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案例式都市規劃支援系統之實證研究

An Empirical Study of a Case-Based Urban Planning Support System

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摘　要

以往都市規劃支援系統的發展，由於規劃知識的高度複雜性與不易結構化的特性，造成專家知識擷取困難，以致系統發展成效受到影響。近年來以案例式為基礎之支援系統逐漸受到重視，因此本文將探討以都市規劃知識為基礎之案例式新型系統之發展方法與幾個系統發展之關鍵技術，以彌補以往都市規劃支援系統發展的不足。文中一則將探討案例的展現與擷取等階段，其系統運作設計構想與方法；另外，亦將探討以認知理論為基礎的知識工程方式，以確實掌握使用者行為進而作為系統設計之基礎。同時透過實驗性系統之運作，可用以檢證系統之發展理論與發展方法。

關鍵字：都市規劃支援系統、案例式系統、知識工程、認知理論

Abstract

The high complexity of planning knowledge and the difficulty of structuralization have fostered the uneasy procurement of professional knowledge and have deterred the development of urban planning support systems. A new type of case-based system has received extensive attention recently. This article presents a new case-based planning support system approach and key techniques of system development to overcome the inadequate developments of previous urban planning support systems. In this article, we study the design ideas and methods of system operation for the phase of case-based development and

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procurement; on the other hand, we also study how to apply the knowledge engineering techniques which are based on cognitive theory to actually control user's behavior to further become the basis of system design. Meanwhile, we operate an experimental system to examine how the developmental theory and the methodology of the system are formed.

Keywords: urban planning support system, case-based system, knowledge engineering, cognitive theory.

Introduction

As geographical information system (GIS) has continued to advance in recent years, planning support systems based on knowledge of urban planning have also attracted greater attention. A review of the relevant historical literature reveals that the approach has widely been adopted by many researchers. With the knowledge engineering techniques, the approach of integrated planning knowledge or a rule-based expert system attains expertise and further dismantles it into reasoned rules for the support of planning or decision-making. However, due to the complex nature of urban planning, the development of the approach is restricted by system functions in terms of insufficiency of the structuralization of expert planning knowledge. Case-based reasoning (CBR) has recently evolved. Rather than dismantling expert knowledge, this system emphasizes solving problems on the basis of case studies. It can, thus, partially improve the restrictions on knowledge expression imposed by conventional expert systems. The idea of a case-based system is an applied model, which assumes that people tend to adopt previous problem-solving patterns as the ground base and then make appropriate modifications to tackle new problems. In retrospect, the general planning practice emphasizes the significance of planning experience. The nature of the planning experience is an accumulation of case-based comparisons. It has many similarities with the principles of case-based systems. Therefore, this article attempts to utilize a primarily case-based development approach to present a new case-based system development approach based on urban planning knowledge to overcome the inadequacies of current urban planning support systems.

Moreover, we can see that in the historical development of support systems, procurement of expertise is the key element to the success of a system. With case-based support systems, determining how to efficiently procure the case used by the expert to solve the problems and to control the behavior and pattern of the case used is the key point in system development. This is related to the process of cognition; thus this article applies cognitive psychology as the theoretical foundation to study its behavior. It also carries out a survey analysis of planners using an experimental approach to initially sum up the behavior design and present the procedures of planning case procurement with reference to virtual system construction.

This article is composed of five parts: (I) Introduction; (II) Case-Based Planning Support System (CBP) procedures, including the content of CBP, and the interpretation of CBP characteristics and position; (III) a study of cognitive science based on a knowledge engineering approach; (IV) key system construction techniques, which focus on elaboration of case storage, presentation, and retrieval in the support system; and (V) illustration of the effect of the system by means of a virtual system simulation. Finally summarized conclusions of this article are presented.

Case-Based System Planning

This article first makes the development and characteristics of past case-based reasoning system, and further elucidates the roles and positions of a case-based planning support system.

1. Operation of a Case-Based Reasoning System

The CBR was derived from an understanding of human beings and their interpretation processes (Schank, 1982). When CBR is operating, a case analysis is required from existing case-based knowledge to induct and retain the predecessor's experiences and use it as a short cut to determine the answer. Therefore, the operating procedures of a CBR are as follows: (1) identifying the problem as a new case; (2) selecting earlier cases which had been solved with similar situations from the current database; (3) comparing the current cases with the existing case and then revising it; (4) determining the optimal alternative; (5) storing the new case into the database; etc.

The number of cases applying CBR is increasing, and it will eventually be widely applied to different fields, including: (1) MEDIATOR (Kolodner and Simpson, 1989) which mainly utilizes past experiences to mediate the conflict between two counterparts; (2) JUDGE (Bain, 1986), a system applied to law precedents, which determines similar cases from previous verdicts and makes suggestions to judges about sentencing in lawsuits; (3) CHEF (Hammond, 1989) and JULIA (Hinrichs, 1992) which are two systems that can set up new dish menus based on past experiences; (4) CASEY (Koton, 1989) and PROTOS (Bareiss, Portor, and Weir, 1988) which are two disease-diagnosing systems that diagnose patients' diseases by comparing the patient's symptoms with previous ones; (5) DES-DS, a design system based on CBR; (6) The Battle Planner (Goodman, 1989), a system which can predict land acquisition lawsuits based on previous cases; (7) ADA (Architectural Design Aid), a system which can attain and evaluate architectural designs based on previous design cases; (8) applications of case-based reasoning to urban planning and integration of case-based systems and GIS in development control (Yeh and Shi, 1999); and (9) application of a case-based system and GA-based engine in E-learning of QandA systems (Fu and Shen, 2004). In early times, CBR was widely applied for medical references, lawsuits, diplomatic strategies, scenario simulations, and menu designs on down to today's military applications, procedural planning, engineering designs, etc. CBR has been upgraded from pure reference functions to the level of assisting with planning designs. It has supportive potential to those ill-structured planning contents and requires many planning experiences as the base for urban planning. Therefore, it has been strongly recommended for support urban planning activities to overcome its difficulty on application during the past time (Yen and Shi, 1999). This shows that CBR is a system with developing potential. Therefore, this article attempts to carry on the research on planning support system development by utilizing the ideas of CBR.

2. The Roles and Functions of Case-Based Planning Support Systems

In the context of urban planning, the following items need to be covered: delimiting the plan, establishing planning objectives, conducting surveys to collect and analyze data, arranging timing for public participation, searching and proposing topics, modifying planning objectives, formulating development strategies and approaches, generating a physical development plan, evaluating relevant cases, assessing budget financing and development installment plans, implementing the plan, etc.

Each aspect of the plan is complex. The CBR system support for each aforementioned step varies in terms of its importance. Obviously, part of the procedure (such as proposing cases) accentuates the application of past experiences, while part of the procedure (such as surveying current physical settings) more highly emphasizes actual data investigations of current physical situations. Thus, the significance of the CBR system varies with different requirements. Hence, it is extremely difficult to expect the support system to structuralize planning expertise and undertake self-modifications. The effectiveness of self-modifications also remains questionable.

In view of this, the function of automatic case adaptation in the CBR will be left to planners' own discretion based on their expertise so that the creativity of planners and designers can be retained. This article applies the Case-Based Planning (CBP) system to support urban planning work and uses semi-structuralized problems as the supported objects. This article mainly focuses of case storage, case representation, and retrieval of similar cases.

Knowledge Engineering Based on Cognition

The design foundation of various case-based systems mentioned above should be based on a behavioral model of users' cognition. This article applies a research analytical approach of knowledge identification to strengthen the study of users' knowledge engineering of the system.

At the present time, research procedures of cognitive science, artificial intelligence, design work, and such related fields need to collate and analyze tremendous amounts of intelligent activity data. Previously, it was relatively difficult to assess these passive and hidden data, therefore much research was undertaken using various approaches. After long-term experimental research, in 1993, Ericsson and Simon presented much scientific evidence and examples to prove that verbal data can become efficient research data of intelligent activity. Protocol Analysis which utilizes verbal data has thus become a widely used analytical method. The principles and experimental methods of Protocol Analysis are described below.

1. Procedural Mode of Protocol Analysis

The kind of data used by Protocol Analysis is verbal data, and these data are obtained by thinking aloud or by retrospection. When carrying out the analysis, the way of human knowledge is stored and thinking models of human being must first be understood.

In the study of cognitive science, scholars like using schema to discuss similar viewpoints. Because the amount of information which can be processed within the human brain is limited (restriction of the Short-Term Memory), the information must be organized into parts in order to process it. This is the so-called behavior of chunking. Each little part of the unit can be a set of key models, and several key models organized together form a new key model. This new concept can be combined with other concepts to form a broaden concept. The key model constitutes an organized structure under the behavior of chunking. Utilizing the key model to foster consciousness and thinking enables us to filter, organize, and process massive amounts of information in an economical and rapid way. Various key models can affect our interpretations of new information and methods to memorize new information. For example, when different people describe some particular place locality, they describe it in different ways due to various personal interpretations.

2. The Experimental Method of Protocol Analysis

A verbal report enables designers to express information which is stored on the Short-Term Memory and Long-Term Memory of the human brain by language when they undertake design work. This means that designers express their own internal thinking activities (Erisson and Simon, 1993). There are two different way to carry out a verbal report.

3. Thinking Aloud

When planners engage in planning, on the one hand, the human brain is undertaking planning action, while on the other hand, the human mouth verbalizes the design thinking action undertaken by the human brain. At that moment, the researcher can use a recorder or camera to record and transcribe this into a verbal protocol for analysis. This method is easier to observe the real behavior of planners. Its disadvantage lies in the uncontrollable disturbance which the working flow of planning that is needed cannot match the research time schedule. The other disturbance is that when planners are engaged in the method of thinking aloud, they have to convey their thinking contents into language and express them. Thus, planners' emotions and thinking operative behavior are easily influenced while making plans.

4. Retrospection

Retrospection implies that a plan generates action and it is carried out for a time period, then planners are asked to recall and express their thinking flow for generating the plan. The host of the experiment can question the action of retrospection, or this can be undertaken by planners themselves. The advantage of this method is that researchers can put several planners together to satisfy special main theme requirements and to efficiently meet the research time schedule; thus, it is a more-efficient method. But according to the research, it is fairly easy for planners to mass around contemporary knowledge with past knowledge when they apply the retrospection method. Thus, it becomes very difficult to procure the actual data, but if the researcher further utilizes the principle of the matrix plan to choose interviewees as quickly as possible, then the difficulty can efficiently be solved.

For planning purposes, because a longer time is needed to plan, more difficulty exists for researchers when they use the experimental mode of thinking aloud to record the entire time period of the planning procedure. Hence, this research attempts to utilize the mode of the retrospection method to guide the interviewee to recall the behavior of the case-based planning procedure, so as to undertake the study of the intelligent behavior of planners in a case-based scenario.

The Theory and Method of the Key Techniques for System Implementation

As mentioned above, the key technical topics in implementation of a case-based urban planning support system include combining urban planning experience with graphic information to properly store them; selecting an appropriate case for reference in supporting a plan, that is a topic of case-based selection; and determining how to express a planning case in an efficient way for reference: this is the issue of case representation. The following sections elaborate on these key elements.

1. Storage of the Planning Case

Except for concrete examples, a case is basically condensed knowledge of problems or alternative solutions, and a mode of solving problems. The presentation pattern of a general case includes three parts: a situation description, solutions to problems, and outcomes. Therefore, the storage mode of knowledge varies with the characters of various problems in different knowledge storage methods. For instance, CASEY and PROTOS (Kolodner, 1993) follow attribute-value expression; GCBRS (Chi, 1993) and MEDIATOR (Kolodner, 1993) utilize a frame-based mode; and the CHEF (Kolodner, 1993) system is a hybrid mode. Basically, the requirements for contents and information formats of the urban planning case are complicated. In addition to requiring text information for the descriptions of themes like planning circumstances, plan alternatives, and plan evaluation, descriptions of photo images, charts, and related geographic information are also required. Moreover, most planners are used to utilizing graphs to understand pertinent information and outcomes of planning sites. Therefore, case descriptions must combine texts with graphs.

The model of integrated information offered by conventional GIS in the production of graphs uses artificial delineations to mince the real world entity into pieces. This method adopts geometric objects (points, lines, planes, etc.), topological relations, and classification attributes to achieve an information description method (Tang, 1996). Nevertheless, the delineation is insufficient to make up the content of a complete planning case. And, it also fails to manifest the linkage between geographic information of planning sites and the significance of planning.

Hence this article further applies features-based geographic information descriptions to achieve thorough storage of the planning case. A feature can be divided into two levels in terms of meaning: the real world entity and a digitized description. In other words, a feature contains spatial and non-spatial characteristics that use attributes and relations to depict relationships between them. In the information representation of planning cases, a feature means distinctive elements of planning coverage. For example, land use zoning of residential areas and public facilities shown on planning maps represent a kind of feature. Features of planning cases can be categorized as:

(1) Describing information on the attributes of spatial characteristics of features by statistical information, such as area and locality;

(2) Describing information on the relations of spatial characteristics of features, obtained from the relativity of objects in the planning coverage by users;

(3) Describing information of the attributes of non-spatial characteristics of features mainly to express the significance of planning features; and

(4) Describing relations of non-spatial characteristics of features to elaborate non-spatial relationships with other features.

This research defines planning features as three relations, including part-of, composed-of, and cause-of. For instance, the land use feature is composed of the residential use feature; the residential use feature is part of the land use plan maps; and the land use plan is the cause of the land use status quo.

During the implementation stage, the system integrates maps, texts, and images using hyper-links to demonstrate graphs and feature information of planning cases. The inquiry, analysis, and representative functions of GIS spatial information are integrated to provide a dynamic space, attribute searching, and an object-oriented database to produce urban planning information cases.

2. Selection of Appropriate Cases

(1) The Design of a Case-Based Retrieval Mechanism

In CBP, case selection is mainly assisted by indexes. This article recalls the selective behavior theory and finds that Luce’s model (1959) is restricted by an unexplainable similarity effect. In 1979, Tversky presented Elimination by the Aspects (EBA) model. The EBA model assumes that for the decision-making procedure when a decision maker is faced with many choices, he will take one important attribute into consideration and exclude those choices without this attribute from consideration. Then the decision maker will select a second attribute for consideration and exclude those options without this attribute from consideration. The cycle is repeated over and over again, until there is only one choice left. Thus adequate selective behavior is generated. The selective attribute of this method is basically the nature of exclusiveness and noncompensation. Case selection is a Yes or No decision. It is hardly sufficient to choose a similar case through recognition of Boolen's logic, and this always generates the nature of mutual compensation between indexes.

In functional designs of similar case retrieval, this research used the EBA model to integrate multi-principled evaluation techniques and to procure the system case using a hierarchical search process scheme.

A two-step search strategy is followed for case selection. The first step is to perform a preliminary screening, then locate the most-appropriate case for reference. The two-step search strategy utilizes the EBA model as the basis for undertaking the application of a critical slot and common slot, respectively. The critical slot is mainly used for the preliminary screening of cases, and a non-compensatory approach is taken to exclude those cases of mismatched key indexes in order to speed up the search process. In the search process, any planning case which has a different critical slot from the current case is thereupon abandoned. Conversely, the common slot uses a compensatory approach for further screening comparisons. Disposal of the general index can be separated into two parts: weighing measurements of each index and assessing criteria of index attribute values. The Analytical Hierarchical Process (AHP) method plays an ancillary role in the measurement of index weighting.

(2) The Attribute Assessment Criteria of the General Index

The general index attribute value is classified into two categories: one category has the attribute of a "quantity" nature, such as area, number of households, road coverage, etc., while the other category has the attribute of a "quality " nature, including topography, land use, and area composition. The ideal point measures can be standardized to deal with quantitative variables and to present reasonable assessment values. In dealing with "quality" index variables, the "qualitative" attribute indexes can further be divided into two categories. One deals with scale relations, such as topography and the clustered dwelling status; and the other deals with categorical attributes, such as land use and area compositions. The planners use either an "interval scale method" or "direct measure method" to rate the order of attributes with their professional sight and express the index attribute values according to a point scale of from 0 to 10. Then the ranked points are standardized to yield rationalized measurement values. The non-scale index has only answers of yes and no, thus the standardized points of its attributes are either yes (0) or no (1). After index weights and index attribute measures are determined, the weighted linear combination method can then be applied to search for more-similar cases for reference.

(3) Application of the General Slot Ideal Point Analysis

For the purpose of evaluating each case's characteristics, the system first utilizes the ideal point analysis of each index. Each index has a special and objective mode to process different types of data. Even if it consists of sequential or categorical data, it all can generate quantifiable numerical values to undertake proper calculation of the following cases. This differs from the nature of the general multiple criteria decision-making method in that the ideal point almost does not exist. The ideal point of this system is meant to serve as the feature value of this planning issue. The appropriate selection of planning cases is the case which is closest to the ideal point. This allows the determination of the shortest distance between the planning case database and the ideal point. It is defined as:

$$d_{\min} = \sum_{j} (1 - e_{ij})\ W_j \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where W_j is the standard weight of j number and e_{ij} is a standardized point which has “quantity” attribute and “quality” scale attribute index, the definition of standardized point is as below:

$$e_{ij} = \frac{|\, S_{ij} - S_i^{ideal} \,|}{\max\ S_j^* - \min\ S_j^*} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

To the “qualitative” categorical attribute index, the definition of its standardized point is given below:

$$e_{ij} = \begin{cases} o & if \quad S_{ij} = S_j^{ideal} \\ 1 & if \quad S_{ij} \neq S_j^{ideal} \end{cases} \ldots\ldots\ldots(3)$$

S_{ij} indicates the ith case of the planning case database and the measurement values of jth index, and S_j^{ideal} represents the measurement value of jth index of the planning case,

Assuming that $\max S_j$ and $\min S_j$ are the maximum and minimum measurement values of jth index of each case in planning case database.

$$\max S_j^* = \max S_j \quad \text{if} \quad \max S_j \geq S_j^{ideal}$$

$$\max S_j^* = S_j^{ideal} \quad \text{if} \quad \max S_j < S_j^{ideal}$$

$$\min S_j^* = \min S_j \quad \text{if} \quad \min S_j \leq S_j^{ideal}$$

$$\min S_j^* = S_j^{ideal} \quad \text{if} \quad \min S_j > S_j^{ideal}$$

To calculate the slot of ith case, it meets with the distance of $d_{\min}$. Each case’s $d_{\min}$ is calculated in the case database, and ranked in an order of small to large. And take the smallest $d_{\min}$ of case as the most appropriate referable planning case for case selection.

Additionally the system must provide case evaluation information to determine whether the retrieved case has referable value. In the case of the evaluation approach, this research suggests the setting up of a dynamic information system to trace implementation effectiveness and to upgrade the case executing process. The user’s evaluation of retrieved cases can further be the basis of the referable value.

3. Representation of Case Knowledge

The primary goal of case knowledge representation is to enable the various system users to obtain needed planning case contents from the computer system as quickly and efficiently as possible. This research presents a view-based procedure which is based on the user’s viewpoint in planning case representation.

Since the CBP support system is offered for the use of different planners who operate the system with distinct areas of concern, the system must, therefore, be adapted to the viewpoints of a myriad of users in providing information and operation. The way of gaining different users’ viewpoints mainly utilizes the aforementioned interview survey of the “retrospection method” to recall the contents of referable cases from interviewee’s past experience. To simulate and analyze various users’ viewpoints in advance and build up the model, different users’ operations should be contained and expressed to solve the problems of multi-applied viewpoints.

Taking official urban planning classification as an example, users can start with the classification of planning type (master plan, detailed plan) and further search for cases with distinct planning natures (city/town plan, hamlet/street plan, special district plan), or in cases with different attributes (city/town plan, hamlet/street plan, special district plan), to search for contents of a master plan or detailed plans. In other words, if the viewpoints of planning contents are a major concern, users can begin with classification of themes (residences, traffic, facilities, etc.), and further search reference reports for contents of various stages (current conditions, predictions, case, evaluations, etc.), or for viewpoints of reference reports (current conditions, predictions, cases, evaluations, etc.) to plan for different stages and further search for issues of concern (residences, traffic, facilities, etc.).

The key techniques conception what have been proposed could be effectively employed as the operating foundation for CBP system. But due to the actual cases study for urban planning were limited that the real operating and application achievements have certain restrictions on system itself. Therefore, this system was more suitable for senior planners to modify those reference cases according to their own experience to avoid mistaking the cases.

Procedures and an Example Interpretation of the CBP

To sum up the structure of the CBP system, it stores cases in the form of graphs, text, and GIS from the CBP database. When in use, the CBP system utilizes the application of critical slots and common slots to undertake the retrieval of similar cases for reference. When the reference cases are represented, it provides the representation procedure of case contents through the requirements of a user's viewpoints (Figure 1).

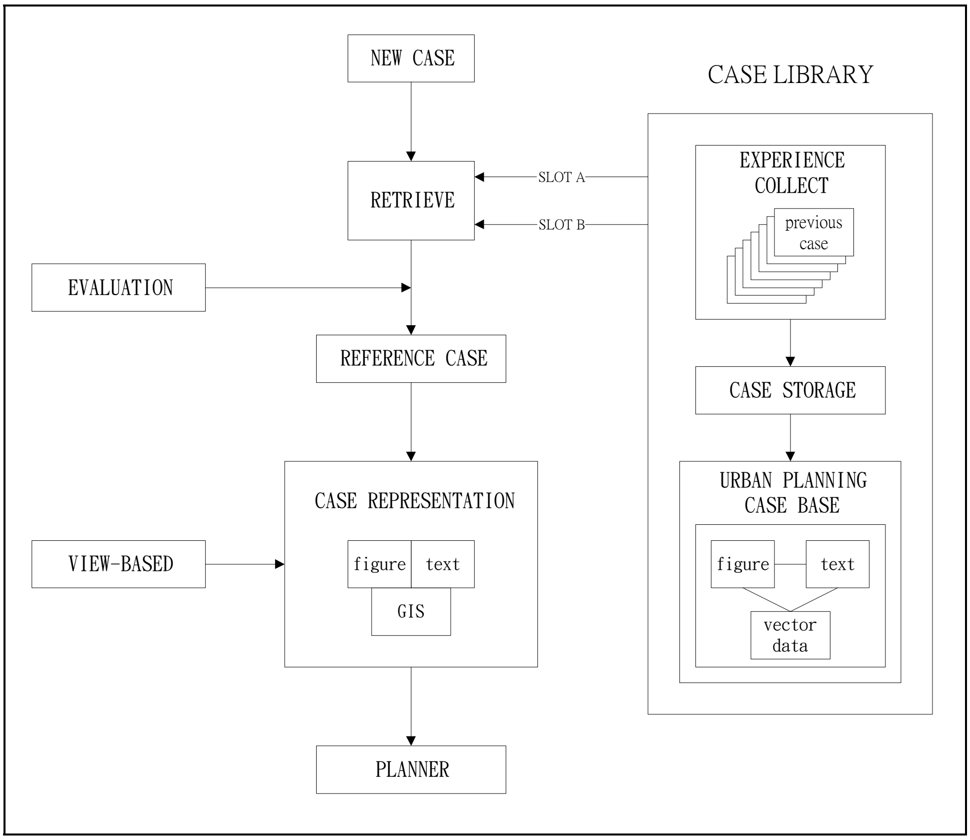

Figure 1 Structure of the case-based planning system

To further clarify the feasibility of the system's operation and structure, this research simulates the mode of an actual scaled-down system constructed to strengthen the application of case-based urban planning support systems. Because the key point of the actual construct lies in simulating the operation of the system structure, therefore, this research concentrates on the retrieval and representation of cases. Meanwhile, for the purpose of easily conducting this survey, this research takes 60 students from the Department of Urban Planning of National Cheng Kung University as the object to carry out the survey research of their former case using behaviors by the retrospection method for the basis of constructing a scaled-down system. In the following section, the course of survey results and system operations are explained in detail.

1. Searching for Reference Cases

After interviewees had shown that, in the past, when they were carrying out urban planning work, the behavior of selecting cases for reference could be induced from the indexes with a non-compensatory nature including:

(1) planning case natures: such as proposing new urban plans, expanding urban plans, or overviews;

(2) planning categories: such as city/town plans, hamlet/street plans, or special district plans; and

(3) urban hierarchies: planning areas such as capital, regional center, sub-regional centers, local centers, general city/town, village centers, etc.

Thus, this research design system's case retrieval takes the aforementioned three indexes as the critical slot. The compensatory indexes of case selection include:

(1) geological environmental features: such as mountains, plains;

(2) demographic scale similarities;

(3) area size analogy;

(4) population movements: the immigration and emigration of that area’s population; and

(5) whether they have the same industrial resources.

This article takes these five indexes as a common slot of the system.

Therefore, when users enter the system to search for reference cases, it fills in the feature terms of current planning cases between the critical slot and common slot for the basis of procuring similar cases. The system also provides various weighting establishments for the common slot, and it can assign significance of each index according to comments of the expert’s questionnaire or individual preferences of users. The system can carry out similar case searches by the exclusion method of the critical slot and multiple criteria assessment procedure of the common slot (Figure 2).

When the system constructs new planning case contents through previous procedures, it matches with the function offered by the SOL server to save the index attributes into the database of CBP.

2. Representation of Search Results

The system calculates similar distances between each case of the CBP database and each case of this planning case, and then ranks planning cases to express the similarity of each case. In addition, the system displays basic information of each case on the bottom screen of the window. Through hyperlinks, users can browse case contents in the sub-system (Figure 3).

As to the procedure of system representation of case contents, after the user interviews are finished, we can initially categorize the case representation procedures into two types according to differences in the reference case contents. The first type is based on the viewpoint of the planning report, and the major contents of the references rely on the chapter orders of the planning report for reference. For the procedure of reference case contents, refer to Figure 4. The other type refers to the particular department of urban planning (Figure 5). Therefore, this research designs different case representation procedures to meet these two requirements.

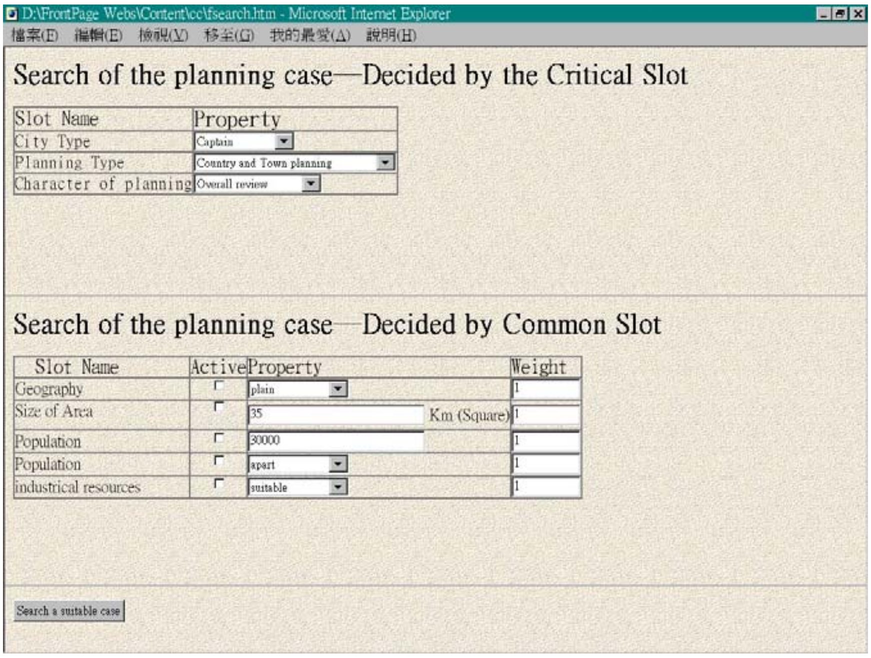

Figure 2 Compilation of the slot search in the planning system

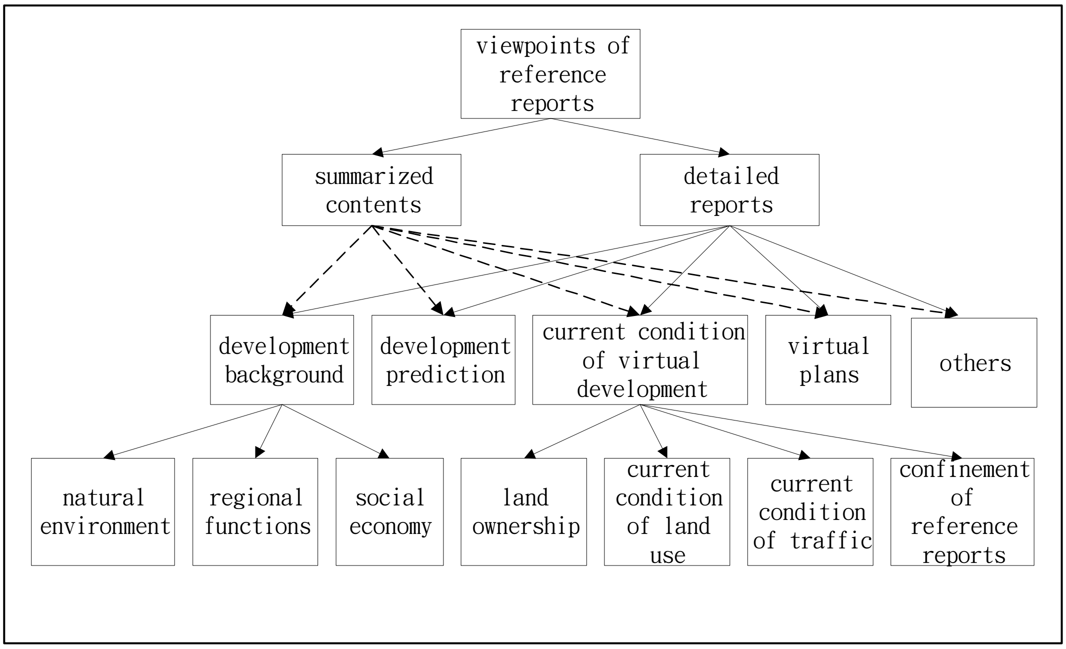

Figure 3 Search results of a planning case

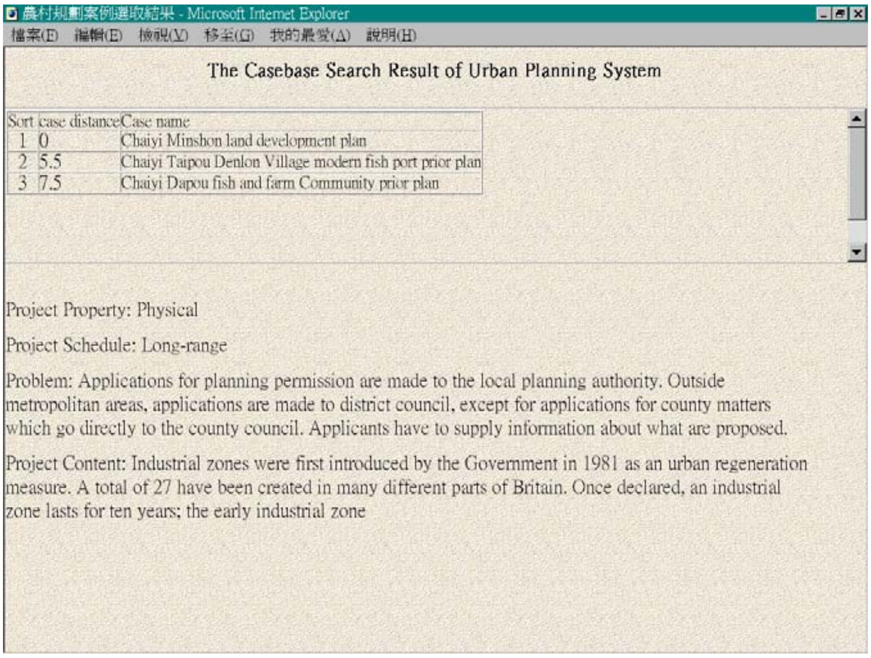

Figure 4 Case representation process for viewpoints of reference reports

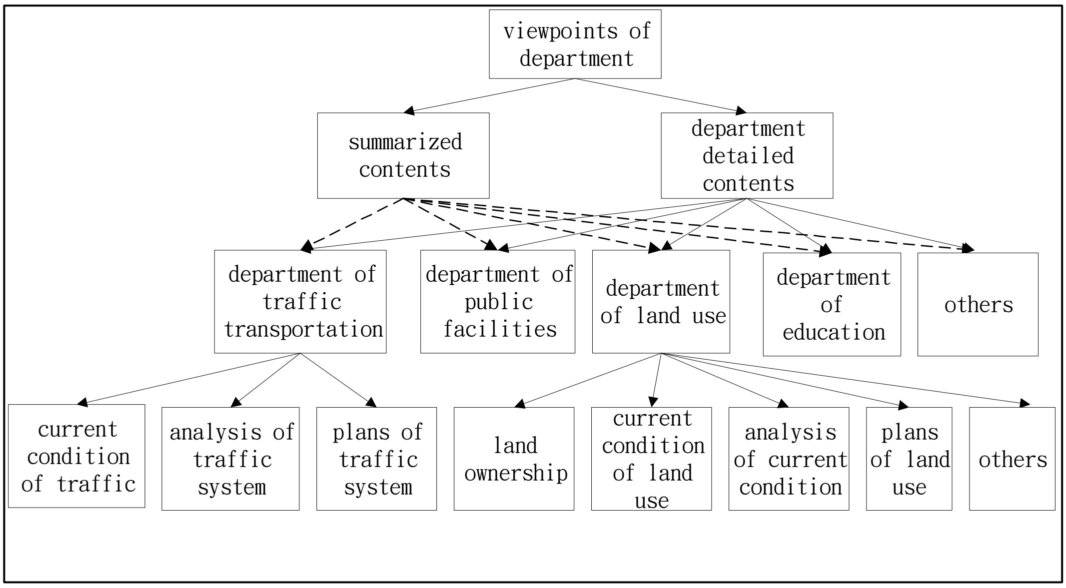

Figure 5 Case representation process for viewpoints of departments

3. Content Representation of Selecting Cases

Upon completing the selection of the most-similar case, users can further choose the content representation mode in accordance with their needs. If a user opts for the viewpoint of planning reports, he or she can first click “summarized report” or “detailed report”, and subsequently choose the contents of “development background”, “development prediction”, “actual condition”, and “virtual planning”. If a user selects the departmental perspective, he or she can select “summarized contents” or “detailed departmental contents”, and then goes for the categorical information of “transportation”, “public facility”, or “land use”.

By choosing the various aforementioned case information representation formats, the designated case contents can be used in the feature-based case representation mode. Users can further inquire about the needed case information based on different planning features and use it as a reference for planning works (Figure 6).

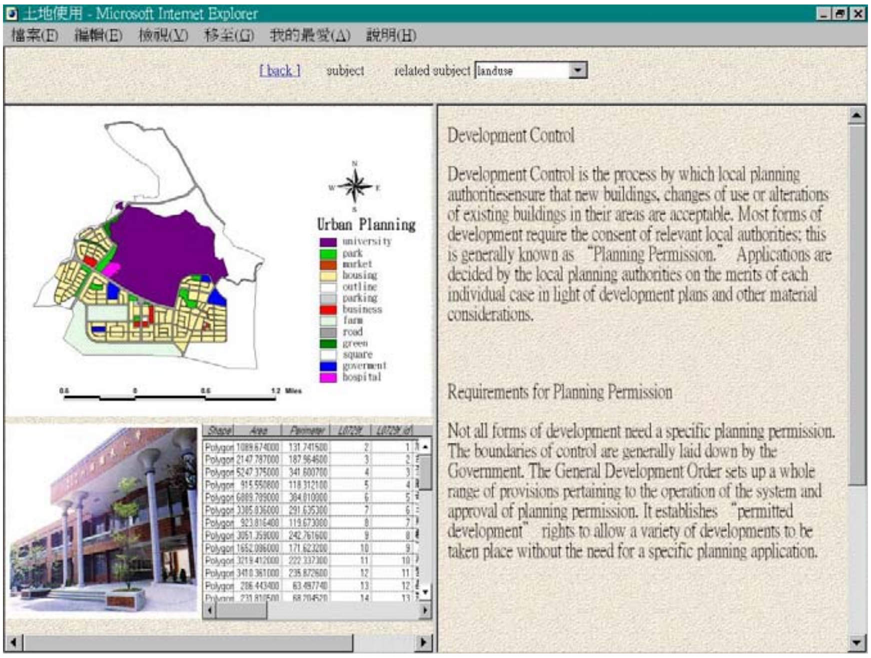

Figure 6 Content representation of a planning case

Conclusions

The main purpose of this article is to study the structural development approaches in implementing the CBP support system. The positioning of the support system and the key approaches of stracturalization are summarized in the following.

1. Owing to the high complexity in urban planning, the functional positioning of the case-based support system emphasizes mechanisms of case representation and appropriate case retrieval in this research. The automatically aided case adaptation technique required in case-based systems allows planners to substitute their own expertise so that their ingenuity can be retained in the planning results.

2. Because urban planning results are generally demonstrated by graphs, the case storage of this research

utilizes feature-based geographic information descriptions that integrate the information of graphs, texts, and images to present urban planning cases according to their attributes and relations.

3. As to the mechanism of appropriate case retrieval, this research elaborates a two-stage search mode of key indexes and general indexes to take care of planners' practices and boost case retrieval efficiencies. Moreover, the system applies a multiple criteria decision-making method as an assessment tool to make case selections.

4. With planners' distinctive needs in mind, the system constructed by this research recommends a view-based case representation to users. The system simulates users' various viewpoints beforehand and establishes different modes or case representations so as to solve problems of multi-utilization viewpoints and enhance usage efficiencies.

5. Due to the actual cases study for domestic urban planning were so limited that the real operating and application achievements have certain restrictions on system itself. Therefore, this system was more suitable for senior planners to modify those reference cases according to their own experience to avoid mistaking the cases.

In addition, two conclusions are proposed by this research.

1. This research is designed for junior urban planners (undergraduates and master degree graduates of urban planning department) to apply the retrospection mode to procure the behavior of utilizing cases and the priority of reference cases. However, planners have different seniorities regardless of whether discrepancies exist for their selection behaviors for reference cases. This will affect the design of the case retrieval mechanism under various system positions. This remains for further study.

2. It is suggested that the system could supplement its abundance of cases of foreign city by Internet to enhance the effectiveness of the system.

When the CBP support system is actually implemented in the future, the key techniques stated above may be well applied. Meanwhile, more studies about planners' actual case usage behaviors, perspectives on multiple systems usage, and evaluations of system effectiveness should be carried out further reinforce the present results.

References

Bain, W. (1986) *Case-based Reasoning: A Computer Model of Subjective ASSESSMENT*, Ph. D. Thesis, Department of Computer Science, Yale University.

Bareiss, E. R., Poter, B. W., and Weir, C. C. (1988) Protos: An exemplar-based learning apprentice, *International Journal of Man-Machine Studies*, 29: 549-561.

Chi, R. T., Chen, M., and Kiang, M. Y. (1993) Generalized case-based reasoning system for portfolio management, *Expert System with Applications*, 6: 67-76.

Ericsson, K. A. and Simon, H. A. (1993) *Protocol Analysis: Verbal Reports as Data*, where: MIT Press.

Fu, Y., and Shen, R. (2004) GA based CBR approach in QandA system, *Expert System with Applications* 26: 167-170

Goodman, M. (1989) *CBR in Battle Planning, Proceedings: Workshop on Case-based Reasoning (DARPA)*, Pensacola Beach, FL. San Mateo, CA: Morgan Kaufmann.

Hammond, K. J. (1989) *Case-based Planning: View Planning as a Memory Task*. Boston: Academic Press.

Hinrichs, T. R. (1992) *Problem Solving in Open World: A Case Study in Design Erlbaum*, NJ: Northvale.

Kolodner, J. L. (1993) *Case-Based Reasoning*, Morgan Kaufmann Publishers, Inc.

Kolodner, J. L. and Simpson, R. L. (1989) The MEDIATOR: analysis of an early case-based problem solver, *Cognitive Science*, 13(4): 507-549.

Koton, P. (1989) *Using Experience in Learning and Problem Solving*, Ph. D. Thesis, Department of Computer Science, MIT.

Luce, R. D. (1959) Individual *Choice Behavior*, New York: J. Wiley.

Schank, R. (1982) *Dynamic Memory: A Theory of Learning in Computer and People*. New York: Cambridge University Press.

Tang, A. Y., Adams, T. M., and Usery, E. L. (1996) A spatial data model design for feature-based geographical information systems, *International Journal of Geographical Information Systems*, 10(5): 643-659.

Yeh, A. G. O. and Shi, X. (1999) Applying case-based reasoning to urban planning: a new planning-support system tool, *Environment and Planning B: Planning and Design*, 26: 101-105.

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