ON-LINE INTEGRATION OF PHOTOGRAMMETRIC SYSTEMS AND SPATIAL DATABASES FOR PRODUCING STRUCTURED AND CONSISTENT DATA FOR GIS

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ABSTRACT:

Photogrammetric systems are important sources for GIS databases. Currently, the trend towards the integration of photogrammetric systems and spatial databases is increased significantly. Integration of photogrammetric systems and spatial databases has great benefits in which some of them are mentioned here. This integration makes it possible to use information stored in spatial databases in the process of automatic or semi-automatic data acquisition and updating. It reduces time and costs of producing and maintaining high quality and up to date information in spatial databases. Also, if on-line data structuring and quality control tools are provided and applied in these systems, the quality of data will be increased significantly. Quality and consistency of data is very important due to the fact that it affects reliability of the results of GIS analysis. For avoiding occurrence of inconsistencies and errors and maintaining the quality of database, on-line data structuring and consistency control must be considered. In this research for achieving mentioned purposes, on-line integration of photogrammetric and spatial database management systems for producing fully structured and consistent data has been investigated. In this way, a rule-based integrated system was developed for on-line and automatic data structuring and applying consistency constraints using object oriented methodology. Results of practical test of this system have shown that the produced and saved data in spatial databases, by means of this system, is consistent and structured efficiently. It shows high flexibility in solving different problems. In addition, time and costs of producing spatially structured and consistent data for GIS applications is significantly reduced.

1. INTRODUCTION

Photogrammetric systems are valuable and important data sources for GISs. They collect reliable 2D/3D geoinformation for GIS databases. The trend toward the integration of photogrammetric systems and GIS databases is increased significantly and various integrated systems in different levels of integration have been introduced to the market. Integration of photogrammetric systems and GIS databases has great benefits which some of them are mentioned here. This integration makes it possible to use information from GIS databases in the process of automatic or semi-automatic data acquisition and updating. It reduces time and costs of producing and maintaining high quality and up-to-date information in spatial databases. Also by using these systems, map generation in different scales would be possible. If active validating and on-line data structuring tools are provided and applied in these systems, the quality of geoinformaion will be increased significantly and the gains of efficiency become considerably greater. Quality and consistency of data are very important, because they effect on the reliability of the results of GIS analysis. However, a few of the existing integrated systems have tools for on-line and automatic 3D data structuring and quality controlling. Therefore, in this research this issue is considered. for this purpose, in the developed integrated system topological relationships have been used for detecting and correcting structural and topological errors. For designing mentioned system, objects and constraints were modeled according to the system requirements. In this system, data is structured and consistency of the produced data is controlled with respect to the stored information in the spatial database. This process is carried out simultaneously with data acquisition process and digitizing features from 3D photogrammetric model. Error detecting process is carried out and the correction process would be performed at the same time if it is needed. After these processes, the produced 3D spatial data will be directly stored in the database. Errors must not be allowed to be entered into the database. For detecting and correcting errors and controlling the consistency and quality of spatial data, consistency constraints are used. Integrity constraints have been classified to topological, semantic and user-defined constraints. Since many of integrity constraints such as semantic constraints are application-dependent, it is necessary to create new constraints or change the existing constraints with respect to the application and then store them in the repository again. So in the mentioned system, stored rules can be changed or even new rules can be created by an expert user. After specifying the rules, they are stored in the database. These stored rules can be used by any user for different problems but only expert users can change or create new rules. This makes it possible to use knowledge of experts that is stored in the database in the form of rules even by a user without this knowledge.

This developed system can be applied in the process of data updating, too. In this paper, the design and implementation of the developed integrated system for acquisition and maintenance of reliable 3D spatial data is explained. For this purpose, Section 2 evaluates integration of photogrammetric systems and spatial database management systems at first. In the section 3 development of the direct integrated system with active validation is explained and in the last section conclusion and some recommendations are presented.

2. A REVIEW ON INTEGRATING PHOTOGRAMMETRIC SYSTEMS AND SPATIAL DATABASE MANAGEMENT SYSTEMS

Currently, various systems in different levels of integration have been introduced to the market. So it is necessary to evaluate integration approaches and various kinds of integrated systems. In this section, integration systems are compared in aspects such as level of integration and connection type. Due to the importance of integration of these two systems it is necessary to make precise studies in this field.

Three level of integration between photogrammetric systems and spatial databases can be considered, that is: File-based Data Exchange, Direct integration and integration with active validatiin. Also, We can classify methods of integration of photogrammetric systems and spatial databases based on various aspects such as connection type, kind of systems and efficiency of systems. Integrated systems can be classified into two major groups based on the criteria of the connection type between photogrammetric systems and spatial database, which influence on efficiency of the system: (a) First group: Integrated systems in which photogrammetric systems and spatial databases are connected to each other with an internal connection and for this purpose some tools have been considered inside these systems. Presenting such systems is limited only to providers of systems because necessary tools should be available in order to create relationship inside Photogrammetry and database systems. Connection between Erdas Imagine with ArcInfo from ESRI, integration of Finnish ESPA with Smallworld and integration of PCI system with Oracle are samples of systems that are connected to each other by direct link inside the systems. In some of these systems such as Socet Set and Lamps2 developed by Laser Scan, this link is much more powerful than other systems and these systems have high efficiency. Samples of such systems will be explained later in this chapter. Since facilities of systems in this group have been provided by companies, they and they may not be completely consistent with user needs in different applications. (b)Second group: Integrated systems in which photogrammetric systems and spatial databases are connected to each other with an external connection. In this case, the important issue is defining an efficient interface between photogrammetric systems and spatial databases that can transfer data directly and provide possibility of active data validation. In this group, various kinds of photogrammetric and database systems can be connected to each other. By developing a powerful interface you can choose photogrammetric and database systems by considering the application needs. These interfaces can present various facilities such as data structuring. They can be developed by programming languages like VB, C++. Some advantages of using this method for connecting photogrammetric and spatial database systems are consistency of interface software to the application, flexibility and possibility of choosing favorite kinds of photogrammetric and spatial database systems. But it should be considered that creating an efficient interface is not easy and it should be used in particular problems. After evaluating existing integrated systems if they couldn't fulfill the application's requirements, this method can be useful.

In the first method of integration, internal link, system facilities provided by photogrammetric and database system providers for integration can be used but this has some restrictions and may not match to the application requirements. By using the second method of integration, external link, application requirements are considered but in this way it is needed to develop a new link between systems with respect to requirements and this may not be so easy. Using this method, it is possible to choose desired photogrammetric and database systems with considering the requirements of the application. After comparison and evaluation of integrated systems, it can be said that each of these systems has some advantages and disadvantages. For solving problems in urban management by considering recent researches, it is proposed to develop and use a direct system with on-line and automatic 3D data structuring and validating tools using rule-based processing with respect to application requirements. In this paper, a new approach of integrating these systems is introduced.

3. DIRECT INTEGRATION OF PHOTOGRAMMETRIC SYSTEMS AND SPATIAL DATABASE MANAGEMENT SYSTEMS WITH ACTIVE VALIDATION

For developing the desired integrated system with on-line and automatic 3D data structuring and validating tools, after evaluating the requirements, it would have been needed to evaluate other activities and recommendations in this field. Then the results of this evaluation were used in developing the system. From the evaluation, it was resulted that active or on-line validation using rule-based processing is needed to efficiently support the more complex data models coming into use (Woodsford, 2004). A strong candidate for supporting rule-based processing is object-oriented technology. In this way, a rule-based system is developed for on-line and automatic validating and applying consistency constraints on data in an object-oriented environment.

In this research a system called OISDBPS(On-line Integrated Spatial Database and Photogrammetric System), has been designed and implemented. The developed system has five main parts that are: (1)main interface, (2)spatial database that can store spatial data and its attributes and also consistency constraints,(3)Quality Control part that contains a rule-based system for controlling consistency and quality of data and algorithms of checking and correcting structural errors of data and (4)data visualization part. In this paper the developed system is described with more emphasis on the development of a rule-based system for controlling consistency and quality of data. It should be mentioned that in the presented system topological relationships are used for detecting and correcting structural and topological errors. For designing this system, objects and constraints are modeled with consideration of the requirements of the system. In this system, data is structured and consistency of the produced data is controlled with respect to the stored information in the spatial database. This process is performed at the time of data producing and digitizing in the 3D/stereo environment of the photogrammetric system. For this purpose, algorithms of detecting errors are applied and the correcting process would be performed at the same time if it is needed. After this process the produced 3D geoinformation will be stored in the database directly. Figure 1 illustrates this process in the developed system.

For detecting and correcting errors and controlling the consistency and quality of spatial data, consistency constraints are used. Consistency or integrity constraints are
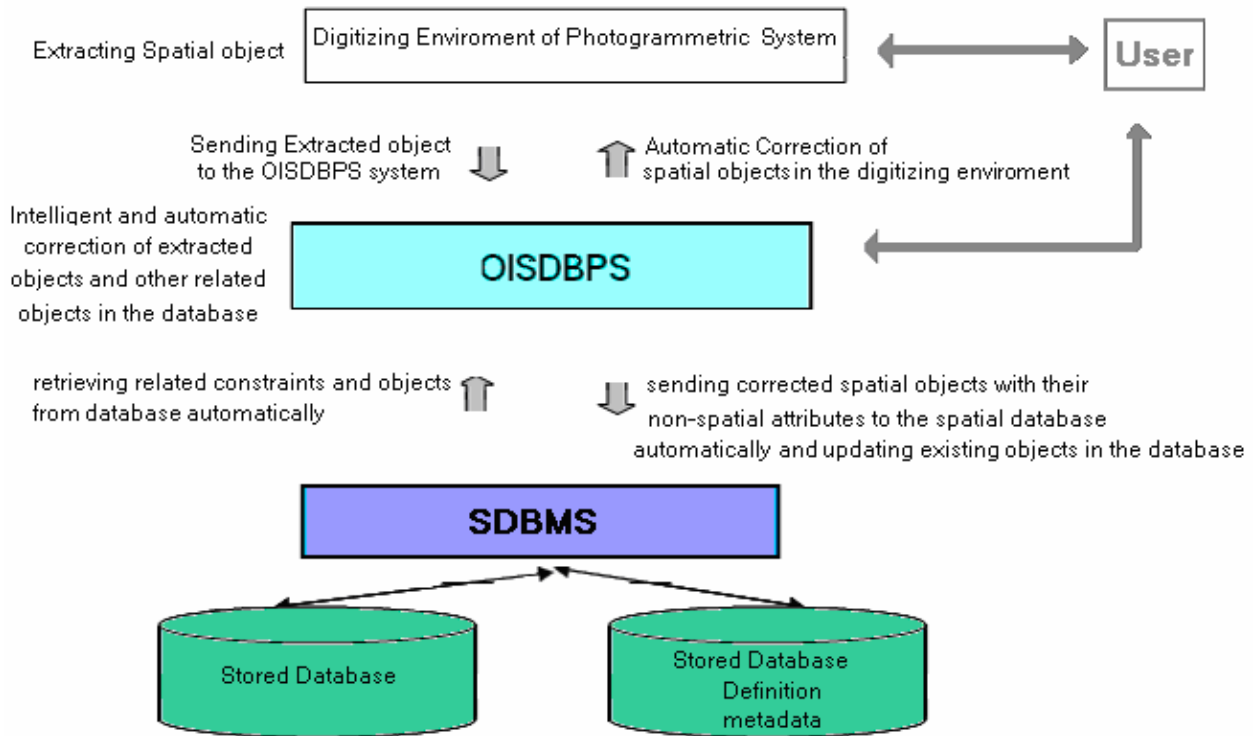
Figure 1. Process of Correcting spatial data in the developed system

conditions that should be held for the data in the database to be consistent. Since many of integrity constraints such as semantic constraints are application-dependent, it is needed to create new constraints or change the existing constraints with respect to the application and then store them in the repository again. So in the system stored rules can be changed or even new rules can be created by an expert user. For simplifying the definition of the rules, a user interface window is provided (as illustrated by figure 2).
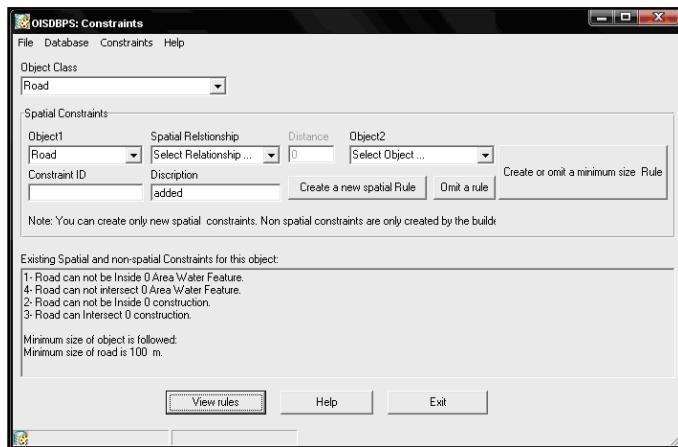

Figure 2. User interface window for definition of the rules

After specifying the rules, they are stored in the database. The stored rules can be enforced on data entry in different problems. These rules can be used by any user for different problems but only expert users can change or create new rules. This makes it possible to use knowledge of experts that is stored in the database in the form of rules even by a user without this

knowledge. Number of user defined rules for a problem can be even more than 1032 in this system. The rules are in the form of: Rule(first object, permission and relationship, second object). For example:
Rule1 for road object class can be like below:

Road _rule_No.1(Road,not intersect,Construction) ➔ *Road can not intersect Construction.*

The defined rules are stored in the database of the developed system and they are automatically applied on data. Figure 3 shows an example of applying consistency constraints on data simultaneously with digitizing feature from 3D photogrammetric model.
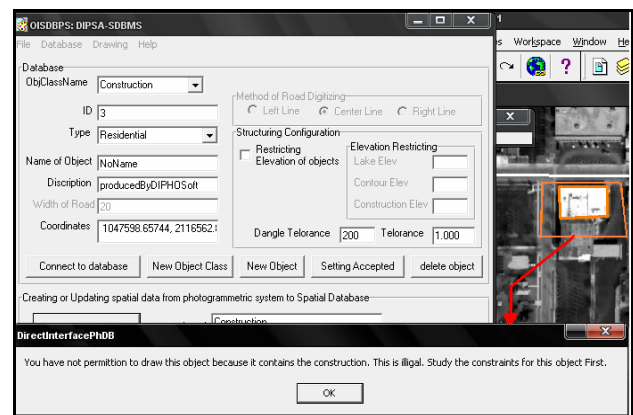

Figure 3. An example of applying consistency constraints on data simultaneously with digitizing feature from 3D photogrammetric model

As it is mentioned, this system is developed for acquisition and maintenance of reliable 3D geo-information. This system uses Oracle as its spatial database system and its constraint database which is an object relational DBMS and it has high interoperability, security and powerful functions. On the other hand, this integrated system applies Photomod photogrammetric system because of its popularity and accuracy and also its 3D stereo environment. In this developed system, algorithms are applied for the process of data structuring and correcting. All parts of the presented system were built using Visual Basic 6.0. This system uses Oracle as both its spatial database and constraint database. For sending, retrieving and updating data in the Oracle database, SQL commands were used in VB6, too. The visualization part of this system that visualized the stored 3D geoinformation in the spatial database was also built using Visual Basic 6.0 based on MapObjects(ESRI). It should be considered that the stored spatial data in the database can be visualized in other ways such as using ArcSDE(ESRI), Microstation(Bently) and VRML, too.

3.1 Evaluation of the Developed System

For testing this system, aerial images of Shiraz (scale: 1:5000 , 2004) were used. The photogrammetric model of this area was produced in Photomod photogrammeric system. Then test objects from different classes were extracted and saved in the database by using OISDBPS system. Saved objects in the database of the system have been assessed by three methods, that are: a) evaluation of data accuracy in the digitizing environment, b) displaying data of spatial database in the visualization part of OISDBPS system, c) using Radius Check software for labeling existing spatial errors in the database of system.

The results of these tests have shown that the produced and stored geoinformation by OISDBPS system is fully structured and consistent (figure 4,5). Also time of data production is saved considerably by using this system.
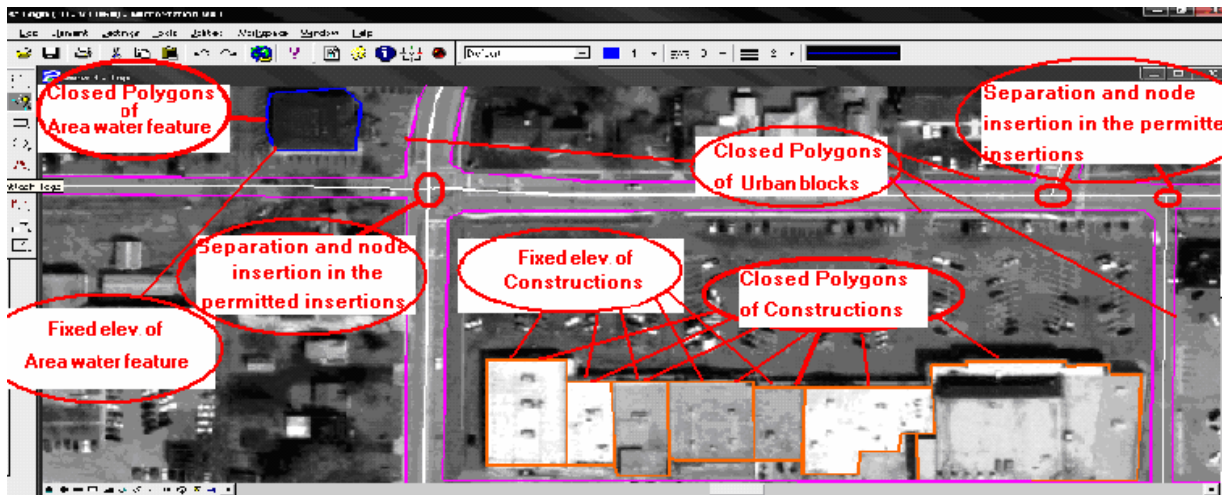

Figure 4. Checking the produced data by OISDBPS system in the digitizing environment
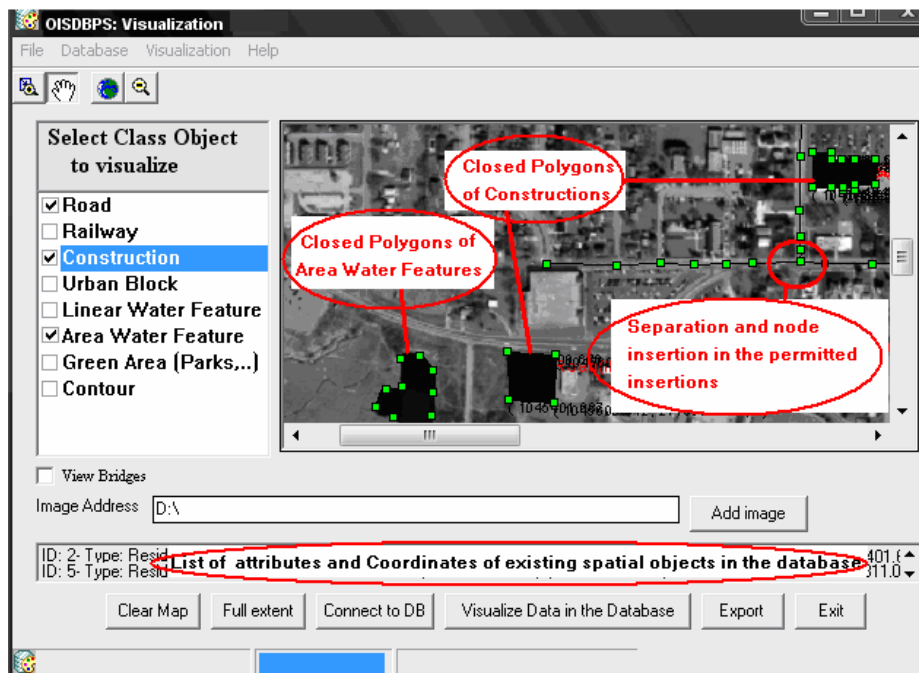

Figure 5. Checking data in the visualization part of OISDBPS system

4. CONCLUSIONS AND RECOMMENDATIONS

This paper illustrates the design and implementation of a direct integrated system with active validation for producing fully structured and consistent data. Testing the presented system and evaluating the results, have shown that the produced and saved information in the database by means of this system is consistent and structured efficiently. In addition, time of producing spatially structured and consistent information for GIS databases is significantly reduced. Using this system for producing and storing structured and consistent data is economic, too. This system also can be used in the process of data producing and updating using other photogrammetric data acquisition systems.

By considering the results of this research we recommend to integrate OISDBPS system with the process of automatic or semi-automatic object extraction to achieve a fully automatic and intelligent system for developing GIS databases.

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