UPDATING CARTOGRAPHIC DATABASES
- MERGING OLD AND NEW DATA

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ABSTRACT:

The merging of old and new cartographic data requires an adjustment of the control networks giving the two sets of data a common orientation in the reference system. The discussion centers around the problems inherent in a database consisting of objects of varying accuracy and of different levels of generalization. To provide the user of a map with a true picture of the contents of the under-lying database, the graphical outputs whether on screen or on a map must reflect the variations.

KEY WORDS: Updating, Generalization, Error propagation.

1. INTRODUCTION

Updating digital databases is a problem that arises when digital maps have been in use for some time. In principle, it is simple to do an updating: outdated objects are removed from the database and replaced by new objects. The updating can be done from day to day, when information about the changes are at hand. Maps drawn on the basis of the database will automatically include all the changes that have been introduced in the database until the moment of extraction.

The objects of the database are not independent of each other. The relative placement of the objects has been determined by making all measurements in a common reference system. In order to place the new or revised objects in a correct relationship to the objects in the existing database, the same reference system must be used, and a least square adjustment of the new and old observations must be carried out (Jacobi,1988). If the coordinates of the existing database are kept fixed, and the new observations are fitted into these coordinates, an error propagation will arise.

By successive updatings, this error propagation will destroy the geometric quality of the database. If the updating is carried out by a least square adjustment of old and new observations, the geometric quality of the database will improve.

With a least square adjustment it is possible to make a correct numerical model consisting of observations of varying precision. On the basis of the adjustment, the accuracy of every point in the database can be computed.

2. GENERALIZATION

The geometric quality of the database will vary from object to object. But this is not the only variable factor, the level of generalization of the objects in the map will vary as well. Standards of mapmaking describing which objects must be included in the map, and by what detail each object must be described will change from time to time and from survey to survey. In some parts of the database, objects may be represented by many points detailing the objects, while in other parts of the database, the same type of objects may be represented by a few points giving only a coarse outline of the object, thus posing the problem of connecting such diverse descriptions.

In contrast to the adjustment theory for treating observations with varying precision, there is no corresponding theory for integrating a minute survey of objects with a coarse survey of objects in the same database.

A cartographic description of the entities of nature is based on a generalization. As a function of the scale of the map, the objects in the map may include varying degrees of details. If it were possible to establish a mathematical description of the cartographic generalization, it would be possible to solve the above-mentioned problem. The generalization would be a direct function of the scale of the map, and it would be possible to compute a lower level of detail from objects representing a higher level of detail.

Methods for automatic generalization are the subject of many investigations and much research, and we may hope that a theory will turn up for solving these problems.

3. COMBINING OLD AND NEW DATA

If the update is done photogrammetrically, we have a new set of pictures which are to be orientated according to the reference system. This can be done in the usual way by an aerotriangulation, perhaps supplemented by geodetic measurements. If the new aerotriangulation has only the geodetic reference points in common with the aerotriangulation which was the basis of the earlier measurements, there is no basis for a change of the existing data. Even if we made the two aerotriangulation adjustments as one big joint adjustment, it would not result in changed coordinates to the existing points, as no new links have been added to the adjustment.

If the new aerotriangulation is to be fitted into the existing aggregation of points, common transfer points have to be established between the two sets of pictures. Such transfer points will give the necessary links between the new and the old measurements and make a joint adjustment possible.

Which points to choose, then? As several years have passed between the taking of the pictures, it can be difficult to find recognizable points which have not been moved and which have the right size. Apart from the control points which can be found again and signalled, it is necessary to look out points already in the database and measure them anew.

In Denmark, experiments have been done with the road gratings used for channelling rain water. The gratings are squares of 30 by 30 centimetres and situated at the edge of the road close to the pavement. It has proved in practice that without signalling the gratings, it is possible to measure them in pictures of a scale larger than 1:10.000, and an accuracy test has shown that the photogrammetric measurements have a standard deviation of approximately 6 centimetres. In an ordinary photogrammetric measurement, 60% to 70% of the gratings will be measured. The rest are covered by cars, trees etc. and may have to be measured from the ground.

However, it is too late to measure such transfer points at the time of the updating. For this purpose, points have to be chosen and measured when the first digital map is made.

With a modern analytical instrument,it is possible to make an automatic search for all the gratings in the existing database, and they can be found again and measured in the new pictures. Other self-signalling objects like pylons or roof corners can also be considered.

A joint adjustment of the old and the new aerotriangulation combined with the gratings which are measured in both sets of pictures will give new values to the absolute orientation in the old as well as the new models. Thereby, the points in the database acquire new changed coordinates, not only in the area where the up-dating is taking place, but also in the surrounding area.

4. CHANGE OF COORDINATES OF STATIONARY OBJECTS

Objects that are not changed in nature may have their coordinates in the database changed. The cause of such changes may be the updating of the reference system, whereby all points in the database will change. In other cases, the change may be caused by a local updating. The least square adjustment will include points in the neighbourhood and result in small changes of coordinates of objects that have not been moved in nature.

If the geometric quality of the database is to be main-

tained or improved, such changes of coordinates are inevitable, and it is therefore important to build up procedures that can manage such changes.

A consequence of this is that coordinates are not fit as keys in tables. Keys in relational databases must not change values. The key must identify an object as long as the object exists (Date,1985). If coordinates are used as keys, they must be updated whenever the map is updated, and it would be difficult to locate all the tables using the coordinates as keys and make the proper corrections. If the key is made as an identifier connected to a point in the database, and if this point is included whenever coordinates are moved, the connection between map and attribute table is preserved.

This will only solve some of the problems related to updating. In addition to tables with attribute data, there are special thematic maps showing land registry or utilities. It is very important that these thematic maps are in geometric agreement with the basic map, if they are to overlap each other. When the basic map is updated and points in some area are moved, there will no longer be agreement between the two maps. Pipelines or parcel boundaries may be displaced in relation to buildings and roads. Updating of the basic map must be followed up by an updating of all thematic maps in the same area. The thematic maps may be scattered in different institutions, and it can be quite a job to locate all the maps. That being done, how should the updating be carried out ?

It would not be possible to make the updating by a least square adjustment of observations, because the thematic maps are made more or less independently of the basic maps, and because the method of survey and the observations are often unknown.

The movement of the coordinates in the basic map must be a function of where the points are placed in the horizontal plane. Such a method based on a subdivision of the plane in triangles followed up by a linear affine transformation inside the triangles is described in (Petersen, 1989). The method is used in Denmark for updating digital databases.
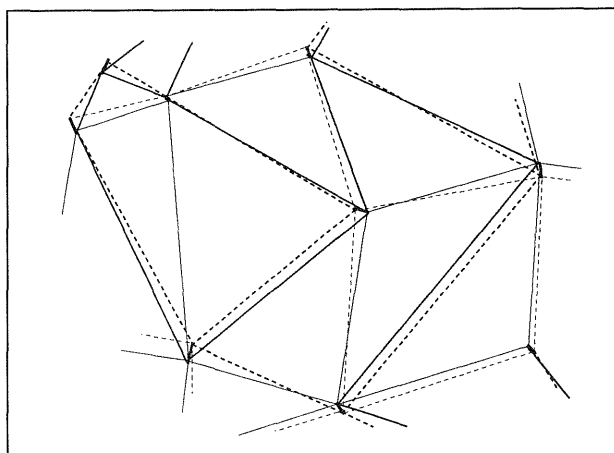
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Every updating must be identified by the date of the relevant survey and an indication of the area involved. This would be a natural part of the code of origin described in (Jacobi,1991). It would then be possible to check if a basic map or a thematic map have been through the same updating, and if not, to find the transformation that will reestablish the geometric agreement.

Transformation parametres describing how every point in the plane is to be moved constitute important information that should be stored for later use. These transformations are just as important to store as the aerotriangulations and control network adjustments in order to preserve a workable database.

5. TREATING A DATABASE WITH VARIABLE ACCURACY AND VARYING LEVELS OF DETAIL

The classical graphical map is divided into sheets. Each sheet is made in a particular scale, and as a consequence of the scale, with a particular level of generalization. The geometric accuracy of the objects in the map is fitted to the scale of the map in such a way that the geometric accuracy is greater than the drawing accuracy. This is usually put between 0.2 and 0.5 millimetres. All points in a sheet will have the same accuracy, and all objects will be described with the same level of generalization. The scale of the map and the level of generalization will only change when changing to another sheet.

For the map-user it is fairly easy to estimate the accuracy and level of detail in a graphical map. The use of cartographic standards for map-making makes it possible for the experienced map-user to develop an understanding of what information can be extracted from the map, and of the accuracy of that information.

When we change to a digital database that is periodically updated, the database will include points of different accuracy. By a least square adjustment it is possible to compute the accuracy of every point in the database, but how can this information be shown to the map-user ?

6. KEEPING THE EXISTING STANDARDS FOR MAPS

The simplest, and perhaps the most correct method of solving this problem is to maintain the cartographic standards that have been developed and refined over many years, and make the computer programs adapt to these standards. The maps that are shown on the computer screens and drawn on the plotters must comply with the cartographic standards.

When the user wishes to have a chosen area displayed, the computer will search for the accuracy of the points in the database included in this area. The point of least accuracy will determine the greatest scale that can be used for the display. If the user tries to make a display in a greater scale, the computer
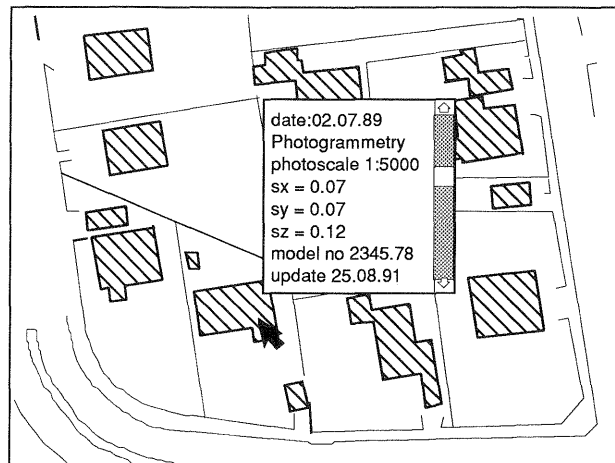
will come up with a warning.

The method is rather easy to program, and it safeguards the database against misuse.

An automatic generalization method would make it possible to use a analogous procedure for choosing the map content. There is as close a connection between the scale of the map, the map content and the level of generalization as there is between the accuracy and the scale of the map. The scale of the map should be chosen according to the objects with the lowest level of generalization, and with an automatic generalization procedure, it would be possible to bring all the objects in the chosen area on the same level of generalization.

7. USER-CONTROL

The experienced map-user who has a knowledge of data capture, error theory and cartography may want a system where he is free to chose any scale for display. In this case, it is important to make a user-interface that gives the user the possibility of getting information about the accuracy of every point in the database, and about the level of detail of each object in the database.

In the graphical map, the concentration of information is so high, that it will be difficult to find space for additional information about accuracy without disturbing the cartographic expression. But a user working on a graphical workstation will have tools from the Graphical User Interface (GUI) to display the additional information. Pointing with the cursor at an object on the screen could make a pop- up window appear with the information on origin, accuracy and level of generalization. A colour scheme could be used to display difference in accuracy or level of generalization of many objects in an area and give an overall view.

8. CONCLUDING REMARKS

Some considerations regarding updating of digital databases are presented in this paper. At this time, only a few of the proposed methods have been developed

and tried out in practical experiments. The use of computer networks as well as the experience gained by sharing databases and combining information from variously located databases will be of great importance for the development of methods for updating digital databases.

The problem is also one that needs urgent attention. If updating is to be successful it is necessary at the time of establishing the database to gather and store information that is to be used at a later time. The following information is important:

1. The geodetic reference system.

2. The areotriangulations and adjustments of networks that connect the database with the reference system.

3. A code of origin telling when and how every point in the database was measured.

4. A set of points, located in the area, that can be found and remeasured many years later. These points can act as tie points connecting old and new measurements.

The use of this information in least square adjustments may lead to an updated, consistent database. The transition from the old to the new database can be described as vector movements which can be computed as a function of the x and y coordinates.

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