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Design and Development of an On-line Integrated Photogrammetry and GIS System for Direct Input of Fully Structured Data to GIS

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Abstract: One of the important stages in the implementation of a GIS is referred to preparation of data to be entered to the system. To produce spatial data for entering to GIS using photogrammetric techniques, common and current method is to utilize photogrammetric and GIS systems individually (off-line procedure). Preparing spatial data on the basis of the mentioned method has a lot of problems, such as: difficulties in conversion process of spatial data from CAD based data to GIS, reduction of the spatial data accuracy in editing process, impossibility of simultaneous attribute data adding to spatial data and increasing the time and cost in data production and preparation process. By on-line integration of photogrammetry and GIS, feature digitizing from photogrammetric models can be performed in an interface GIS environment. In this way, generated data can be saved with standard structure and format defined by GIS environments and directly used for GIS analysis without the need for further editing. In this research, a software package called On-line Integrated Photogrammetric GIS (OIPGIS) was developed and successfully implemented. Above system overcomes the mentioned problems, significantly saves time (around 37 percent) and cost (around 10 percent) of spatial data production to be used in GIS and reduces distance between spatial data production system and GIS.

Key words: Fully structured data · GIS · interface system · on-line integration · photogrammetric system

INTRODUCTION

One of the most significant stages in implementation of a GIS system is preparation of data for entering to GIS system. It could be said that the most important factor in a successful GIS project is referred to the quality of entered data [1]. Spatial information extracted from the aerial photos by using of photogrammetric techniques is considered as one the most important resources for generating spatial data in GIS. Nowadays, the importance of imagery as a resource for obtaining spatial data is increasing; as in near future around 50% of the existing data in the organization related to management of spatial information will be attained by this approach [3].

The current and conventional method for the spatial data preparation to be entered in GIS by photogrammetric techniques is to use photogrammetric and GIS systems individually. On the basis of this method, at first, the spatial data are generated in a CAD based environment as digitised maps without considering GIS system characteristics and requirements, thereafter preparation and editing of the spatial data is applied and the required structure for data to be entered in GIS system is created.

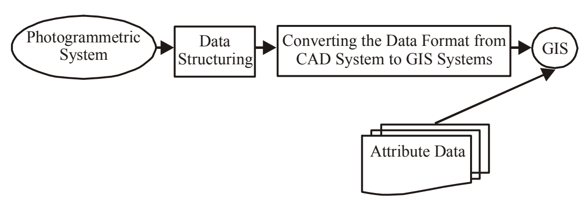

Fig. 1: Stages to conventional approach for preparation of spatial data to be entered in GIS

After this stage, to enter the prepared spatial data in GIS, some processes for converting the data format from CAD systems to GIS systems is carried out. Related after entering spatial data to GIS, the attribute data should be amalgamated to the spatial data through a separate process (Fig. 1).

Spatial data preparation on the basis of mentioned method will posed some problems to the integration system, such as:

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Difficulties in conversion of spatial data from CAD systems to GIS: Most of the commercial GIS soft wares have a conversion module in order to convert the spatial data format from CAD based environment systems to GIS. If the storing process of spatial data in CAD environment is carried out based on necessary constraint and condition of feature extraction operations, conversion of data format would be straightforward. But it is also mentionable that in the most spatial data storing process in CAD environment, above constraints are not applied and consequently due to the conversion process a lot of problems will be occurred which their types and categories could be different on the basis of entered file structure from CAD environment. The cause of these problems is referred to the differences between CAD and GIS design issue and therefore a great disparity between data modelling of these systems is expectable. [4]. The major differences between these two systems that could affect on the conversion process are as following [4]:

- Differences in spatial data-base structure
- Differences between the concept of layer (in CAD systems) and Theme (in GIS systems)
- Existing differences in the useable coordinate systems
- Existing differences in storing procedure of features.

Consequently it is necessary to work out some edition on the preparation of the output CAD systems in favour of entering them to the format conversion environment.

Reduction of the spatial data accuracy in editing process: All of the defined analyses in GIS are based on digital processing and analysis of spatial and attribute. Although spatial data analysis in digitised form has advantages, (e.g. accuracy, speed and cost) but existing of slight errors in spatial data which are dispensable in CAD systems, are considerable and could cause serious p roblems due to GIS analysis process [2]. For instance, if the distance between endpoints of some line segments is expressed in the level map scale accuracy, the disconnection of the line segments would not cause a problem in a CAD system, but it is identified as a solemn problem for GIS systems. Therefore it is necessary to do some editing operations for preparation of spatial data to be used for GIS analyses in addition to editing operations described in previous section.

Because of the off-line data editing in a separate stage, without the existence of photogrammetric model (which extracting process has done within), in the most situation applying these types of editing operations will cause reduction in spatial data accuracy [2].

Impossibility of adding attribute data to spatial data at the time of spatial data production: in the spatial data production using photogrammetric method, the produced 3-dimensional model from aerial photos which can be regarded as a resource for spatial data in photogrammetric systems, could be a proper resource for obtaining some of attribute data related to the existing features in the study area.

As for the mentioned method, GIS and photogrammetric systems are independently utilized, it is not possible to access an attribute data base simultaneously with feature digitisation process and for this reason it is not possible to attach attribute data to spatial data during feature digitization process.

Increasing the cost and time of spatial data production and preparation for entering to gis system: Applying each stage related to spatial data production and preparation including features digitising from the produced model in photogrammetric systems, editing of spatial data so as to create the necessary structure for entering information to GIS, converting data format and eventually adding attribute data in separate stages, requires different sections and working groups, appropriate hardwares as well as experts. These considerations will pose a substantial cost and time for spatial data production and preparation, moreover existence of independence between mentioned sections will enhance the duration of working stages.

ON-LINE INTEGRATION OF PHOTOGRAMMETRY AND GIS

The aim of integration of several systems into a unique integrated system, is to access simultaneously to all or a number of sections abilities provided by each system and to abolish each system blemish by others capability.

As it was pointed out before, individual usage of photogrammetry and GIS systems leads to serious problems during production and preparation of spatial data. By on-line integration of these two systems, digitising operation of features from created model in photogrammetric systems will be done in a GIS environment interface. Due to the fact that storage of spatial data on the base of GIS format is possible and spatial data could be entered in GIS analysis without

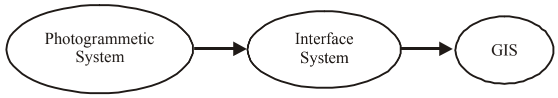

Fig. 2: Creating an interface system between photogrammetric and GIS systems

further editing and/or conversion, therefore problems such as spatial data conversion from CAD format to GIS format and reduction of spatial data accuracy during editing procedure will be omitted.

Also the ability of attainment to attribute data bases, which could be given to users, by GIS systems, will make it possible to attach simultaneously some attribute data extracted from photogrammetric model to spatial data during feature digitising process. Consequently integration of photogrammetry and GIS, would decrease distance between spatial data production systems and processing systems and therefore will cause a diminution in time and cost in spatial data production and preparation to be entered in GIS.

The first step in integration of photogrammetric and GIS systems, is to create a interface system between these systems. This system could be a device for converting data format while are sent from photogrammetric environment, to a proper format for GIS systems, or a device for structuring spatial data, or a combination between the two (Fig. 2).

The mentioned interface system is known as the midst of the integration system and its structure is a description of type and operation of the integration system. So it is necessary to investigate targets and requirements of project and users expectation during designing and system implementation thoroughly.

MAIN STRUCTURE OF INTERFACE SYSTEM

As it was mentioned before, our aim in this research is to perform an on-line integration between photogrammetric and GIS systems in order to create appropriate structure for spatial data at the time of feature digitising operation from the created model in photogrammetric model. Thus interface system has to have the following characteristics and capabilities:

- Possibility of receiving 3-dimensional extracting points from the interface GIS environment model in photogrammetric system and sending it to a interface GIS with feature digitising at the same time.
- Ability to depict and draw of each feature in interface GIS environment with its digitising in photogrammetric environment simultaneously.
- Possibility to add some attribute data to features during digitising.
- Capability to save spatial and attribute data according to the standard format of GIS systems through three segregated feature layers (point, Line and polygon) directly.

Accordingly four major sections have been considered in the general comprehensive scheme.

- Input section
- Documentation and feature drawing section
- Receiving section of attribute information
- Storage section

The main structure of system is shown in Fig. 3.

Input section: Input section of interface system as one of its main and basic parts, enables the system to receive data points sent from Photogrammetric system and send them for drawing and documentation section simultaneously during measurement operation.

Input section of the system has been designed based on Photogrammetric systems such as Photo MOD which uses MicoStation environment for features documentation. In these types of Photogrammetric systems, coordinates of measured points are sent to

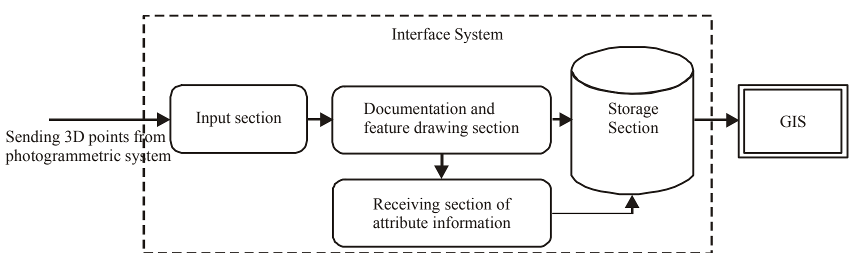

Fig. 3: Main structure of interface system

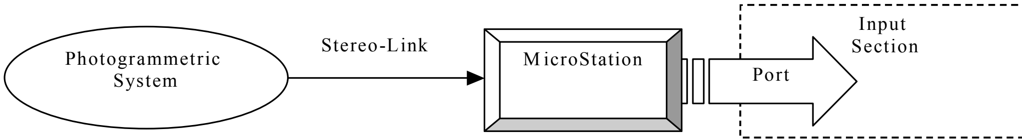

Fig. 4: Flowchart of input section

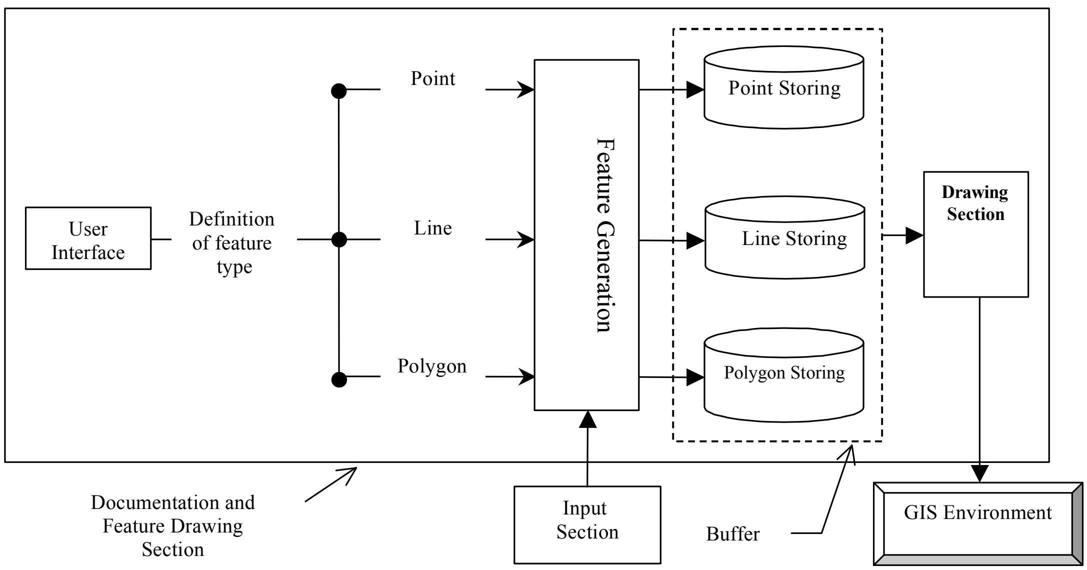

Fig. 5: Main structure of documentation and feature drawing section

MicroStation environment by means of stereo-link simultaneously during digitizing operation. For receiving these data points and sending them to interface system, a software port which can be known as the heart of input section has been designed and implemented in input section. The flowchart of the input section has been shown in Fig. 4.

Documentation and feature drawing section: After transferring measured points to interface system through input section, received points must be structured in the form of point, line, or polygon features. In order to inform user about digitized features, it is necessary to draw each feature in GIS environment simultaneously during digitizing of this feature. These two operations are carried out by means of documentation and feature drawing section.

Three major sections have been considered in design and implementation of documentation and feature drawing section:

- User interface: By means of this section, user defines the type of feature which he/she wants to digitize it from photogrammetric model.
- Structuring and Feature Registration section: This section obtains the feature type from user interface and saves data points sent from input section, in the form of point, line, or polygon features in three special structures.
- Drawing section: In this section, the features structured by means of previous section, are drawn.

The main structure of documentation and feature drawing section has been shown in Fig. 5.

Attribute information receiving section: For adding attribute data to spatial data at the time of spatial data production, a real time connection between documentation and feature drawing section and attribute information receiving section should be carried out, in which each section must be able to gain access to data and events of the other section. According to different nature of spatial and attribute data used in each mentioned section, making direct connection between two sections was very difficult. Thus, for solving this problem in design and implementation of interface system, a module has been used as an interface environment to link these two sections. The main

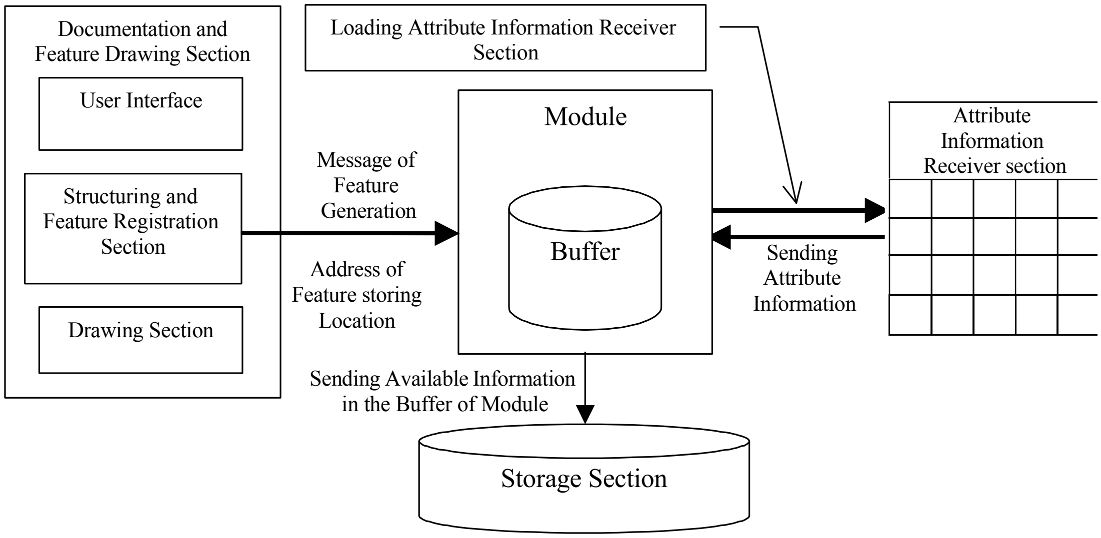

Fig. 6: Main structure of aattribute information receiving section

structure of attribute information receiving section has been shown in Fig. 6.

Storage section: For direct input of interface system output to GIS environments, information must be saved based on defined structure for GIS systems. Storage section of interface system has been designed in a way that input information to this section, has been saved in three independent groups (point, line and polygon features) with shapefile format. In this section, adding of attribute data to features is carried out simultaneously during storing process.

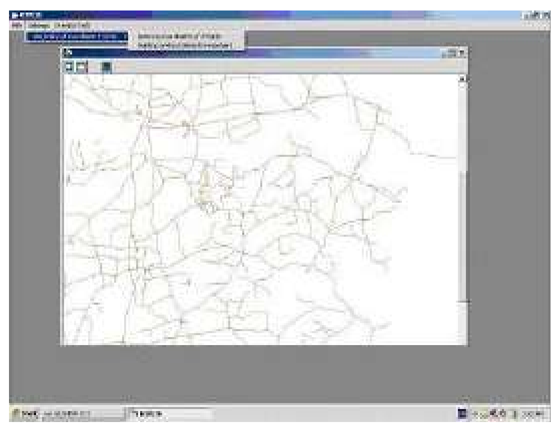

Fig. 7: OIPGIS user interface

IMPLEMENTATION AND TEST OF SYSTEM

In order to implement the first version of interface system which has been presented as OIPGIS (On-line Integrated photogrammetric-GIS), Visual Basic programming language has been used.

Since the OIPGIS system is designed on the basis of photogrammetric systems which utilizes Micro Station environment for digitising operation and uses Micro Station environment as an interface environment in order to receive points, therefore to use this system, MicroStation software should be installed on the computer.

MDI (Multiple Document Interface) technique has been used in implementation of OIPGIS interface system and offers an appropriate user friendly system (Fig. 7).

Considered port in OIPGIS input section is designed in such a way that makes it possible to control MicroStation environment completely when input section is activated and makes OIPGIS system able to receive input points which can be entered from input devices such as Stereo-Link, mouse, digitizer and etc. as measured points.

So, it could be said that OIPGIS system is independent from input devices, It is also possible to use this system for online connection of digitizers, which its documentation is MicroStation to GIS.

For evaluation of the system, IPGIS was used to make a connection between PhotoMode as a digital photogrammetric station and GIS. For this test, after 3-dimensional model creation in photogrammetric system, digitising operation for each feature (point, line and polygon) was applied in different sections of model at the scale of 1:2000. In this method some attribute data has

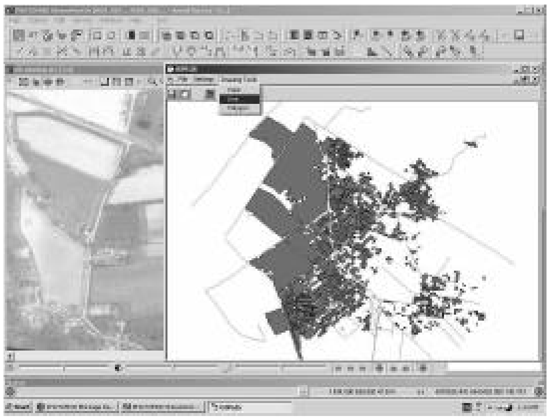

Fig. 8: Digitising operation with OIPGIS system from 3-dimensional photogrammetric model created in photomod

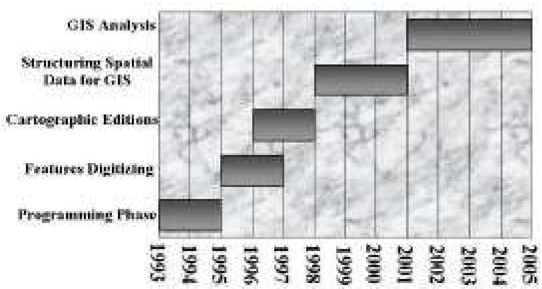

Fig. 9: Different stages of map production project at 1:2000 scale maps of Tehran

been added to features during digitising operation (Fig. 8). Output of IPGIS in this test, was directly entered to GIS environment without further editing and structuring processes.

In order to determine precise value of time and cost saving in GIS projects using OIPGIS system, it is necessary to apply this system in different projects. Although, assessment of available statistics can help to estimate the approximate value of time and cost saving.

Based on the TGIC (Tehran Geographic Information Center) report, in a map production project at 1:2000 scale maps of Tehran, produced using photogrammetric method, production and preparation of spatial data took 8 years when 3 years of this period (more than 37% of the production time) was spent on structuring and preparation stage. Different stages of this project, started in 1993, are shown in Fig. 9.

Due to the fact that OIPGIS facilitates direct entering of GIS data by eliminating the structuring and preparation stage, it can improve the efficiency of photogrammetric spatial data generation process more than 37% and thus cuts considerably the map generation expenses.

Regarding the NCC (National Cartography Center of IRAN) tariff instructions for surveying services, data preparation of maps generated using photogrammetric method to be entered to the GIS, comprises 10% of data reduction and cartographic costs [9]. Accordingly, it can be concluded that OIPGIS can reduce the cost of photogrammetric spatial data production for GIS in order of 10%.

CONCLUSIONS AND RECOMMENDATIONS

Design and implementation of OIPGIS system as the first integrated system for On-Line integration of photogrammetric and GIS systems, could be considered as a great step in reducing distance between the spatial data production systems and Geographic Information Systems (GISs), which could be known as an immense revolution in development of production and spatial data analysing systems.

By on-line integration of photogrammetry and GIS, feature digitizing from photogrammetric models can be performed in an interface GIS environment and spatial data are saved into GIS systems with appropriate standard and data structure. Thus spatial data could be directly entered to GIS analysis without further editing and conversion. Hence by using these systems problems such as spatial data conversion from CAD format to GIS format and reduction of spatial data accuracy during edition procedure will be omitted. Also the ability of attainment to attribute data-bases, which could be given to users, by GIS systems, will make it possible to add simultaneously some attribute data extracted from photogrammetric model to spatial data during feature digitising process. As a result integration of photogrammetry and GIS, would decrease distance between spatial data production systems and processing systems and therefore will save time (around 37 percent) and cost (around 10 percent) in spatial data production and preparation.

Regarding to problems arising from using photogrammetric and GIS systems individually and considering capabilities of On-Line integration of these systems abilities, it is recommended to replace to conventional methods with OIPGIS systems in order to reduce time and cost of production and preparation of spatial data to be entered into GIS.

Researches are underway to further develop the integrated system for topology creation, detection and repair of existing errors in spatial data and making logical relations among features in an automatic and intelligent way.

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