ON-LINE INTEGRATION OF GIS AND GPS FOR AUTOMATIC AND INTELLIGENT UPDATING OF SPATIAL DATA

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ABSTRACT:

One of the most expensive stages in implementation of a GIS system is preparation of spatial data to be entered to the system. It can be said that about 60-80 percent of the project cost is spent for spatial data preparation. Since the quality and reliability of obtained results in GIS analysis is directly affected by input data, entered data quality can be known as the most important factor to achieve a successful GIS project.

Temporal changes of features as one of the most important factor in reducing accuracy and reliability of spatial data should be considered carefully to avoid waste of financial resources. To have an everlasting GIS system, spatial data in GIS must be regularly updated. Since updating stages for large amount of spatial data are cost and time consuming, therefore automatic and intelligent approaches to perform these stages can help to save time and cost of the project.

An automatic method for spatial data updating will be more efficient when updating process is performed simultaneously with data collecting stage (on-line updating approach).

Due to the fact that high-speed spatial data collection can be performed by GPS, on-line integration of GPS and GIS can be a practical and appropriate method for on-line and automatic updating of spatial data.

In this paper, after reviewing problems and technical requirements for on-line integration of GIS and GPS, the stages of design, implementation and test of GGISIU as an on-line integrated GPS and GIS system for automatic updating of spatial data, are described.

1. INTRODUCTION

One of the most expensive stages in implementation of a GIS system is preparation of spatial data for entering to this system. It can be said that about 60-80 percent of the project cost is spent for mentioned stage (Ebadi, et al., 2004).

Because the accuracy of results of performed analysis in GIS systems is based on entered data to these systems, collected data quality can be known as the most important factor in achievement of a GIS project.

Temporal change of features, is one of the most important factors in reducing accuracy and reliability of spatial data, and if it is not considered, the consuming costs will be useless. Therefore, for accessing to a lasting GIS system, entered spatial data to GIS systems must be updated.

Recent developments in the field of geomathic science enable users to use different techniques such as photogrammetry, remote sensing, GPS and etc. for fast and systematic spatial data updating. Spatial data updating process includes tree stages as (Haj-Yehia, Peled, 2004):

- Detection of changed objects
- Identification of change type
- Revision and updating of spatial data

Since, performing each mentioned stages for large amount of spatial data, is cost and time consuming, so automatic and intelligent performing of these stages can help to save a lot of time and cost of project.

An automatic method for spatial data updating will be more efficient when updating process is performed simultaneously with data collecting stage (on-line updating approach).

Nowadays, most of developed methods for automatic detection of changed objects and identification of change type, are based on geometric and radiometric information that is extracted from aerial and satellite images. For using these methods, some complex and time consuming processes must be performed on images and therefore mentioned methods are not convenient for on-line updating of spatial data that is one of the most important purposes in updating of dynamic GIS data-bases (Vafaeinezhad, 2002).

Based on ability of GPS system to collect spatial data easily and fast, on-line integration of GPS and GIS systems can be known as a practical and appropriate method for on-line and automatic updating of spatial data.

In this paper by studying problems and requirements of on-line integration of GIS and GPS systems for automatic and intelligent updating of spatial data, design and development of a new software package called GGISIU is described.

2. ON-LINE SPATIAL DATA UPDATING USING RULE-BASED APPROACH

In this research, updating of spatial data stored in a GIS data-base, is carried out by the use of GPS. Collected data by GPS, offers the 3D coordinates of points and does not have any additional information such as geometric or radiometric information about features. So, detection of changed objects and identification of change type can not be accomplished completely using this data. Thus, the method that will be used to control and make a decision, must be able to demonstrate an acceptable operation by the use of least amount of information and minimizing the guide of human operator. For accessing such a method, all events that can be occurred in various conditions, must be recognized and decided procedure in each condition must be defined as documented and complete rules. By implementation of such method, in facing to predicted events, system will operate based on defined rules.

According to mentioned comments, employing rule-based systems can be convenient for performing controls and making

intelligent decisions in relation to spatial data updating by the use of GPS.
It is necessary to mention that the operation of rule-based systems depend on the defined rules in these systems. If defined rules for controlling and making decisions are more comprehensive and accurate, then operation of system in different conditions will be more ideal. For accessing such comprehensive rules, two following clauses must be provided:

1- The nature of feature must be rule-based.
2- All events that can occur in different conditions, must be completely identified.

The factors such as:

- complexity and closeness of existing objects in an area
- Different behavior of each group of features (Points, Lines, and Polygons) in relation to updating methods.
- Abundance of change range from map resolution
- Lacking enough information for detection of changed objects and identification of changes type

in relation to spatial data updating by the use of GPS, make serious problems. To overcome these problems, not only we should design a robust intelligent algorithm, but also in some cases it is necessary to have an operator guidance for appropriate decision making by designed system.
In following sections, theoretical concepts of the rules that will be used to control and make decisions have been described.

3. THEORETICAL CONCEPTS AND DESIGN OF RULES

3.1. Detection of Changed Object

Collected data by GPS receivers can be delivered as 3D points and dose not carry other information about specifications of features. Therefore detection of the feature which measured point is an ingredient of it, is very difficult just by using this data. Use of tolerance as a rule is a method for relative detection of mentioned features. This rule can be stated as:
"The feature that measured point belongs to it, is one of the features that are located in defined distance from measured point."
This rule is not complete and detection of correct object can not be performed by the use of it. In other words, selected feature via this rule is not unique. By this rule only the search area of features is limited. If the range of changes is smaller than map resolution, the efficiency of mentioned rule will reduce.

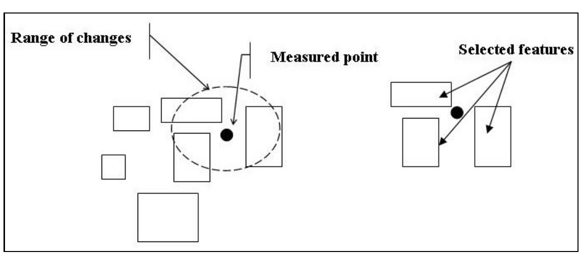

Figure1: Selected features in defined distance of measured point

In this research, two solutions have been used for overcoming mentioned problem.
In the first method, specifications of each selected feature and its attributes, are shown to human operator and he/she can select appropriate feature. This method is efficient when human operator is not aware of registered ID for the feature.
In the second method, ID of feature is defined to system before processing operation and selection is performed by the use of this ID. This method is possible when the registered ID for the feature is known.

3.2. Identification of Change Location

After selection of appropriate feature by one of the mentioned methods, location of the change in the feature must be identified. In the other word, it must be recognized that measured point relates to which vertex or line segment. In this case, following criterions can be used for making a decision:

1- Nearest vertex to measured point
2- Nearest line segment to measured point

By means of these criteria, we can not research to a unique selection. For example in figure 2, if we use "nearest line segment to measured point" as a selection criterion, point A that is located on nearest line segment, will be selected while if "nearest vertex to measured point" is used as a selection criterion, point B will be selected.

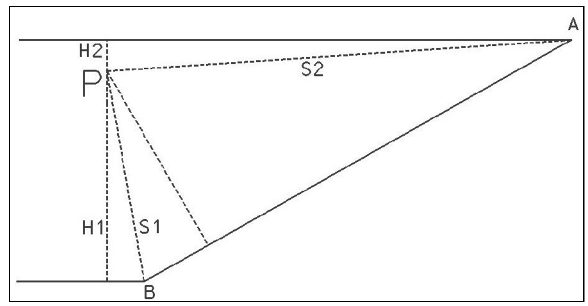

Figure2: The difference between two selection criterions

To overcome mentioned problem, one of two criteria must be selected. Use of "nearest vertex to measured point" as a selection criterion is appropriate when updating process is limited to the shift of feature vertex. Usually, updating of features needs to add new vertices which are located between the existing ones, so, use of "nearest line segment to measured point" can be more acceptable.

3.3. Identification of Change Type by Means of Measured Point

After detection of changed feature and identification of the change location, this feature must be updated by the use of measured point. Automatic and intelligent updating of features needs to design an algorithm which is capable of making one of following decisions automatically:

- Without adding a vertex, the nearest vertex to measured point located on the nearest line segment of feature to measured point, is moved to measured point.
- A new vertex is added at the location of measured point.

According to the rules of Euclidian's geometry, it can be said that distance of a point from another point that is start or end point of a line segment, is equal or more than distance from this point to the line segment. Thus, in figure 3, we can say: $S \geq L$
Based on mentioned rule, comparing distance from vertex (S) to distance from line segment (L), can not be used as a criterion for defining the algorithm functionality. Use of D that is shown in figure 3, can overcome mentioned problem. Following algorithm that has been designed by the use of D as a decision

criterion explains the rules that have been used in the implementation of the system.

$$D = \sqrt{S^2 - L^2} \quad (1)$$

- If D>defined tolerance, then add a new vertex at the location of measured point
- If D<=defined tolerance, then move the nearest vertex to the measured point, to its location

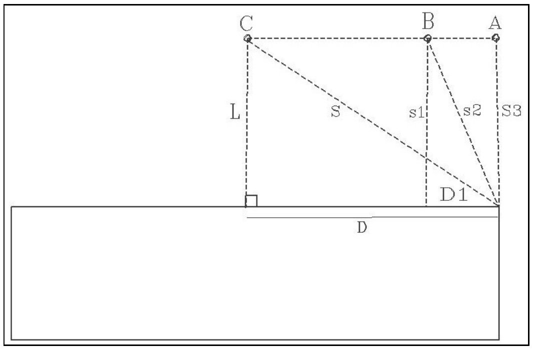

Figure3: Situation of measured points relative to the selected feature

4. IMPLEMENTATION OF THE SYSTEM

As mentioned, in this investigation, the main purpose was to integrate GIS and GPS systems for updating of spatial data stored in a GIS data-base, simultaneously with data collection process. Transferring of collected data by GPS to GIS, must be performed immediately. For such a transferring task:

1- An interface environment must be available that each system would be able to access it immediately and format of saved data in this environment would be recognizable by both systems.
2- GPS receiver must be able to transfer the coordinates of measured points to interface environment simultaneously with data collection process.

A GPS receiver that is able to transfer collected data to a digital interface environment immediately, is called Real-Time GPS. Most of these receivers use Microsoft Access data-base or standard CAD system as an interface environment. Thus, interface GIS environment must be designed and implemented in such a way that would be able to connect to mentioned environments in an on-line mode. In addition to this ability, according to the purpose of this investigation, interface GIS environment should have the following characteristics and capabilities:

- Possibility of recognition of GIS standard formats such as shapefile
- Ability to retrieve, edit, and depict spatial data according to the GIS standards
- Possibility of real-time data transferring from Microsoft Access data-base or standard CAD environments.
- Capability to create and save new features through three segregated feature layers (point, Line and polygon)
- Ability to recognize and perform all defined rules in different situations completely

In this research, for implementation of an interface GIS environment with mentioned characteristics and capabilities, Visual-Basic programming language has been used. General view of this system called OGGISIU (On-line GPS and GIS Integrated System for Intelligent Updating of Spatial databases), has been shown in Figure 4.

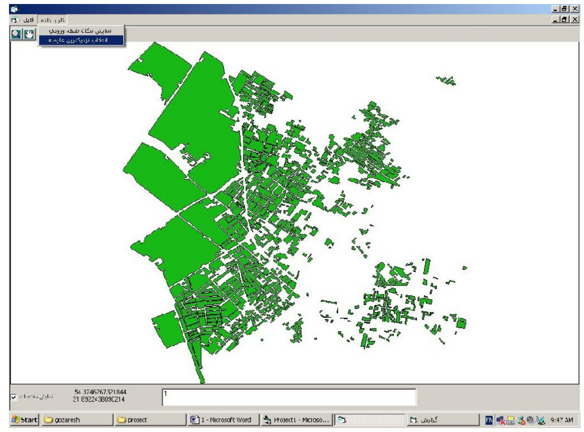
Figure4: General view of OGGISIU environment

Results of practical test of this system for spatial data of Esfahan (Scale: 1:25,000, projection system: UTM, Datum: WGS84), show that, in areas where features density is low, distance between features is long, and the rate of variations is little, the system can update features automatically and intelligently without the need for operator guidance. But if features density is high, especially when the rate of features variation is more than distance between adjacent features, although search domain of features will be limited to 3 or 4 features, system will need operator guidance for recognition of interest feature. It is necessary to mention that after feature recognition, two later steps (Identification of change location and type, feature updating) are automatically carried out.

5. CONCLUSION

Following conclusions can be made based on this research:

1- Although collected data by GPS receivers is 3D coordinates of points and not carries other information about feature characteristics, by the use of Rule-based systems and definition of comprehensive and complete rules, measured points can be used to update spatial data sets automatically or semi-automatically.
2- Use of features variation range as a tolerance for automatic detection of changed object, in areas where features density around measured point is low and distance between adjacent features is more than feature variation range, is suitable. But increasing features density decreases its capability.
3- On-line integration of GPS and GIS enables users to have abilities of both systems simultaneously for automatic and intelligent updating of spatial data sets and by removing procedures between spatial data collection, entrance of spatial data to GIS data-base and updating spatial information, saves cost and time of these types of projects considerably.
4- In this research, all controls and decision making routines were designed based on one measured point. Use of a set of points can offer some information about feature geometry. This information can be used to improve automatic detection of changed object.

5- During updating of spatial data stored in GIS data-bases, topological and logical relationships among features must be considered, in such a way that, at the time of updating a feature, related features to it, and their topological and logical relations to be controlled and changed.

It is necessary to mention that researches are continuing for implementation of two recent cases.

6. REFERENCES

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