On-line Integration of Photogrammetric and CAD Based Systems with Emphasis on Logical Relations among Features

Hamid Ebadi, Farshid Farnood Ahmadi, Masood Varshosaz

Address: No 1346, Valiasr Ave, Mirdamad cross, Faculty of Geodesy & Geomatics Engineering
K.N.Toosi university of Technology
, Tehran, Iran
Tel: +98218786212
Fax: +98218786213
E-mail: ebadi@kntu.ac.ir, farshid_farnood@sina.kntu.ac.ir, varshosazm@kntu.ac.ir

Abstract

Simultaneous error removal with feature digitization, in map production process eliminates spatial data editing stage after digitization operations and spatial information can be directly entered to other computer environments for modeling or digital cartography and/or can be used in GIS analyses. Therefore, we will considerably save time and cost in map production process. Because editing operations are carried out by using photogrammetric reference model, then problems of unavailability of source data will be solved. CAD environments which in most of the photogrammetric systems are given to users access as an external digitization environment, contains powerful functions for storage, retrieval, editing and displaying 3D data according to user needs.

All of these functions are required for spatial data preparation and to enter prepared data into GIS system. Considering facility of making interface between users and CAD systems, it is possible to produce refined spatial information. In this paper, a new approach to detect and eliminate errors simultaneously with feature digitization process, in CAD environment has been presented. We have used primitives of object oriented systems presented for feature modeling based on logical relations among features. To show applicability of presented method, an Object-Oriented CAD-Based Photogrammetric System (OCBPS) was designed, implemented, and tested for elimination of errors related to contour line features.

1.0 Introduction

One of the important stages in implementing of a GIS system is preparation of data for entering to this system (2). Spatial information extracted from aerial photos using photogrammetric method is considered as one of the most important spatial data recourses used in GIS. Conventional approach for production of spatial information using photogrammetric technique is carried out in two steps. In first step, various features are digitized without considering appropriate structure required by GIS systems (Digitization process). In the second step, digitized data are edited to remove various geometric and topological errors (Editing process). Spatial data production without considering the required data structure for GIS and carrying out editing process after editing stage make spatial data preparation and editing to be more expensive and time consuming for GISs. On the basis of reports released from Tehran Geographical Information Center, in a map production project at 1:2000 for city of Tehran, digitization process took two years (from 1995 to 1997) while the editing and preparation of data operation for GIS (Production of GIS ready data) extended from 1996 to 2001. On the other side, due to not having photogrammetric model at the time of editing process, doing data editing in an independent stage (off-line) reduces accuracy and reliability of data.

Simultaneous error removal and producing fully structured data during feature digitization, in map production process eliminates spatial data editing stage after digitization operations and spatial information can be directly entered to other computer environments for modeling or digital cartography and/or can be used in GIS analyses. In this case, editing operations are carried out using photogrammetric reference model, therefore, problems of unavailability of source data will be solved.

In this research, the aim is to directly integrate photogrammetric and CAD-based systems based on editing facilities provided by CAD systems which are accounted as digitization environment of most photogrammetric systems. By integrating these systems, the editing operation and production of fully structured data for GIS are performed simultaneously during digitization process (On-line approach).

At first, CAD-Based photogrammetric systems and the integration of CAD and Photogrammetric systems including their capabilities are reviewed. Then, a new method developed by authors is presented for eliminating errors and structuring the spatial data simultaneously during digitization considering the possibility of its implementation in standard CAD environments. Finally, to show the applicability of the presented method, an object-oriented CAD-based photogrammetric system was designed, implemented, and tested for elimination of errors related to altimetric features (i.e., contours)

2.0 Integration of Photogrammetric Systems and CAD-Based Systems in Order to Edit Data Simultaneously with Feature Digitization

Nowadays, photogrammetric systems use CAD environments as their feature digitization environment. Photogrammetric systems are divided into three main categories from the digitization environment point of view;

- Photogrammetric Systems with Internal Digitization Environment: This group of Photogrammetric systems use their own CAD environment, which has been specialized to that system and have very limited abilities in comparison to standard CAD systems.

- Photogrammetric Systems with External Digitization Environment. : This group of Photogrammetric systems use standard CAD environments such as MicroStation or AutoCAD as digitization environment. Output from Photogrammetric system (e.g., 3D coordinates of points) is sent to CAD environment through a coder.

- Photogrammetric Systems with Integrated Digitization Environment : Photogrammetric systems belonging to the this group, have offered both internal and external digitization environments for the user.

In the first type of Photogrammetric systems, CAD environment is just a tool to facilitate drawing and low level editing operations, while CAD environment, which are available to the users in the second and third types of systems as external digitization environment have powerful functions for saving, retrieval, editing, and visualization of spatial data in accordance to the user needs. All of these functions are required in order to prepare and produce fully structured data for Geographical Information System (GIS). Users try to utilize capabilities of CAD environment in order to reduce geometrical errors and to make topology for data.

Making an interface between CAD and Photogrammetric systems is the first stage in integration of these two systems. This interface can be a tool for changing 3D information format

to the readable format by CAD and/or a tool for adding topology in which CAD is able to form a model from object [5].
There are three main approaches for implementation of CAD- Based Photogrammetry as following:

1- The systems, which use Photogrammetric tools in the CAD environment. These systems have been developed on the basis of the existing CAD systems such as MicroStation or AutoCAD and use their data structure [5].

2- Photogrammetric systems developed by CAD functions. These systems have added topological information to geometrical data and in most cases they can establish a parametric description from geometrical elements [5].

3- The systems, which use advanced techniques of modeling such as CSG method [4].

The first type of integrated systems are suitable for implementation of a Photogrammetric system in CAD environment and 3D accurate measurements on the objects. In these systems, photogrammetric functions have been added to CAD environment in order to extract 3D coordinate of objects, while modeling process is carried out by functions of CAD system.

In the second type of integrated systems, the CAD and Photogrammetric systems operate as two independent environments and they are related to each other through an interface.

In this type of systems, the interface system undertakes the key role and it's accounted as the heart of CAD-based Photogrammetric system. As the transferring operation of sending data to the CAD environment is made through this interface, if it's required to perform a set of filters, controls and/or constraints on data before entering the data from photogrammetric system to drawing environment, it's preferable to utilize this type of systems.

In the third type of integrated systems, advanced techniques of modeling in CAD, have been integrated with Photogrammetric techniques. In this type of systems, extracted 3D data from Photogrammetric system are not point features. These systems directly produce 3D models of the features. This approach is applied for 3D modeling of industrial units.

In order to remove errors and produce fully structured spatial data simultaneously during digitizing operation, it's required that the measured points in photogrammetric system be entered into the interface system as On-line and after processing and making assurance of required accuracy be sent to CAD environment for drawing. On the same basis, applying second approach for integration of second and third types of photogrammetric systems with standard CAD systems can be considered as a suitable method for achieving the mentioned aim.

3.0 Application of Object-Oriented Structures for Automatic Detection and Removal of Errors Simultaneously with Feature Digitizing Operation

What is entered to the data-base as spatial data, is a generalized mode from reality and it's not able to introduce reality as it is, therefore, the existence of some errors are unavoidable [2]. Based on this, one can be perform quality control on spatial data in order to detect existing errors. The following cases should be investigated for studying spatial data quality [6]:

1- Positional accuracy or spatial accuracy
2- Attribute accuracy
3- Logical consistency
4- Data completeness

5- Lineage

In that group of detection and correcting error approaches, which are based on controlling spatial accuracy, attributes' accuracy, completeness and Lineage, the presence of human operator for comparing collected data with reality or existing data with higher degree of reliability, are unavoidable. Therefore, applying these criteria for automation of error detection and correction processes is very difficult and even impossible. Capability of using logical consistency and constraints in algorithms and the possibility for controlling these conditions by computer soft wares, facilitate usage of logical consistency for automatic detection and elimination of some errors. In this case, internal constraints can be considered as a set of conditions that non-following from these conditions can be detected as error and the feature with error can be corrected in such a manner that the appropriate constraint is satisfied. For example, the following constraints are set and satisfied for contour line features [1](Figure 1);

a. All points located on a contour line have the same elevation
b : Contour lines do not intersect each other
c : Each contour line is closed
d : All segments of a contour line are seamless

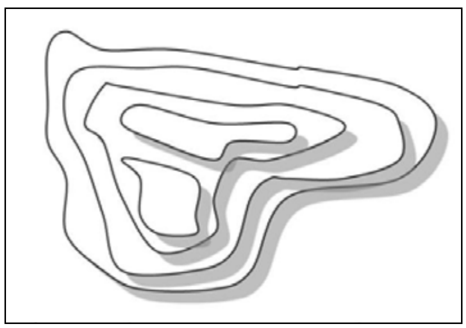

Figure 1: Logical relationship between contour lines

We can consider each of the features produced during digitization operation, as an object with defined properties and attributes. Each group of features should follow a set of logical constraints that can be used for definition of objects properties and characteristics of different feature classes. On the other hand, if we consider features as objects and logical constraints of features as object characteristics, an object oriented structure can be defined for feature attribute (Figure 2).

At a higher level, a set of objects having the same constraints that are true for them, can be defined as a class. It is clear that in this case, each object, which is the member of this class, should follow from these constraints and non-following from these constraints is accounted as contrary to inheritance relation. In such a condition, the mentioned object is identified as an object with having error and should be modified in such a way that the defined properties about it to be correct.

Therefore, using an object-oriented system in which the logical constraints have been applied for definition of objects characteristics and properties, can be a suitable method for detection and correction of existing errors on the features.

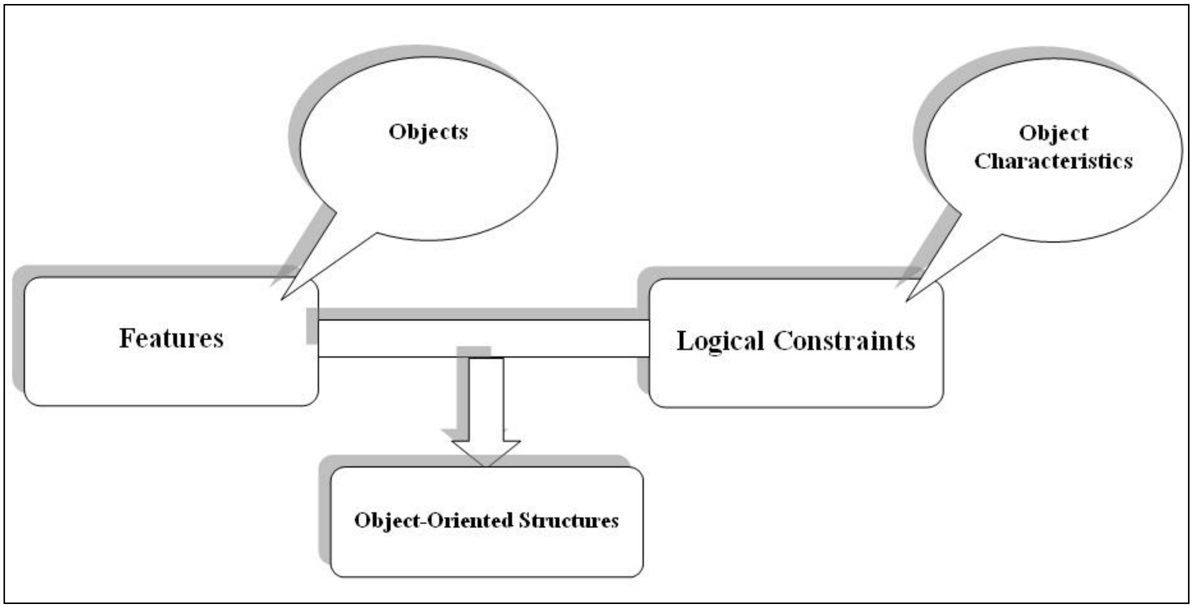

Figure 2: Object-Oriented Structure

4.0 Design and Implementation of an Object Oriented CAD-Based Photgrammetric System (OCBPS)

4.1 General Design of System

On the basis of expressed matters in sections 2 & 3, we can say that in order to detect and eliminate errors simultaneously with feature digitization process, it is necessary that second and third types of photogrammetric systems are related to CAD systems directly through an object-oriented interface.

In such a manner, spatial data extracted by photogrammetric system, can be analyzed immediately after digitization through this interface and entered to drawing environment after correction (Figure 3).

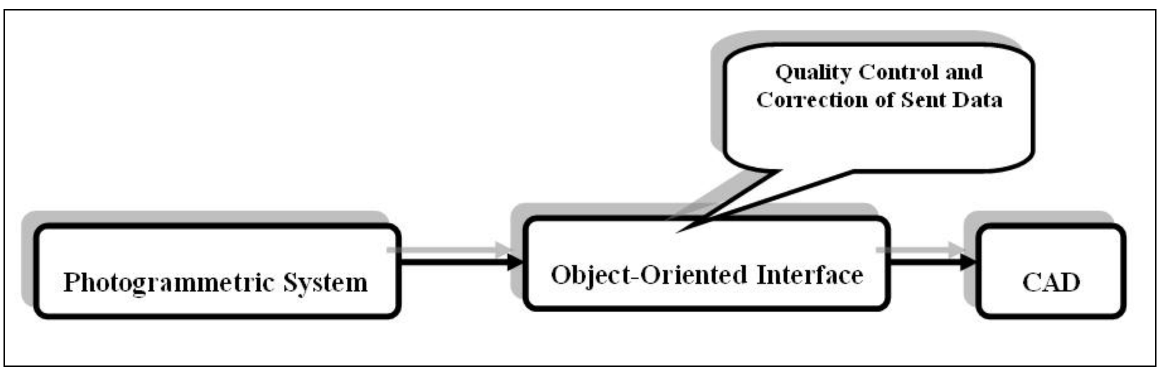

Figure 3: General structure of developed integrated system

To show the applicability of presented method, an Object-Oriented CAD-Based Photogrammetric System (OCBPS) was designed, implemented, and tested for elimination of errors related to contour line features.

The first version of this system, which belong to the second type of integrated systems, has been implemented using Visual Basic programming language in MicroStation8 called VBA and appeared as a part of MicroStation environment after execution of the program (Figure 4).

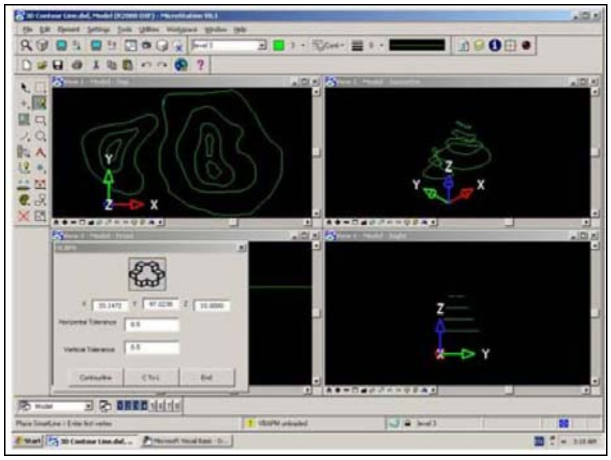

Figure 4: OCBPS as a part of MicroStation environment

OCBPS is an object-oriented interface that can be used for integration of second and third types photogrammetric systems with CAD environment.. This system can apply and control the following constraints simultaneously with contour-lines digitization operation and automatically recognize non-following from these conditions as an error and correct them in on-line mode:

1- Having the same height for points located on a contour line feature
2- Non-Cross-Section of a contour line with itself or with the other contour lines
3- Contour lines are closed features (those are that completely located in study area)
4- All segments of a contour line are seamless

The function of OCBPS system can be explained as follows:

1- OCBPS system is called in MicroStation environment.
2- Using contour-line key, the controller unit of constraints related to this object, which is known as the properties of this object, is activated.
3- The sent data by photogrammetric system enter this system for further processing. OCBPS has defined functions for two types of operational modes as:
   A: Data point
   B: Reset
4- If the received data by OCBPS is in Data Point mode, the set of controls related to first group of logical constraints including “having same height”, “non-cross-section” and “being seamless” will be performed on the data and results will be sent to the drawing environment after correction. In such a manner, the sent points from photogrammetric system are drawn in the corrected position.

   If the received data by OCBPS is in Reset mode, it means that the digitization stage of contour line’s segment has been finished and the set of controls related to second group of logical constraints including “contour-lines are closed features”, and “ being seamless” will be performed on active curve.

This system has been designed in such a way that it can be used for automatic cartography and GIS systems. In automatic cartography, the segments of a contour line is a Curve Element. Most GIS systems have difficulties for accepting curve elements. To overcome this problem, it is possible to convert digitized contour lines from Curve Element to String Line using Curve To String Line key in OCBPS.

The input for OCBPS has been defined in such a way that is independent of input tools. On the other words, it's no difference for system that how input data are generated and sent to it. It is just required that these data are recognizable formats by MicroStation environment and, therefore, we can introduce the data to OCPBS by using different input tools such as key board, mouse and etc. On the same basis, we can use OCBPS as a digitizing tool as well.

The output of OCBPS has the standard format of CAD environment (DXF, DWG, DGN) and without further editing, it can be used for automatic cartography and/or can be entered to GIS systems.

4.2 Preparation of Contour Lines Using OCBPS

In order to evaluate the efficiency of the system, preparation operation of contour-line features for entering to GIS system was performed using OCBPS in two different approaches. In the first approach, a scanned topographic map sheet at the scale of 1:2,000 was used for spatial data extraction. The map was entered into MicroStation environment as a raster image. After loading OCBPS, the digitizing operation of contour-lines was performed. During digitizing operation, the different cases that may cause errors in digitizing operation of contour-lines, have been introduced and the efficiency of system was evaluated in all cases. After finishing digitization stage, the conversion operation of Curve Element to the String Line was performed by TOL key and corrected DGN file was generated (Figure 5).

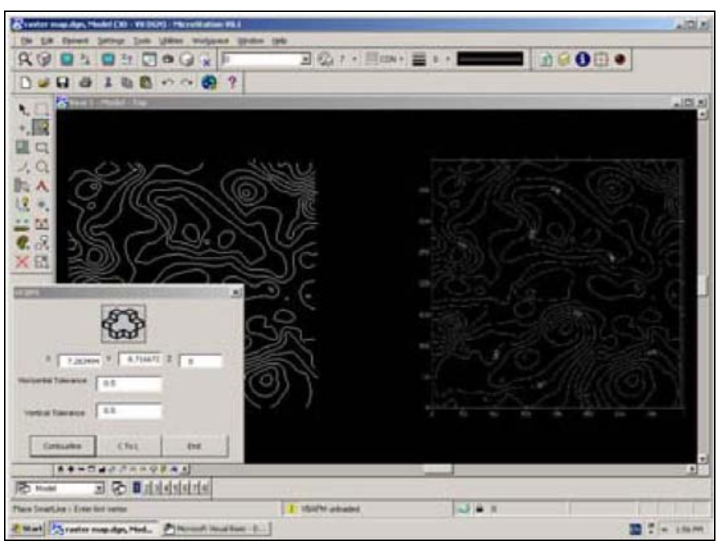

Figure 5: Using OCBPS for digitizing a raster map

Finally, a DGN file was entered into GIS environment without the need for further editing (Figure 6).

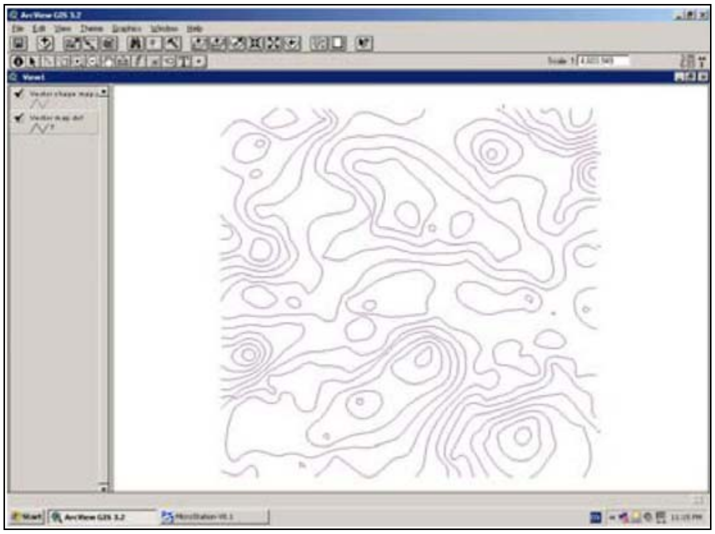

Figure 6: DGN file of digitized raster map produced by OCBPS, entered to GIS environment without the need for further editing.

In the second approach, after formation of a three dimensional model in photogrammetric system, drawing operation of contour-lines was performed by OCBPS. At this mode, all errors which the operator may perpetrate at the time of drawing of contour lines were deliberately made. All of these errors were automatically detected and corrected at the time of drawing by OCBPS. The output of system without requiring for further editing operations was entered to GIS system (Figure 7).

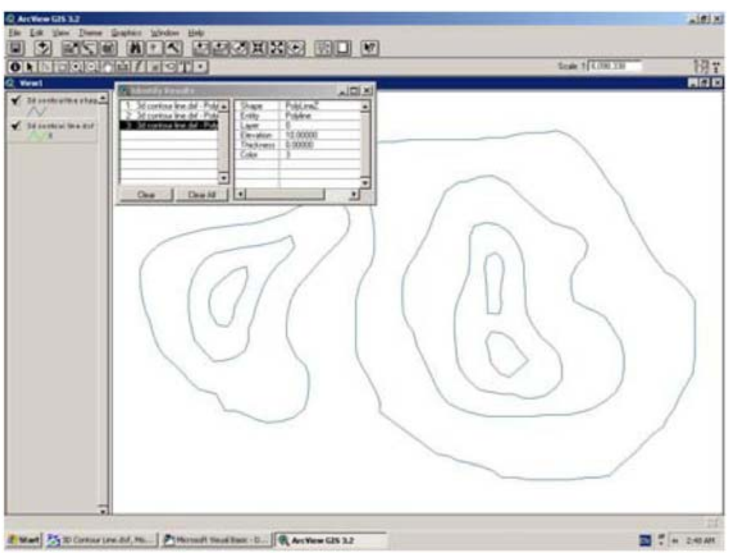

Figure 7: The output of OCBPS without requiring for further editing operations was entered to GIS environment (second approach).

5.0 Conclusions & Suggestions

With considering to what has been said, we can summarize the achieved results from this research as following:

1-It is required for each feature, on the basis of its nature and for keeping of its own logical consistency with real world, to follow from a set of constraints. We can use these logical constraints for automatic detection and elimination of errors in the CAD-Based systems, and in this case, quality control operation of data, is changed from tolerance-based mode to the combined mode of tolerance and logical constraints.

2-By implementation of an object-oriented interface between CAD and photogrammetric systems, we can detect and eliminate errors on the basis of nature and behavior of features and ,therefore, in addition to geometrical errors that are general, the special errors of each feature will be detected and eliminated simultaneously during digitizing operation.

.

3-Using OCBPS, preparation, documentation and editing operations of spatial data will be performed simultaneously (on-line) and spatial data editing stage after digitization operations will be eliminated and spatial information can be directly entered to other computer environments for modeling or digital cartography and/or can be used in GIS analyses. Therefore, we will considerably save time and cost in map production process. On the other hand, because editing operations are carried out using photogrammetric reference model, then, extracted information are more reliable compared to those obtained in off-line mode.

4- In object-oriented systems, it is required that the nature and type of object is introduced to the system. In first version of OCBPS, operator does this operation. If we can design a system that can intelligently and automatically identify type and nature of feature using logical constraints, this will be a great challenge in the field of automatic data editing operation. On the same basis, further research is required to automatically identify type and nature of features.

6.0 References

1. Ebadi H., Valadan Zoej M.J., 2003, Design and Implementation of Geographic Information System of Shiraz City, Faculty of Geodesy and Geomatics Eng, K.N.Toosi University of Technology, Tehran, Iran

2. Goodchild M.F., Davis F.W., 1991. The Use of Vegetation Maps and Geographic Information System For Assessing Conifer Lands in California, NCGIA, University of California.

3. Rolf A., 2000, Principles of Geographic Information Systems, ITC Educational Text Book, Netherlands.

4. Tanglder J.W.H., Ermes P., 2003, CAD-Based Photogrammetry for Reverse Engineering of Industrial Installations, Computer-Aided Civil and Infrastructure Engineering 18 , Black well Publishing.

5. Van Den Heuvel F.A., 2002, Trends in CAD-Based Photogrammetric Measurement, Delft University of Technology.

6. “*Accuracy of Spatial Data-Bases* “ (http://www.env.duke.edu/lel/env351/lectures/ accuracy1.pdf).