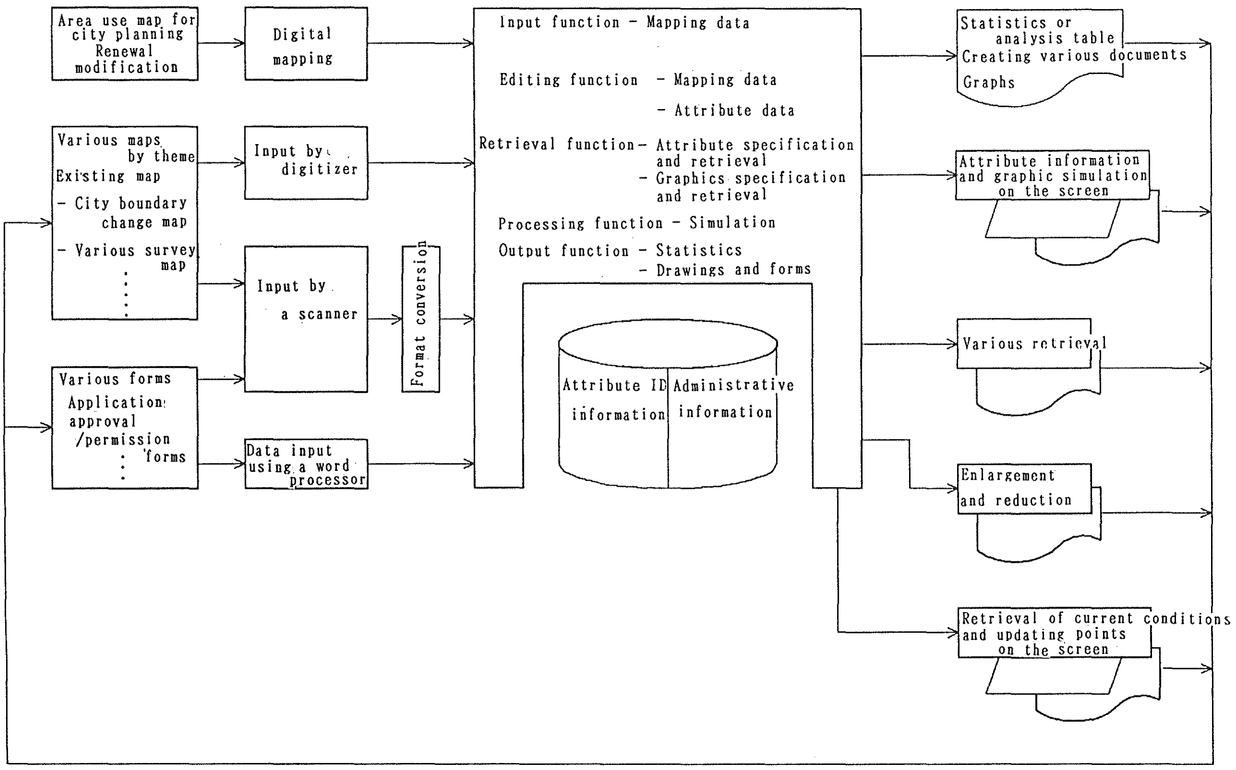


Figure 3.4.1 Conceptional Drawing of System Functions

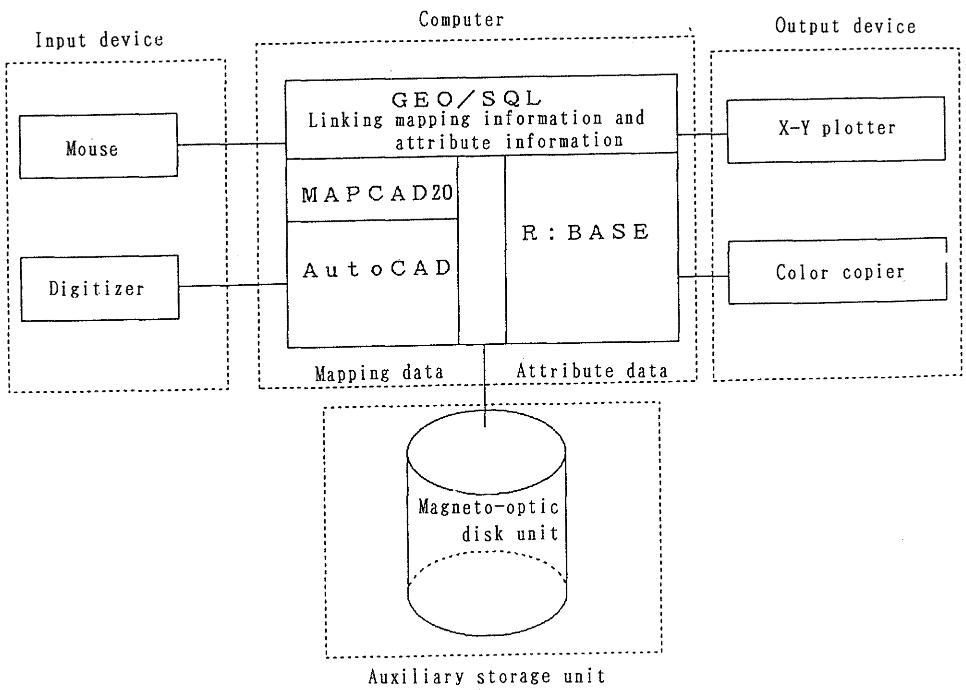


Figure 3.5.1 Example of System Configuration on a PC

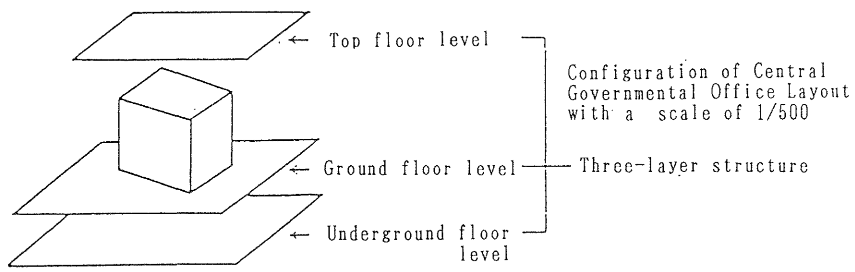


Figure 4.1.1 Three-layer structure of data

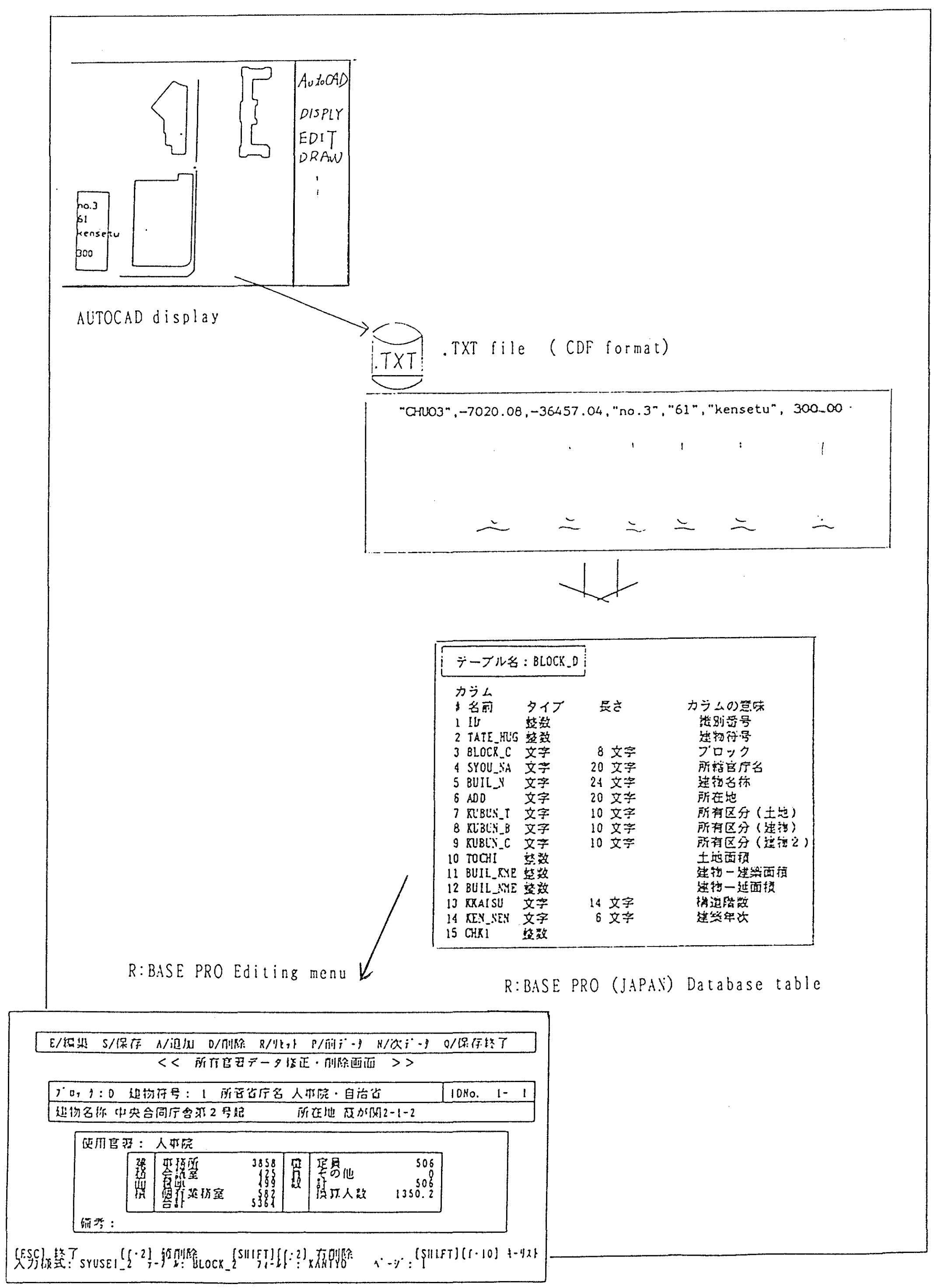


Figure 4.1.2 Retrieval of Attribute Data

Name of Item	Graphic data	Acquisition procedure	Attribute data	Contents in attribute data
Area renewal plan	○	MAPCAD20(Digitizer)	○	name,address,details of renwal plan
Road planning	○	MAPCAD20(Digitizer)	○	name,starting and ending points,renewal ratio
Registration park area	○	MAPCAD20(Digitizer)	○	name,area,plan determined data of park
Sewage stream		MAPCAD20(Digitizer)	○	type,name,planned sewage block etc.
City sewage piping		MAPCAD20(Digitizer)	○	name,plan determined date, outline of plan
Land use planning project	○	MAPCAD20(Digitizer)	○	name,organization of the project,etc.
Building attribute	○	MAPCAD30(A/D Plotter)	○	building type,structure height in floors

Table 4.2.1 Items to be stored in Database

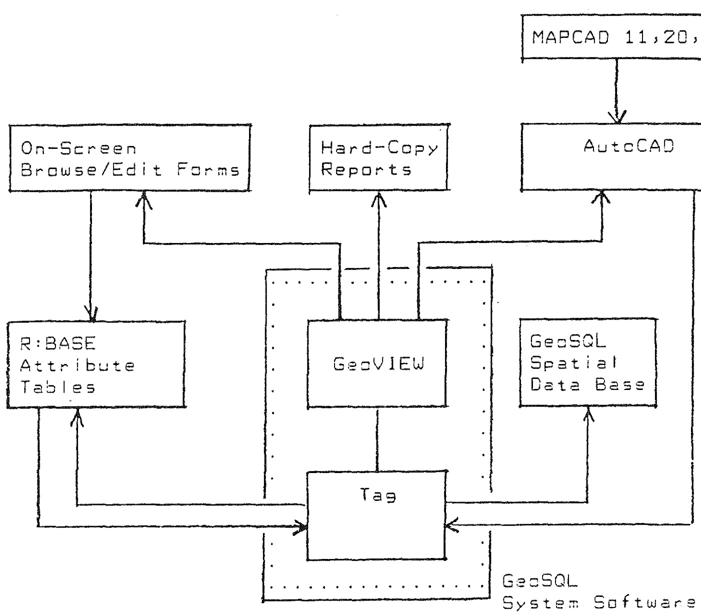


Figure 4.3.1 System Configuration GEO/SQL

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