Multi-scale Representation: Modelling and Updating

Osman Nuri ÇOBANKAYA[1], Necla ULUĞTEKİN[2]

[1] General Command of Mapping, Ankara
osmannuri.cobankaya@hgk.msb.gov.tr

[2] İstanbul Technical University, İstanbul
ulugtek@itu.edu.tr

ABSTRACT

Although there is only one world, representing of this reality can change according to the purpose and scale. So, different products can be formed to represent the same world reality for different purposes. National Mapping Agencies are responsible to produce map series at different scales. This situation reveals an updating problem of the digital map series with a relevant method. Updating the digital map series is a process requiring time and cost because of the volume of data at national level. In order to perform this process more efficiently, dataset with lower resolution can be updated and generalized automatically after master dataset with high resolution is updated manually. In this study, it is aimed to establish the relationship between spatial objects belonging to the same world reality in a multiple representation database and to apply the revisions in master digital landscape model to the other digital landscape models with low resolution automatically.

Keywords: Multiple Representation Database, Updating Database, Incremental Generalization.

1. Introduction

Due to the requirement of information and analysis in several scales of different subjects (especially in engineering applications), maps and geographic information systems at various scales and resolution are needed. Necessity of different representations concerning the same world reality has been increasingly handled with the development of geographic information systems (GIS) technologies. Because, in GIS applications same data is tried to be represented for different purposes and scales by users in various disciplines (Figure1). It means that various representations derive from only one database. As a result of these similar reasons, researchers have been compelled to find a new database and representation model named multiple representation and multiple representation database (MRDB). Multiple representation concept is expressed as multi scale or multi resolution.

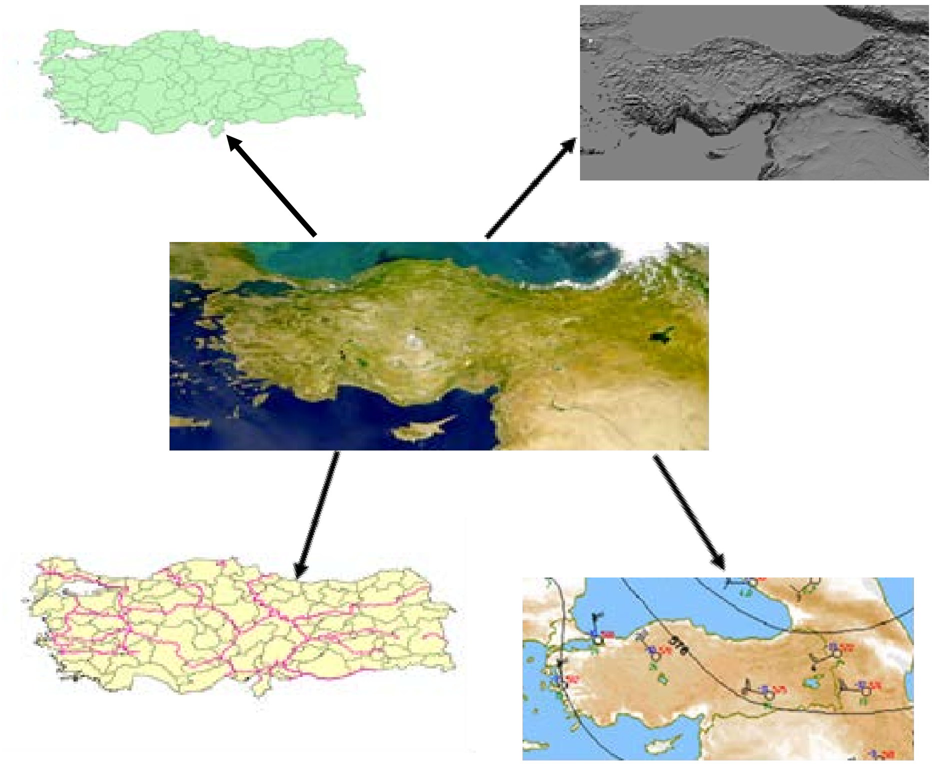


Figure 1) Various representations of the world for GIS applications.

1.1 Why MRDB?

There are differences among the various scaled spatial representations in terms of accuracy and resolution. Model with lower resolution is a simplified representation of the original model. Different databases are kept for every scale in current systems but this reveals updating and inconsistent data problems. Because, there is no connection between different databases about same real world objects (Figure2). Major advantage of MRDB is the availablity for updating. In MRDB system, changing world realities are applied to master database and then these changes are performed to the other levels of the MRDB automatically.

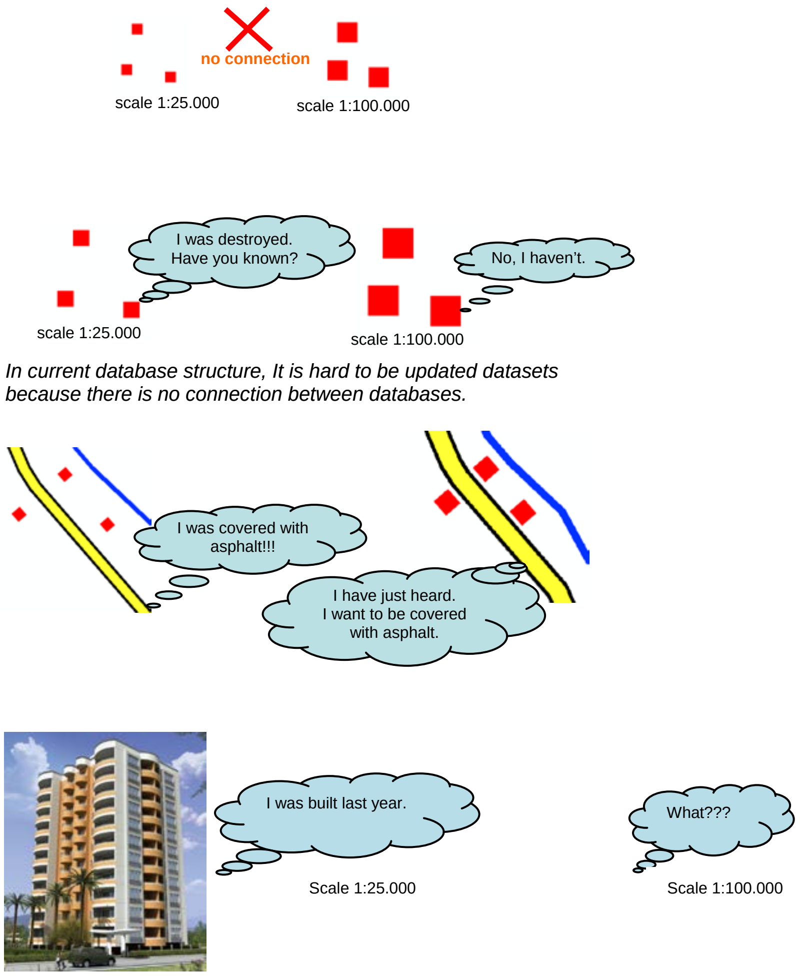


Figure 2) Unconnected objects at different scales.

1.2 Structure of MRDB

Kilpelainen (1997) described the most detailed model of MRDB. According to her model, MRDB is a structure arranging the model generelization stage and a preparation process for cartographic generalization (Figure3).

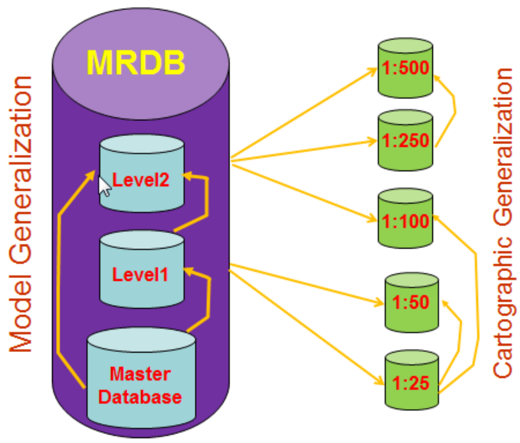


Figure 3) MRDB structure.

Kilpelainen described an MRDB model as follows;

- MRDB occurs in a model generalization environment.
- The data in an MRDB are arranged with levels.
- Geographic data at each level are organized as objects with their spatial information, attributes, behavior and defined relations between the objects.
- Different representations of the same object at the various levels are linked with bidirectional interlevel connectivities.
- Reasoning processes control the use of model generalization operators. Utilization and maintenance of the bidirectional connectivities is essential in this context (Figure4).

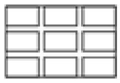
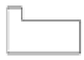
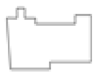
Representation Levels	Geographic meaning	Reasoning processes	Cartographic representation
Level 4 (Polygon)	Built-up area	Aggregate buildings from level 3	
Level 3 (Point)	Building	Replace the center point of the building at level 2 point symbol	
Level 2 (Simple polygon)	Building	Simplify the outline of the building at level 1	
Level 1 (master representation level) (Complex polygon)	Building	Use the master level representation	

Figure 4) Representation levels for an building object (Kilpelainen, 1997).

In an MRDB, master level is the most important level. Because, other levels are derived from the master or previous level. Updating at master level is transmitted to the other levels automatically and each object has a unique identifier. Kilpelainen proposed an approach called "incremental generalization" for propagating updates through different abstraction levels in an MRDB (Kilpelainen, 1995a; Kilpelainen, 1995b).

1.3 Unique Identifier

In MRDB, identifiers are the records maintainig the relation between the same real world objects at different representation levels. These records generally consist of alphanumeric values. Life cycle of these records will not halt as long as object is not deleted. An identifier can not be given more than one object. There isn't a certain rule for creating an identifier but most importantly, identifier must represent only one object in a database. Using identifiers makes it much easier to share data between various kinds of applications and systems. Some unique identifiers are seen below (Figure 5).

osgb (Ordnance Survey Great Britain) + 13-16 character numeric value

TOpographic IDentifier for London Castle, TOID=osgb1000006032892

DENW123412345678

DE country code

NW North Rhine-Westfalia (province code) + 1234

12345678 numeric value

ATKIS database unique identifier.

Figure 5) Unique Identifiers (Ordnance Survey, 2011; AdV, 2004).

2. Method

In national mapping agency of Turkey, different scale of maps have been produced. In national scale, there are various datasets with different scale and resolution but there is no connection between these datasets. Studies about creating of master digital landscape model named TOPO25 (Topographic Database) have been continuied in Turkey in a matter of years. In this study, an MRDB including five different levels of detail about population objects was designed (Figure 6). This MRDB contains 1:25.000 (master level), 1:50.000 (level2), 1:100.000 (level3), 1:250.000 (level4) and 1:500.000 (level5) scaled digital landscape models (DLM).

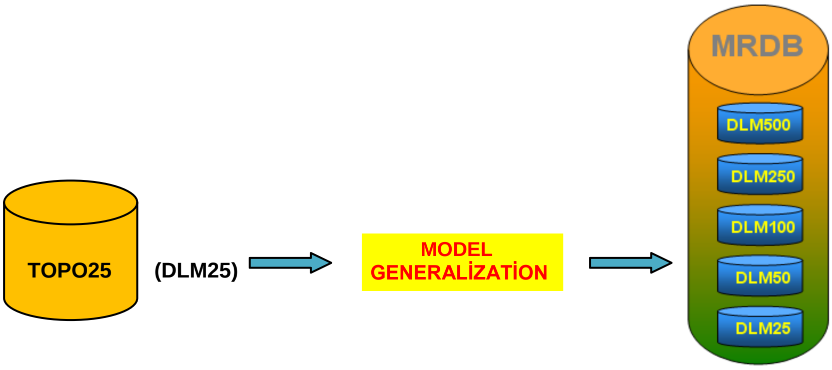


Figure 6) TOPO25 master database to MRDB.

Model generalization is controlled data reduction for various purposes. Data reduction may be desirable to save storage and increase the computational efficiency of analytical functions. Model generalization may further serve the purpose of deriving datasets of reduced accuracy and/or resolution. While model generalization may also be used as preprocessing step to cartographic generalization, it is important to note that it isn’t oriented towards graphical depiction, and thus involves no artistic, intuitive components (Başaraner, 2002). In this study, classification, simplification, aggregation, collapse, elimination and amalgamation processes was used as model generalization operators. The objects existing in population class was reclassified according to their geographic meanings and attributes thus new object classes were created. Some objects were eliminated from master level through level5. Some of these model generalization processes are seen below (Figure 7).

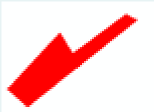
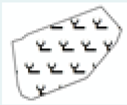
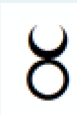
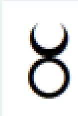
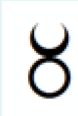
OBJECT	DLM25	DLM50	DLM100	DLM250	DLM500
Building (polygon)		If area <= 625 and max. segment length <= 50 then transform to point.	If area <= 2500 and max. segment length <= 100 then transform to point.	If area <= 15625 and max. segment length <= 125 then delete.	If area <= 60000 and max. segment length <= 250 then delete.
Building (point)				X	X
Cemetery (polygon)		If area <= 7000 then transform to point.	If area <= 28000 then transform to point.	X	X
Park (polygon)		If area <= 20000 then delete.	If area <= 80000 then delete.	X	X
Mosque (point)				X	X

Figure 7) Some model generalization processes.

The population class was considered as main class and 10 subclasses were created. Every object in population class was inserted into these 10 subclasses according to the geographic meanings and attributes of the objects. We produced unique identifiers with 16 characters containing country, agency and main class code (Figure 8).

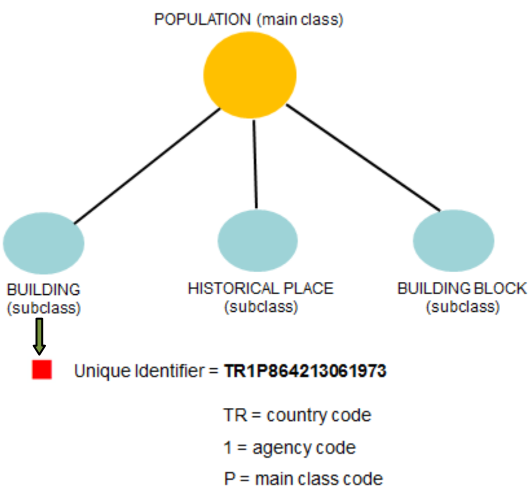


Figure 8) Some reclassified object classes and characteristics of our unique identifier.

Main goal of our study is designing an MRDB and propagating updates through different abstraction levels in an MRDB. The idea is to update only the lowest level with the highest geometric and semantic resolution and to update all other levels automatically. The update propagation should be understood as calling an appropriate generalization process for the linked object at the next level. We linked objects at different levels as table (Figure 9).

Unique ID of the object at DLM25	Unique ID of the object at DLM50	ID of the object class at DLM25	ID of the object class at DLM50
ID_DLM25	ID_DLM50	SOURCE_ID	TARGET_ID
TR1P948310765480	TR1P130197548039	1	4
TR1P980136448527	TR1P368201975038	1	4
TR1P301976524391	TR1P590176305842	1	4

Figure 9) Linked objects at different levels.

There are three changes on objects; create, delete and modify. When there is a change on an object, we record this change into a table immediately (Figure 10). At this change table, there are uniqe identifier of the changed object, the process defining the change type and identifier of the object class.

Unique ID of the changed object	Process code defining the change type. Example: 1=delete	Object class ID of the changed object
UID	PROCESS	OBJECT CLASS ID
TR1P130197548039	1	2
TR1P301976524391	1	2

Figure 10) Change table of the objects.

3. Conclusion

In this study, subject of updating the MRDB is depicted. Propagation of updating is important for national mapping agencies which are responsible to produce and update datasets at different scales. Today, matter in question is how MRDB is performed not the necessity of MRDB. In this paper we have described the structure of an MRDB system based on ESRI software and the possibility of propagating updates. For now we have no complete system implemented. We have implemented an MRDB system with five levels of detail. We have also implemented linking of the objects at different representation levels and recording changes on objects. Now, we are trying to implement an automatic update system including appropriate generalisation methods for the linked objects.

References

AdV (2004), “ Documentation on the Modelling of Geoinformation of Official Surveying and Mapping in Germany”, Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV), Bonn.

Başaraner, M., 2002. Model Generalization in GIS, International Symposium on GIS, 23-26 September 2002, Istanbul, Turkey.

Kilpelainen, T., 1995a. Requirements of a multiple representation database for topographical data with emphasis on incremental generalization, *Proceedings of the 17th International Cartographic Conference*, Barcelona, 2, 1815-1825.

Kilpelainen, T., 1995b. Updating multiple representation geodata bases by incremental generalization, *Geo - Informations - Systeme*, Jahrgang 8, Heft 4, Wichmann, pp. 13-18.

Kilpelainen, T., 1997. Multiple representation and generalization of geo-databases for topographic maps, *PhD Thesis,* Finnish Geodetic Institute, Finland.

Ordnance Survey (2011), “Policy Statement – OS MasterMap Topographic Identifiers – TOIDs”, 2011