Updating the Multiple Representation Database

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1. Introduction

Modeling and representing the real world at several scales for the different requirements are among the main goals of the cartography discipline. Therefore, generalization has been assessed as one of the priority research topics for the cartographers and the researchers who have involved in related disciplines and lots of studies have been carried out so far. Data providers are forced to construct one basic geographical database because of the high production costs, updating problems, and increasing needs for the geographical information and maps and produce other products from this database through generalization methods as much as possible. 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.

Although there is only one world, representing of this reality can change according to the purpose. So, different products can be formed to represent the same world entity for different purposes (Doğru, 2009). 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. In addition, integration and management of data at different levels has come out as a problem because of the increasing data volume day by day (Pavia, 1998). 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. Basically, scale is used for representation whereas resolution is used for database.

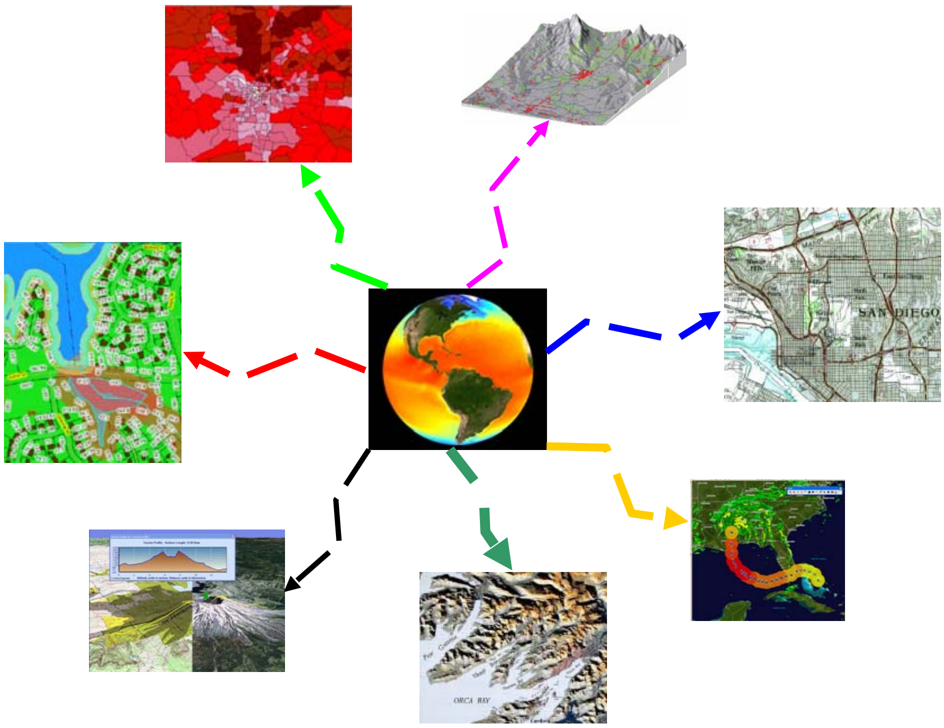


Figure 1) GIS applications. Various representations of the world for different purposes.

1.1 Historical Development of MRDB

Studies about MRDB have started in America at the end of the 1980 (Buttenfield and Delotto, 1989). In these studies, it was stated that databases for GIS must be able to support modifications across resolution levels. The studies about MRDB like modelling of MRDB, object oriented data model for MRDB, database design for multiscale GIS have been done in recent years (Kilpelainen, 1997). AGENT (1997-2000), MurMur (2000-2002), GiMoDig (2001-2004), Gemure (2002-2005) projects can be lately indicated as the multi national multiple representation projects.

1.2 Why Do We Need 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 worl 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.

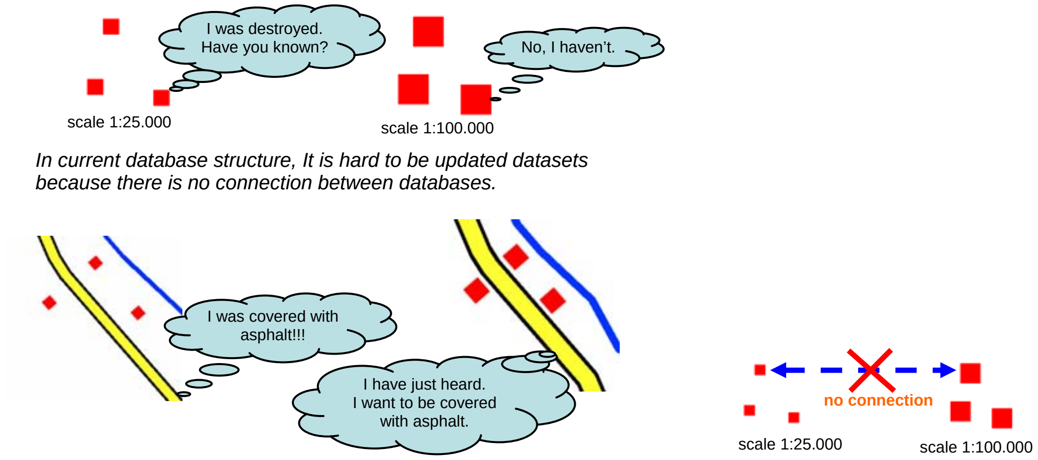


Figure 2) Unconnected objects at different scales.

1.3 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).

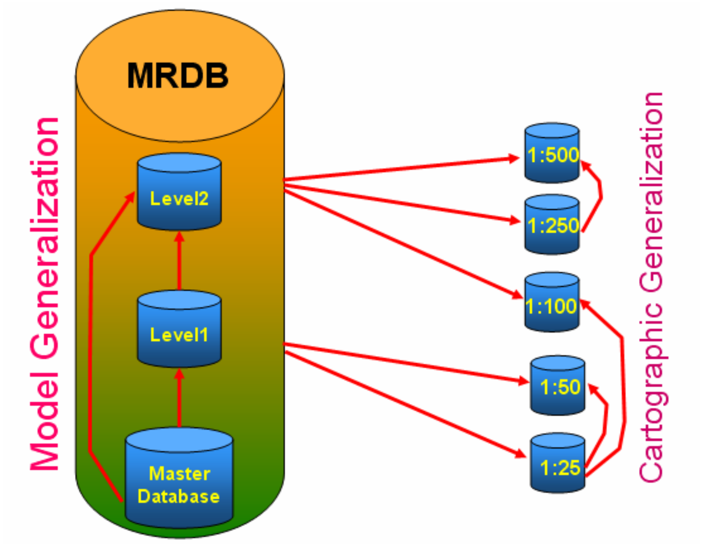


Figure 3) MRDB structure.

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.

Dunkars (2004) emphasized that representation levels in an MRDB could be derived from master level or previous level. Besides, relations between levels in an MRDB could be organized by object matching. Many studies have been done about matching of point, polygon and line objects (Volz, 2006; Olteanu, 2007a; Olteanu, 2007b; Mustiere and Devogele, 2008).

MRDB contains different levels of detail for various purposes. Every level includes representation of same data for different scale and purpose. The master level of the MRDB is the most accurate level and is rarely be visualized entirely. Geographical objects are available at the master level in maximum detail. Representation of an object changes from level to level. For instance, building may be represented with a complex polygon at the base level while next level the representation is a simple polygon, at the third level a point and at the fourth level a building is part of an aggregated area (Figure4). The number of the levels and complexity of the levels is an application dependent decision.

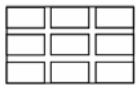
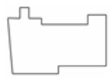
Representation Levels	***Geographic meaning***	***Reasoning processes***	***Cartographic representation***	***Geometric representation***
Level 4	*Built-up area*	*Aggregate buildings from level 3*		*Polygon*
Level 3	*Building*	*Replace the center point of the building at level 2 point symbol*		*Point*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

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. Kilpelainen proposed an approach called “incremental generalization” for propagating updates through different abstraction levels in an MRDB (Kilpelainen, 1995a; Kilpelainen, 1995b). The principle for incremental generalization was derived from software engineering (Ledgard, 1983). Representation levels in an MRDB are not enough for generalization and updating processes. In addition to representation levels, relation of these levels with each other must be defined (Figure5).

Figure 5) Relations between objects.

In many studies, it has been emphasized that design of MRDB should be done with object-oriented approach (Kilpelainen, 1997; Hardy, 2000; Dunkars, 2004). Various object-oriented geographic data models have been studied. In an object-oriented paradigm, real world entities are represented by objects which have defined properties and behaviours. A geographical object can be described as a package of spatial information, attributes describing the characteristics of the objects and operations that are descriptions of their manipulations. The behavior of the object can be realized by using methods, and the objects can communicate with each other by sending messages. Each object has a unique identifier.

2. Method

2.1 What is Model Generalization?

The main objective of model generalization is controlled data reduction for various purposes (Figure6). Data reduction may be desirable to save storage and increase the computational efficiency of analytical functions. It also speeds data transfer via communication networks. It may further serve the purpose of deriving datasets of reduced accuracy and/or resolution. This capability is particulary useful in the integration of datasets of differing resolution and accuracy as well as in the context of multi representation databases. While model generalization may also be used as a preprocessing step to cartographic generalization, it is important to note that it is not oriented towards graphical depiction, and thus involves no artistic, intuitive components (Başaraner, 2002).

(a) (b)

Figure 6) Examples of model generalization operators: (a) elimination, (b) amalgamation

2.2 Workflow

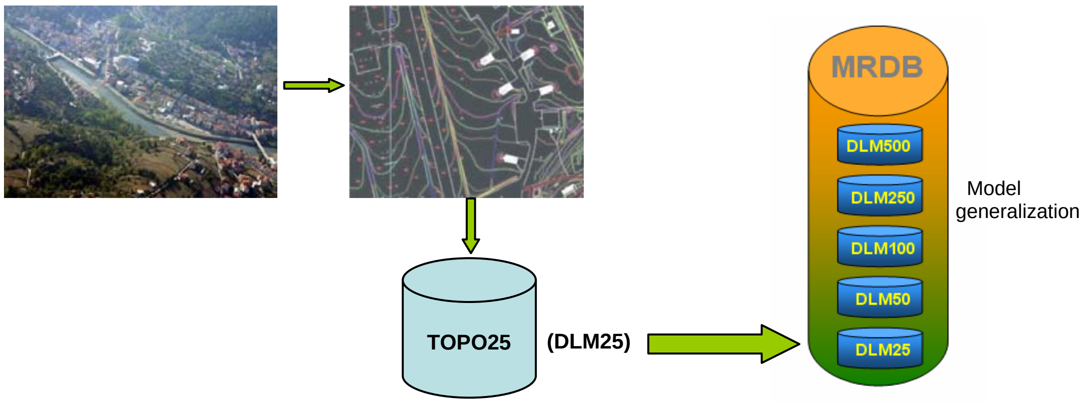
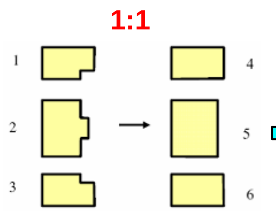
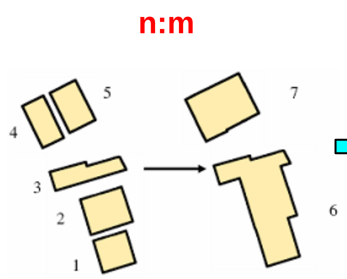


Figure 7) MRDB will be designed.

In this study, an MRDB including five different levels of detail will be designed. This MRDB will have 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). After conceptual model is produced, levels of detail will be derived by model generalization approach (Figure7). Links between levels will be stored as table information (Figure8). Finally, we will try to create case tools (delete, create, modify) to propagate updates from master level to other levels.



Master level objectID (1:25k)	Target level objectID (1:50k)
1	4
2	5
3	6



Master level objectID (1:25k)	Target level objectID (1:50k)
1	6
2	6
3	6
4	7
5	7

Figure 8) Links between MRDB levels in spatial and table representation.

In MRDB, every object must have identifier information to be able to describe the relation of the objects with each other at different levels. Especially in multiple representation database, 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. Figure 9 is represented how the objects behave at representation levels and figure 10 is represented how the propagation of updates is performed to the representation levels.

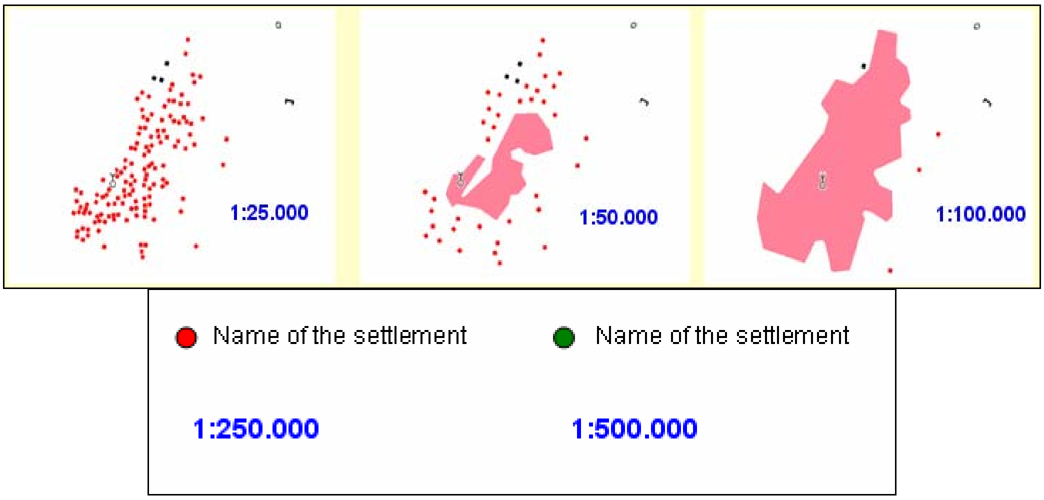
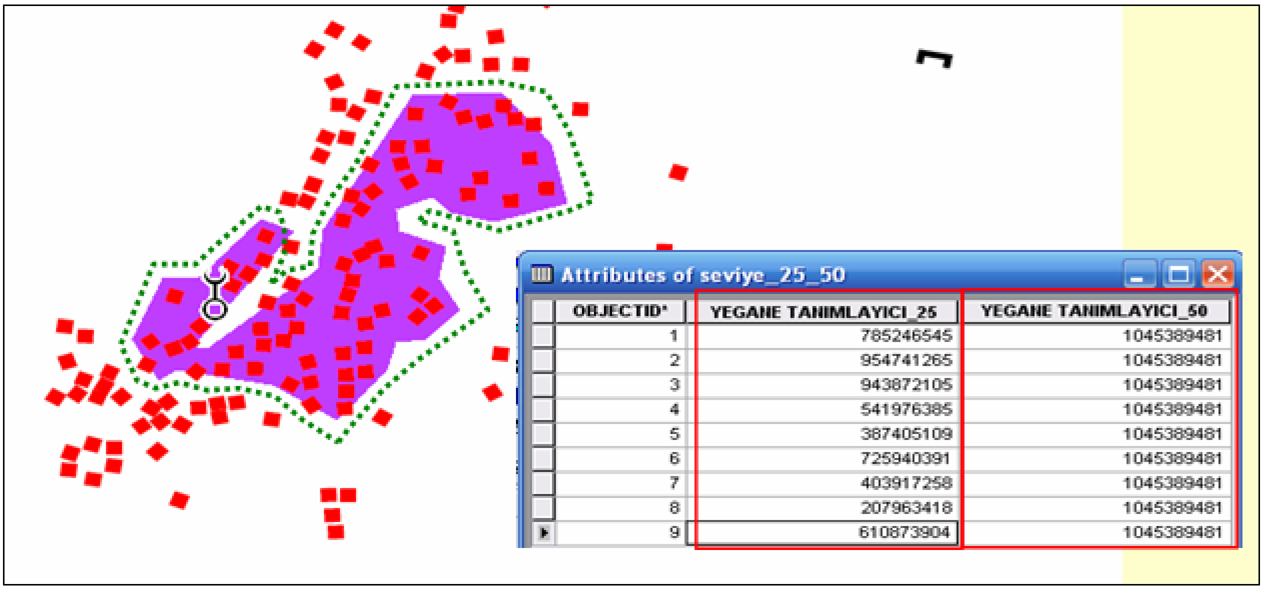


Figure 9) Object behaviours at representation levels.



OBJECTID*	YEGANE TANIMLAYICI_25	YEGANE TANIMLAYICI_50
1	785246545	1045389481
2	954741265	1045389481
3	943872105	1045389481
4	541976385	1045389481
5	387405109	1045389481
6	725940391	1045389481
7	403917258	1045389481
8	207963418	1045389481
9	610873904	1045389481

Figure 10) Propagation of updates.

In addition to the example relation table in figure 10, there will be another tables fallowing the changes on objects. In these tables, changes (delete, modify, create) on objects will be saved as soon as object change. Propagation of updates is going to be performed by means of these tables.

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 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 have been continuied in Turkey in a matter of years. In this study, we will try to organize the different scaled datasets with MRDB approach and find solutions to propagate updates.

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