TOWARD AUTOMATIC UPDATING OF THE ISRAELI NATIONAL GIS – PAHSE III

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ABSTRACT

Spatial Information revision and updating is the main concern and production effort of maintaining the ever-growing GIS systems and spatial Databases. Developing easily effected automatic updating methods of spatial information becomes the key to the successful maintenance of the large GIS data bases established by many mapping agencies all over the world. The paper presents the third phase in a three-year research effort for the development of automatic capabilities for updating the Israeli National Spatial Database. This ongoing research in funded by the Survey of Israel within the framework of maintaining the Israeli National GIS. Discussed are the experiments and the evaluation steps to define an efficient method for Change Identification and Feature Extraction. Presented are the GIS-Driven change identification and the texture classification methods.

1 INTRODUCTION

There are two approaches for updating spatial databases. The first one is to, gradually, establish a new database which will replace the old one. This approach is guiding many private vendors who are mapping road networks. A second approach is to detect, identify and update only the changes. This approach is suitable, for instance, were customers are attaching value added information of their own. In this research, the later approach was chosen. A modular Change Identification System was developed, which comprises three major stages: (a) Change Detection; (b) Change Recognition; and (c) Change Identification.

The steps taken by the Survey of Israel for the transition from traditional updating methods to advanced digital-domain methods, were reported on the ISPRS' IC meeting in Haifa, September 1997 [Peled and Raizman, 1997]. The experiments of change detection algorithms, were discussed and presented in the ISPRS commission IV meeting in Sttutgart, Germany, september 1998 [Peled and Haj-Yehia, 1998]. This paper deals with the experiments of the change recognition and identification methods. A GIS-Driven method to identify changes is presented in this paper. The objectives of GIS-Driven Identification algorithms, suggested by Peled [1992], are to exploit the existing spatial information, stored in the old database. This enables the building of training sets for the classification and identification algorithms. In addition, edge detection algorithms were evaluated, to extract geographic objects. Also, geometric parameters (size, shape, etc.) classifier was tested to recognize the regions of changes and the geographic objects. Furthermore, statistical and texture parameters filters were developed to identify the radiometric signatures of the objects. The above algorithms, for the recognition and identification steps, were integrated together according to a strategy of developing a modular system. This enables applying identification rules related to recognition (geometric) with rules related to identification (statistical and texture).

These experiments were applied for two layers (streets and buildings) from the Israeli National Database. This was due to the limitation of using black&white aerial photographs which served the Survey of Israel, originally, to remap the country and, nowadays, to update the National GIS.

2 GIS-DRIVEN CHANGE IDENTIFICATION

The GIS-Driven change identification method was suggested, by Peled [1992; 1993; 1994], as an advanced algorithm for identifying changes. By this method, the existing geographic database is used to build the spectral training sets, which are used for classification.

The objective of a GIS-Driven change identification algorithm, is to build a correlation system (geographic and radiometric) between the digital images and the existing GIS database. The geographic correlation system was established, as the first step, when producing the “orthophoto”. The radiometric correlation system is defined by establishing training sets. Histograms and other statistical parameters, of gray levels, may be build, for each feature type (class), based upon the GIS coverages. Intersecting the “orthophoto” images with the coverages, will result with the definition of the features (In terms of geographic position, over the image, gray level matrix). These intersections, which are applied only for the “unchanged” regions, are implemented, much faster, in the raster environment. Therefore the vector coverages must be converted to a raster format. According to these histograms and statistical parameters, it is possible to define what are the specific signatures or statistical parameters that define, uniquely, a required feature class.

To establish the specific signature value ranges, that define, uniquely, a required features class, were generated histograms, that describe the distribution of the gray level value for the pixels within the interested features.

Statistical parameters (mean, standard deviation, minimum, maximum, etc.) were calculated for the gray level values for the neighboring pixels within the interested feature.

2.1 Statistical Matching Classifications

To examine the potential of the statistical matching classifications, the gray level scale was divided to characteristics groups. For each group, an “estimated” frequency percents ranges was determined for the signatures and the statistical parameters. According to these “estimated” ranges, histogram and statistical matching algorithms were implemented, for each pixel to one of the feature classes.

The division of the gray level was done according to one of the following options:

(a) manually division, according to the peaks and spikes of the histograms.

(b) Automatic division to 8 groups. 32-gray levels wide for each.

(c) Automatic division to 12 groups. 8-gray levels wide for the first&last groups, and 24-gray level width for all other (“middle”) groups.

(d) Automatic division to 16 groups. 16-gray level wide for each.

The “estimated” ranges, were determined, for each gray level group, by the consideration of the statistical parameters. In general, two methods were used to determine these “estimated” ranges:

(a) Automatic calculation by formula: mean ± a specific multiplication of the standard deviation.

(b) Manually determination according to the characteristics of the histograms.

The Neighboring pixels were determined by different filter sizes. It is clear that the results are affected by the filter size. This must depend on the size of the examined feature class.

The statistical matching was implemented for several combinations of the above parameters (gray level groups, “estimated ranges and filter size).

2.2 Experiments

At this stage, two coverages from the Israeli National GIS, were tested: coverage #1 (“Transportation”) and coverage #7 (“Buildings”). These coverages were selected due to a rapid changing for both, in contrast with the other coverages.

2.2.1 “Buildings” Coverage

The majority of the buildings in coverage #7, are “regular” buildings. Therefore one class of buildings was tested. A histogram of gray level values for the pixels that fall in “regular” buildings in “unchanged” regions, was established. According to this histogram, it is not possible to define a unique interval of gray levels that uniquely characterize the class of buildings. Therefore, it was decided to check if there is a correlation between the gray level values and the position of the pixels within the polygon of the “building”. The motivation was to find whether the shadow, or other special partitions of the buildings (image), affects the histogram of gray level values. Another test was to check for a correlation between the gray levels and the direction (in terms of positive or negative difference) of changed regions. As a result of these tests, it was found that the gray level values are distributed, arbitrary, over the buildings and the change region types.

Nevertheless, a decision was made to further “exploit” the black&white aerial photographs. Histograms of gray level values were established for each building (see fig. 1). According to these histograms, series of classification processes were implemented. These differ by the gray level groups, the "estimated" ranges and the filter size. These analyses resulted with the edges of the building being detected. Yet, the problem was that roads were detected also, in addition to the building's edges. The best result, was achieved with the following parameters: (a) 16 groups that were determined automatically, (b) "estimated" ranges that were calculated automatically by the formula: "Mean±2.5*Standard_Deviation", and (c) 21X21 filer size.

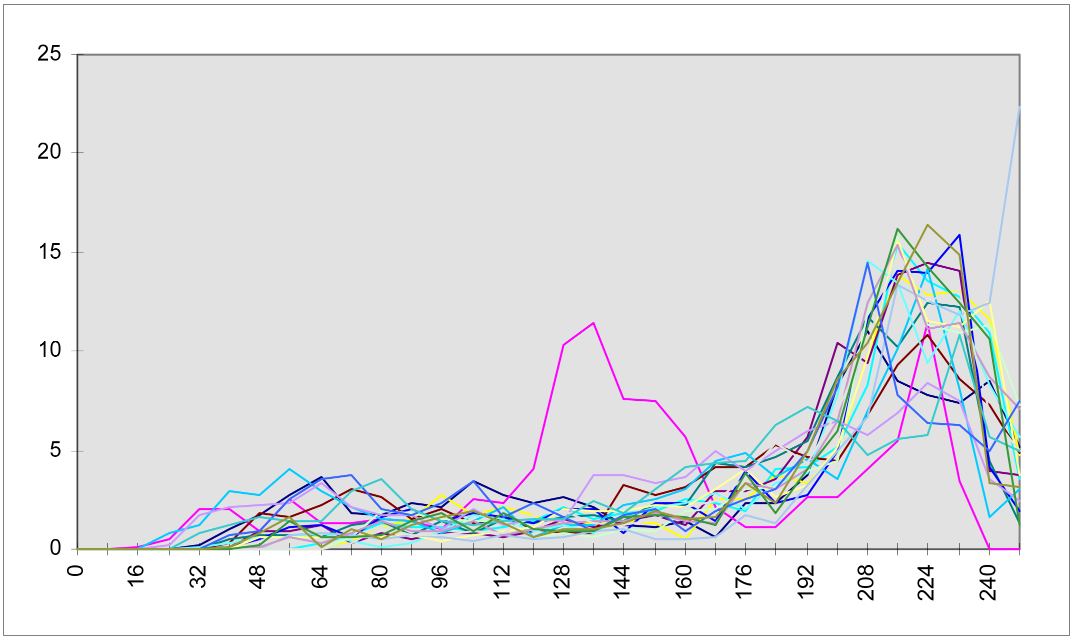

Figure 1: Histograms of gray level values for the pixels within buildings.

2.2.2 "Transportation" Coverage

The "transportation" coverage includes seven different types of roads. According to the distribution of gray level values, for each road type that fall in "unchanged" regions, it was difficult to define gray level interval for each road class, uniquely.

Therefore, separate histograms were established for each road segment (see fig. 2 and fig. 3). According to several classification processes, the results show a mixed detection of roads and buildings, similar to the "buildings" classifications. The best result, was achieved with the following parameters: (a) 8 groups that were determined automatically, (b) "estimated" ranges that were determined manually, and (c) 7X7 filer size.

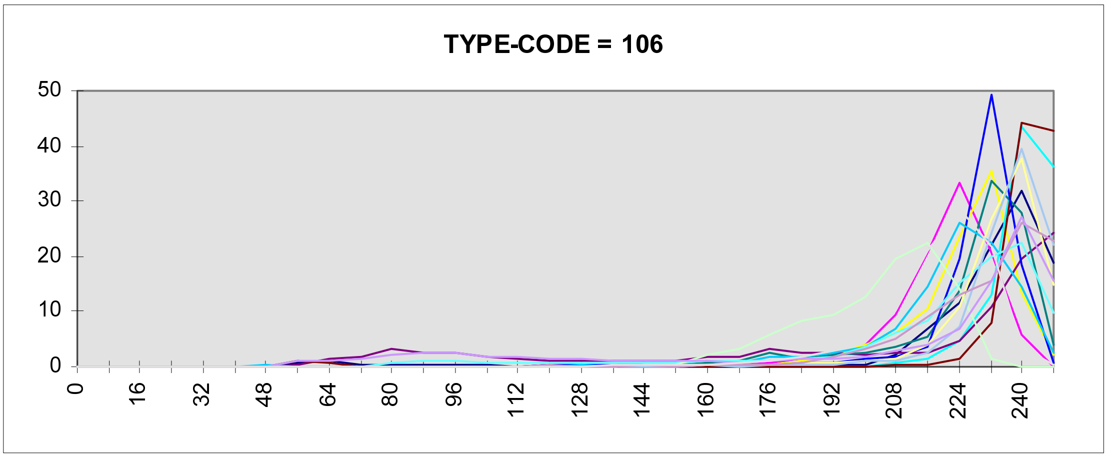

Figure 2: Histograms of gray level values for the pixels within "under-paving" roads.

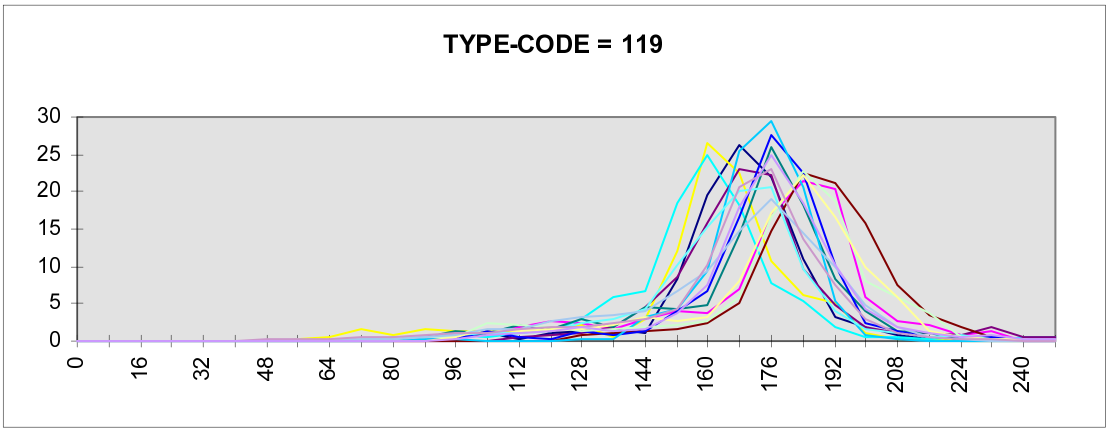

Figure 3: Histograms of gray level values for the pixels within "Stone-Paved" roads.

2.2.3 Buildings & Roads Combined Together

According to the classification processing, of buildings and roads, separately, the results show a mixed detection of both buildings and roads. Therefore, the decision was to implement an integrated classification. Also here, the results show a mixed detection, of buildings and roads, with a large percentage of "noise".

2.3 Conclusions

According to the above mentioned experiments, the conclusion was that using, only, radiometric data (from black and white aerial photographs), is not enough to enable change identification, obviously. Therefore, the decision was to continue the research by using color photographs and multi-spectral remotely sensed images. Nevertheless, the research was continued to test "texture classification approach".

3 TEXTURE CLASSIFICATION

The objective of texture classification, is to determine specific pattern templates, which define, uniquely, a required feature class. In this research, advanced algorithms for texture identifications in a statistical approach, were applied. Three types of statistical textures were tested:

(a) The differences between the gray level value of the tested pixel and the average value for the neighboring pixels.

(b) The maximum difference between the gray level value of the tested pixel and each of neighboring pixel.

(c) The difference between the extremum gray level values of the neighboring pixels.

3.1 Experiments

In the first step, a different "texture images" (according to the above three types) were produced according to different filter sizes. The results of these "texture images" were detection of edges. The texture classification was developed in a similar way to the GIS-Driven classification. For each feature (building or road), three histograms, which describe the distribution of the above three types of statistical texture parameters, were generated. According to these histograms, the groups of gray level values were determined, depending on the peaks and spikes depicted in the histogram functions.

For each group, an "estimated" frequency percentage of the texture value ranges was determined. This, according to the mean and standard deviation of all histograms related to same feature class type. The statistical matching algorithms were implemented for each pixel to one of the feature classes. Several texture classifications processes were implemented, with a different filter size.

3.2 Conclusions

The results of the texture classification experiments, show a distinct detection of edges (for both roads and buildings). I.e., instead of detecting the feature itself, the operator detected it's edge. In spite of this successful edge-detection, It was found that it is not possible to define the feature types by unique values set of the texture parameters.

4 SUMMARY

According to the above mentioned experiments, the conclusion was that using, only, radiometric data from black and white aerial photographs, is not enough to enable automatic change identification processes. Therefore, it was concluded to continue this research by using color photographs and multi-spectral remotely sensed images. In addition, a geometric identification approach is suggested to this future research.

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