MAP AND DATA BASE REVISION

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ABSTRACT

Digital spatial data base revision is gradually taking place as the main goal and production effort of many mapping agencies all over the world. Developing easily effected updating methods of digital mapping information now becomes the key to the successful maintenance of the large GIS data bases established by these institutions. The "digital era" of mapping where objects and features are to be defined rather than just described in the traditional cartography, is facing us with an additional dimension. In an ever-growing domain, in terms of activities and the developing demand of information, non-spatial data becomes a major issue in maintaining the spatial data bases we generated until only recently. In the era of the Information Highway, a vast quantity of new users have surfaced who are seeking a multitude of information in terms of variety and details that were unfamiliar to traditional mapping. Today, it is not enough to map a building and position it correctly. Most of the users are seeking the information about the activities taking place at that particular address rather than the physical description of the structure. The paper describes the experience gained at the Survey of Israel in updating the National GIS data base that is established based on remapping the country using 1:40,000-scale air photographs. The paper presents all the sources used to update the base layers (i.e., large-scale photographs, satellite images, large-scale maps, etc.). Also described is the shift in field surveys, for updating, from traditional mobile surveying to airborne (helicopter) surveying, based on GPS instruments and techniques. Also presented is the methodology developed for semi-automatic revision of digital maps that were produced from the GIS data base revised since the last map production.

BACKGROUND

In 1992, the Survey of Israel launched a remapping project. In this effort, the whole country was to be remapped using 1:40,000-scale air photographs. This effort is based on a 2.5-D scaleless model [Peled et al., 1991], and aims to establish a National Seamless data base of the country. This data base serves both as a national digital mapping source and also for the Survey's map-series production. Four years after launching the remapping project of the country, the Survey of Israel has found itself in a most complicated transition era. On one hand, most of its maps are produced by using traditional cartographic methods. Conversely, new digital maps are being produced directly from the newly established National GIS data bases. Furthermore, some of the data were gathered three and four years ago, which in some areas in Israel means they are critically out of date. Thus, in the midst of the remapping effort, passing the 50% point in terms of remapped area, the Survey must proceed in three major production efforts: (a) Revision of reproduced analogue map-series; (b) Continuing with remapping the country; and (c) Revision of the digital GIS data base in areas that were just recently remapped. In addition, two additional revision and updating procedures are carried in parallel efforts; one being to revise old map series by validating functioning and position of objects like water holes, caves, springs, etc; the second is to update the GIS data base on information such as activity centres, landmarks, etc. These efforts aim not only to update the digital data base, but also to revise the traditionally produced maps, and in a second phase for developing an automatic revision of town maps where these data are mostly needed.

DATA BASE COMPLETION

The data base completion phase is regarded at the Survey of Israel as a revision process. All data that were detected and identified on the 1:40,000-scale air photographs are mapped according to the new digital mapping guidelines that were developed for the project. These data are tested and corrected according to a detailed quality control process, and only when passing the tests are added to the GIS library. This process is carried out in batches of a single photogrammetric model that is connected to existing data to generate a seamless data base.

Cartographic Completion

Some features that were depicted, traditionally, in the "analogue" map-series are not mapped in this process. These are features such as: water holes, wells, springs, caves, religious landmarks, to name just a few. These were collected over the years, starting in the late 1930s. Thus, the position and validity of many of these features are questionable.

These features are then digitized off existing maps to enable the production of the new map-series. Yet, one should not "contaminate" the digital data base with features of non-homogeneous origin. Such problems were foreseen and taken care of when developing the remapping protocols and the GIS data base model. Each of the features in the GIS library also carries a SOURCE-CODE. This SOURCE-CODE is a special pointer to the SOURCE-CODE look-up table. This table contains the characteristics of the mapping, including: method, date, planimetric and altimetric accuracy, the mapping company code, etc. Thus, all the features that were mapped off on 1:40,000-scale photographs taken at the same date by the same photogrammetric company, will have the same SOURCE-CODE. In the same manner, all features that were digitized off an old existing topographic map, are given the same source-code. This enables fast production of new maps, and also the launching of a revision process of validating the existence of these features by field surveyors.

Field Completion

As mentioned previously, field crews are sent to the newly remapped areas in order to validate the existence of the features that cannot be detected on the air photographs. This aims also to resurvey those objects that are found, in order to map them within the planimetric accuracy restriction of the new National GIS Data Base.

During 1994, and most of 1995, some experiments were performed over several areas of 400 sq.km. each. This is the area covered by the traditional 1:50,000-scale map-series quads. At first, field crews would set out, using new work maps that were generated directly from the GIS Data Base, using an inkjet or electrostatic plotters. The surveyors used traditional methods of surveying, and were limited to terrestrial transportation. Due to the restricted manpower and other resources of the Survey, it took between 2-3 months to cover an area of one quad. It was obvious that this was not a solution for the field-completion surveying. At the end of 1995, the Survey launched an experiment using mobile GPS surveying, complemented by transporting the field crews by helicopter. This experiment showed a saving of 90% in terms of time, and between 65-75% in terms of cost. Not only was it possible to remap, accurately, existing objects that were "neglected" over the years, but it was also possible to validate their existence. Thus, many of the features depicted in old topographic maps were omitted as it was found they no longer existed. In addition, many new objects were found and added to the National GIS Data Base. This was made possible by flying the surveyors and scouts over the area, thus giving a better view, and enabling them to detect new objects. Using a helicopter added to their mobility, and thus reduced the time needed to move from one object to another.

Non-Spatial Data Completion

Non-spatial information becomes more and more in demand as users begin to regard the spatial data as a base layer for georeferencing the more "important" thematic (non-spatial) data. This is a new domain for a mapping agency that is in charge of acquiring, updating and distribution of spatial information. Gathering non-spatial information focuses mainly on urban areas. In such areas, the municipalities are regarded as the best information source, and also as a potential client for revised and updated town plans and maps. Thus, the consumer has the motivation also to provide the information, as by producing such non-spatial knowledge, he is reimbursed by georeferencing these data.

Georeferencing is carried out by an interactive process. All public and other activities are given a special code. This is defined as a Secondary-code. There is no limitation on the types and variety of these codes, and each of the features in the Data Base may carry several Secondary-codes. Also, the digital transfer standard, IEF'91 [Peled et al., 1991] is open, and enables to attach as many as desired of these Secondary-codes to the main Type-code (feature). A user-friendly module was devised for this georefering. The Secondary-codes are organized in logical groups, and are easy to access, so the operator need not memorize them. This "logic" was tested, and as some of the activities were defined by several people in different groups, they appear in those groups, e.g., the Muslim courts appear in the "judicial," "religious," and "government" groups. By this concept, the "logical-connectivity" of the operator will enable him to access the same Secondary-code, no matter what initial logical-group was chosen. Once a new activity is introduced, it is processed by the GIS-Completion manager, given a Secondary-code, added to a logical-group, and added to the menu and the distribution standard.

This concept also enables the Survey to distribute information acquired and coded by other authorities. These codes are either given a prefix digit to identify the coding authority, or are recoded by a pre-defined Transformation Look-up Table. Such is the case with the forestry authority. All the flora codes given by this authority are kept, intact as secondary-codes. The Survey itself has Type-codes only for trees, bushes, forests, etc. The actual type of the trees are coded according to the Secondary-codes given by the forestry authority.

MAP REVISION

Map revision is envisaged as a by-product of the data base revision and updating. Here again, there is utilization of the SOURCE-CODE. All data extracted from the GIS data base are kept in a special library which is referred to as the "Cartographic GIS." These files are the exact copy of the original data base, and should not be confused with the "cartographic" copy (backup) of the final digital file used to generate the map. These files are the result of tedious work of cartographic treatment, hierarchy manipulation, and other procedures aiming for a better quality visual product, namely the map, that depict, but not necessarily copy, the spatial and non-spatial data stored in the National GIS data base.

The simple solution is to revise the map by running the map production process from starting point, using the updated

Data base. This solution, although simple to operate, is costly in the long run, as the cartographers work will duplicate for each map revision [Tait, 1991]. Here again, the SOURCE-CODE attached to each feature in the GIS Data base, plays a major role. The date of mapping is part of the information within the SOURCE-CODE table. Thus, all features acquired after the date of providing the cartographers with data for last revision, are selected for the current map revision process.

These features are collected in separate layers, according to their TYPE-CODE, and are superimposed over the cartographic copy files, using somewhat different symbols. The cartographers may now detect the superimposed features, and treat them according to their protocols. These treatments include some changes that are made with the data depicted already in the old file. Once all treatments are done, the "new" features are imbedded in the "old" file in original layers and hierarchy levels, in order to produce the revised map.

Old files are archived in a separate workspace. This is done both for the direct extraction from the GIS library, and for the final cartographic copies. This is performed in the same mode as keeping old separations, in order to keep track of changes and to enable any repetition of the GIS Data base updating, or map revision and reproduction. This protocol has not yet been tested in its full length, but the process was proven when adding additional features surveyed in-situ to the cartographic copy processed before the field completion step was implemented.

DATA BASE UPDATING

The National GIS Data base updating is planned as a 5-6 year circle. Within this time frame, all the data base should be rechecked and updated. In addition, two more instances of updating may take place: (a) When the amount of changes detected will pass a certain criteria (not yet devised); and (b) Under special order of digital data in a particular area. This strategy aims to update the populated areas more frequently, while keeping up with customer demands and with the minimum updating time.

Change Detection

As reported by Peled [1994], the key to a successful updating would be the development of advanced change detection capabilities at the Survey. This year, only two quads are to be updated; traditional processes are still in use. Comparing two sets of air photographs, it took a trained photo interpreter four days to mark the changes, using a work map, produced directly from the data base, as reference. This map directed the operators to map and acquire the new features detected by the photointerpreter. Just recently, the Survey commissioned a photogrammetric company to update a full quad. The company is giiven an extraction of the GIS Data base that will be superimposed on the stereoscopic model, and the operators may map only the changes they detect. It was clearly observed that, although possible, this procedure is error-prone and time-consuming. The pre-process of change detection is important, as it removes the burden from the operators, who are then able to carry-out their work, free of the tension involved in the original protocol. In addition , the Survey has just made a grant to research and develop customatic change detection capabilities. This research is based on modular steps, starting with epoch-based change detection to continue with GIS-driven change detection and Data base updating [Peled, 1994].

Epoch-Based Change Detection

Epoch-Based change detection appears to be the simple and rapid solution to aid both the updating priority and traditional map revision, and as a basis for the GIS Data base updating. The Survey of Israel is covering the country with 1:12,500-scale photographs at two-year intervals. Experiments were carried out to test whether these data may be used to detect changes, and also to quantitize them. These photographs were found very useful to achieve clear change detection. Nevertheless, this process demands the scanning of thousands of photographs, and the work involved with georeferencing them, solely for the purpose of change detection, does not seem worthwhile. Thus, the experiments are now focused on two parallel efforts. Spot-HRV panchromatic images are tested as a tool to quantitize the "amount of changes," in order to solve the updating priority problem. The question here is to devise some area-wide criteria, as the geometric resolution does not permit to continue with the freature-based criteria devised for the 1:12,500-scale photographs. In a second effort, epoch-based change detection is tested on 1:40,000-scale photographs. These are the same photographs that are used in the remapping effort. As orthophotos are becoming a by-product of the remapping project, this appears an affordable solution, as most of the georeferencing work has already been performed. The idea is to use satellite images in order to define whether a certain area should be updated. Then, by using the 1:40,000-scale photographs, a second epoch-based change detection process will serve the actual updating.

GIS-Driven Change Detection

The basic idea in GIS-Driven change detection is to use the inherent information in the GIS data base, in order to find the changes, toward updating the very same data base. This research effort commenced only at the end of 1995, after some progress was made in detecting changes in roads [Peled, 1993], and buildings. Here again, modular process is envisaged, first, to replace the photointerpreter's work. The idea is to use more lenient restrictions in the position accuracy, and to serve the stereoplotter operators with a change model that will also show the type of change detected. In the long run, the idea is to vectorize the detected changes, and to import them directly to the GIS data base, bypassing the photogrammetric mapping process.

SUMMARY

Automatic change detection methods seem to be the only solution to large-scale operation of map revision and GIS data base updating. The transition from traditional mapping to the new era of digital mapping is not straightforward. As both processes are still operable side-by-side, a modular transition seems the only solution in order not to shut down traditional production lines before the new digital methods and techniques are imbedded in the mapping institute. The introduction of image processing techniques will aid in carrying out map revision and GIS data base updating efforts within the framework of affordable costs and a reasonable processing time length.

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