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Dynamic geoinformatic models

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Abstract

In geoinformatics consecutive transition from creation of planar models to space ones, from creation of static models to dynamic ones with the use of dynamic visualizations tools and technologies, animations and virtual reality is apparent. The approach to creation and update of geoinformatic models issues from the principles and approaches of digital technologies. Geoinformatic modelling must be viewed as a system problem. Dynamic models can be used in many areas. Dynamical modelling means an innovative approach and technology. In this paper are mentioned technologies which must be accepted during creation of geoinformatic models. Key problem is that of data organization in correspondence with requirement to visualization-invariant models. Not only GIS systems are available to create dynamic models or dynamic visualizations. In many cases the professional graphic and CAD systems must be used to create professional dynamic visualization and animation of geoinformatic model.

Key words: geoinformatic model, dynamic model, animation, virtual reality, digital technologies

1. Introduction

In geoinformatics and cartography consecutive transition from creation of planar models to space ones, from creation of static models to dynamic ones with the use of dynamic visualizations tools and technologies, animations and virtual reality (both for presentation and use) is apparent. Thereby models gain further dimensions which can be used both in the area of models creation as well as in the area of their use and applications.

The approach to creation and update of geoinformatic models issues from the principles and approaches of digital technologies. In addition geoinformatic modelling must be viewed as a system problem. From this viewpoint, modelling is decomposed into separate informatic and functional systems: data acquisition, data organization, data generalization and data visualization. Data organization is the key problem in modelling. Using the object oriented approach in the process of creation of geoinformatic model, potential for dynamic modelling is apparent.

Dynamic models can be used in many areas. Dynamical modelling means an innovative approach and technology that can free data visualization from the expediency of static images and afford thorough cartographic treatments of geography and earth science.

Static map is but one of many cartographic views of the same phenomenon or data set. The static nature of the paper map was the limiting factor in improving the human interface with maps. The computer is often used to create maps on paper – maps that duplicate in exacting detail the limitations of the printed map. For cartography and geoinformatics the computer medium presents the potential of interaction and animation.

Unlike a paper maps, a map on the computer screen can dynamically change in response to various interactive operations. It is possible to design such operations that enhance the expressiveness of the map and thus significantly promote data exploration. Interactive and animated cartography is based on a conception of the computer as a medium form communication, not only as a tool to store and manipulate data that will be printed as a map.

Animation helps to demonstrate that individual maps are only a snap shot in time but also in terms of how the data is represented, in the choice of the representational forms that are used to depict the world. If the time is viewed as an animation, if a map is viewed along with other related data sets, some temporal and non temporal trends would be evident. Dynamic mapping capabilities provide enormous potential for spatial data visualizing.

2. Modelling and models

Geoinformatic model is an abstraction of the world. Some features are omitted while others are exaggerated in correspondence with purpose of modelling.

The approach to creation and update of geoinformatic models issues from the principles and approaches of digital technologies. In addition geoinformatic modelling must be viewed as a system problem. From this viewpoint, modelling is decomposed into separate informatic and functional systems: data acquisition, data organization, data generalization and data visualization. Data organization is the key problem in modelling. Using the object oriented approach in the process of creation of geoinformatic model, potential for dynamic modelling is apparent.

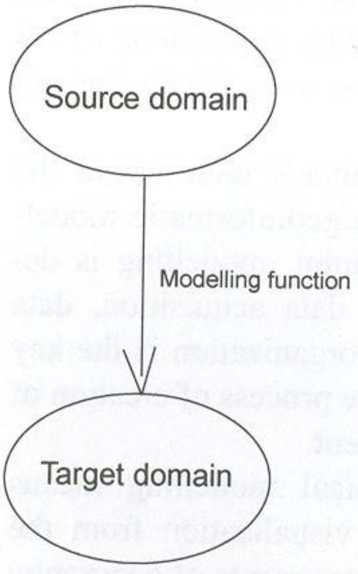
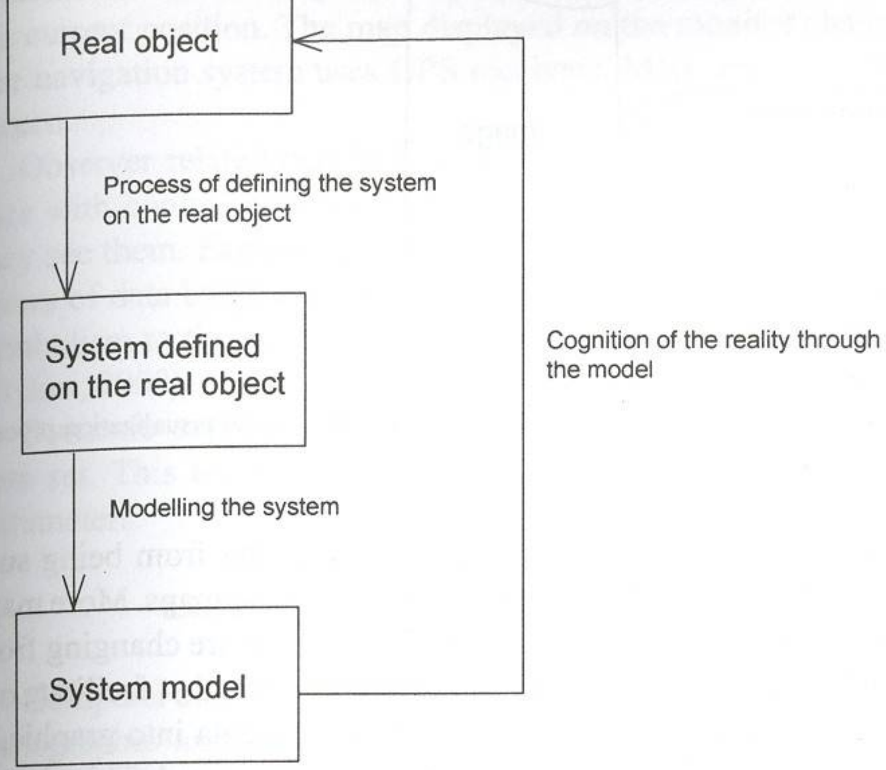


Fig. 1 Modelling function

With use of object oriented approach in the process of creation of geoinformatic models, we can use object's dynamics and create dynamic model. A key concept of object orientation is that of methods defined on objects. The methods are bound to behaviours. The dynamic, behavioural side of an object is expressed as a set of operations that the object will perform under appropriate conditions.

The purpose of the model is to simplify and abstract from the source domain. The constituents of the source domain are translated by model into the target domain and viewed and analyzed in tis new context (Fig. 1). Modelling process from real object to system model is illustrated on Figure 2 and the process of data modelling on Figure 3.

Fig. 2 Modelling process (Veverka,1987)



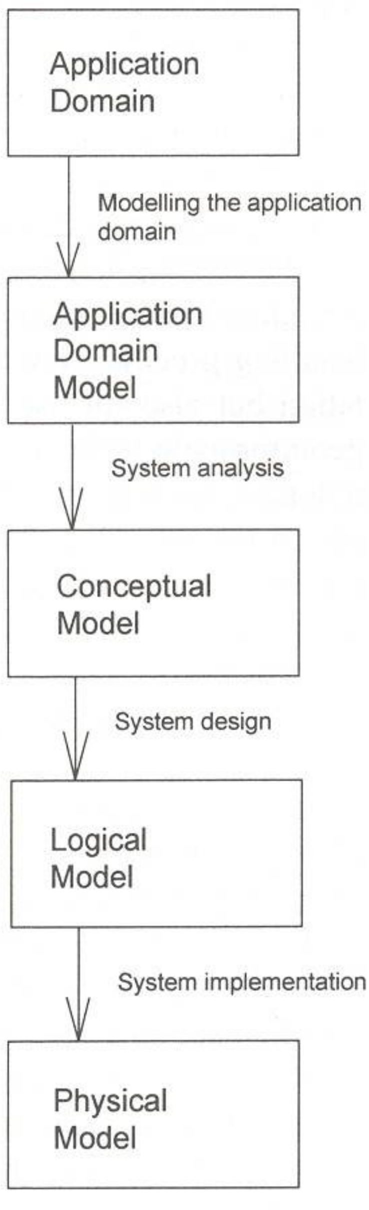


Fig. 3 Data modelling (Worboys, 1995)

3. Dynamic models and dynamic visualizations

Dynamic models can be used in many areas. Dynamical modelling means an innovative approach and technology that can free data visualization from the expediency of static images and afford thorough cartographic treatments of geography and earth science. Dynamic modelling issues from the principles and approaches of system modelling (Figs. 1–3).

Static map is but one of many cartographic views of the same phenomenon or data set. The static nature of the paper map was the limiting factor in improving the human interface with maps. Worst of all, the computer continued to be used to create maps on paper – maps that duplicated in exacting detail the limitations of the hand-drawn printed map. The computer's potential for interaction and animation was essentially ignored. For cartography the computer medium presents the potential of interaction and animation.

Interactive and animated cartography is based on a conception of the computer as a medium form communication, not as a tool to store and manipulate data that will be printed as a map. (Peterson, 1995).

The visualization process is considered to be the translation or conversion of spatial data from a database into

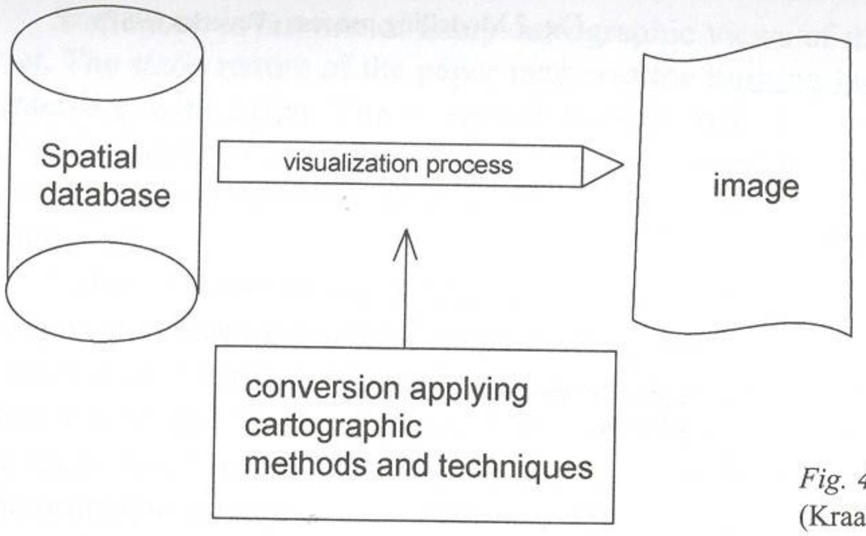


Fig. 4 cartographic visualization process (Kraak, 1995)

graphic (Fig. 4). The cartographic visualization process is changing from being supply-driven to demand-driven. More people will be involved in making maps. More maps will be created, many of them only for a single purpose. These maps are changing from being final products presenting spatial information to interim products that facilitate our visual thinking. To be able to execute the translation from spatial data into graphic, it is assumed that data are available and that the database is well structured. This should ensure that the data can respond to all the queries required to the application field for which the database has been designed (Kraak, 1998).

The visualization process can vary greatly depending on the purpose for which it is intended. Visualizations can be, and are, created during any phase of the spatial data handling process. New media and technologies not only allow for dynamic presentation but also for user interaction. New technologies in informatics influence also geoinformatic technologies. Computer graphic and visualization tools, internet technologies, animation and virtual reality have impact to geoinformatic modelling and possibilities for geoinformatic and cartographic visualizations. Dynamic visualizations that provide more than a single static view of a spatial data set, those which vary in some way over time, are increasingly common and becoming ever easier to produce.

3.1. Interactive visualization

Interactive cartography also promises a renewed appreciation of geography. Geography arranges world in one-dimensional sentences and it is seldom adequate for describing and explaining phenomena that occur in a three-dimensional space and evolved over time (Peterson, 1995).

The interactive maps consist of map user, a computer, a pointing device and a graphic user interface designed for the display and analysis of map (Peterson, 1995). In literature map interaction used to be divided into three categories: electronic atlases, maps for navigation and data analysis. Electronic atlases attempt to combine multimedia techniques with display of maps. Programs for way finding, called personal navigation, are another example of interactive mapping. This type of software finds the shortest distance between two locations and then displays the best route on a map. Other interactive maps combine an electronic atlas with route finding. Car navigation systems include a computer display of a road map and a moving symbol indicating the current position. The map displayed on the monitor changes as the vehicle moves. Car navigation system uses GPS receivers. Maps are used directly from the computer screen.

Observer related map behaviour has a wide variety of applications, providing the user with control over what aspects of spatial data set they see, and how and when they see them. Each of observer-related techniques involves interaction with dynamic views of data by identifying cases in a single o multiple views and applying transient symbolism to the graphic that represent them to show some characteristic of the case (Dykes, 2000).

Dynamic expression involves alternating more than one graphical version of a data set. This technique include the interactive modification of cartographic display parameters.

3.2. Animations

Computer animation offers new potentialities in sphere of presence and visualization cartographic and geoinformatic data. Computer animations have become relatively common.

Animation helps to demonstrate that individual maps are only a snap shot in time. What trends would be evident if the time element could be wiewed as an animation? The individual map is a snap shot not only in time but also in terms of how the data is represented. What non temporal trends would be evident if a map were viewed along with other related data sets? The individual map is a snap shot in the choice of the representational forms that are used to depict the world. A series of maps with different symbols or data classifications can also constitute an animation. (Peterson, 1995)

Computer animation accepts principles of computer graphics. The basic idea of animation is the quick sequential visualization of images with small differences for illusion of changes and movement generation.

The animated map is a series of individual maps that are shown in quick succession for the purpose of depicting some type of trend or change. Its interpretation is based on the human sensitivity to detect movement or change in a display. The objective of cartographic animation is to visualize a phenomenon that would not be apparent if the maps were viewed individually.

Animation may be viewed as one of the defining characteristics of cartographic visualization, which may itself be viewed as a further manifestation of a general research direction in cartographic communication. A basic distinction is made in cartography between temporal and non-temporal cartographic animation. Temporal animations are limited to the display of change over time. Non-temporal cartographic animations depict changes caused by some other variable, and may include viewing temporal data in a non-temporal way, depicting different but related spatial data sets, or showing data with different levels of generalization. This latter form of animation is particularly important because it can be used to depict the cartographic process and thereby convey both a data set and the transformations that have been made for its display (Peterson, 1996).

In cartography a major distinction is made between temporal and non-temporal animation. Most cartographic animations that are created are temporal animations and depict change over time.

In non-temporal animation, there is a change in the objects and phenomena relative to factors other than time. These can be also such factors as a change in the position of the "camera" or light source, or some other non-temporal variable. Time, however, is an aspect of every animation.

Peterson (1996) identifies two general forms of non-temporal cartographic animation:

1) A change in the representation of the data that is being animated (cartographic zoom, classification animation, generalization animation, etc.), and
2) a change in the data that is being shown.
   Animations that depict a change in the data (2) can be further categorized by animations that
   2a) depict events that happen in time in a non-temporal way (reordering, pacing, etc.), and
   2b) depict data that are not related in time (fly-through, graphic zoom, etc.).

It is important to note that the two forms of animation can be combined in a single animation.

Characteristics of chosen types of animations (after Peterson, 1996):

Reordering: The order of scenes in a time-series animation is usually from beginning to end. Reordering involves the presentation of the scenes in a different order, usually according to an attribute.

Pacing: Pacing refers to varying the duration of scenes.

Fly-through: Probably the most widely used non-temporal animation in cartography. A large number of oblique views are then constructed to simulate flying through a terrain.

Graphic zoom: Similar to the fly-through, the zoom changes the position of the map viewer relative to the objects being viewed. Like zooming into a photograph, features become larger but there is no change in the detail that is shown.

Cartographic zoom: On maps of different scale, a decrease in scale is accompanied by a decrease in detail. The removal of featues for the smaller scale map is called selection. The removal of detail from a line such as a coastline or a river is called simplification. A normal graphic zoom does not add extra information; it simply enlarges the display. A true cartographic zoom adds extra detail to the maps at each stage in the animation process and ultimately involves all aspects of the cartographic abstraction process.

Classification animation: Here each frame of the animation depicts a different classification scheme.

Generalization animation: Depicts changes caused by different numbers of classes.

3.3. Virtual reality (VR)

Virtual reality is step beyond visualization. It is a simulation that includes the ability to control the display.The virtual reality application has to display scenes in the real time with quick response on the user activity. The scene and also included objects has three dimensions or they at least compile spatial illusion. The user does not examine the scene only outside, but he has possibility to enter inside and move over the various tracks.

Application of VR is program where following characteristics are aparent:

- VR is working in real time, it is able to react to user's interaction.
- Virtual world with its object has character of 3D graphic. It must create the best illusion.
- User can enter the scene, go through it along different ways. User is not limited to look at scene from the outside.
- Scene is not static, user can manipulate with object.

Advantage of VR is clear in working with spatial (3D) models. The view of the model is closer to reality. In the future this way of presentation of cartographic and geoinformatic models will be common. Virtual reality through VRML language is effective tool for data presentation. VRML language defines the way of description of virtual worlds in text format. It can be used both in internet and local systems.

4. Approaches to creation of dynamic models

Data organization is the key problem in modeling. There is the field for use of XML technologies in creation of the data model. Visualization of models can be solved also through the XML technologies – in particular the transformation between XML documents – and converted into VML or SVG formats, XML coded graphic with potentiality for animations. Visualization of 3D models and animation can be described and realized through VRML. XML and XML-coded graphic can be included in HTML documents, VRML can be easy connected with HTML language too. Visualizations and animations can be realized in systems of graphic used in other application area. For creation professional visualizations and animations, it is necessary to use some professional graphic systems with functionality needed for solving tasks of visualizations and animations.

The software systems used in creation of animations presented was 3D Studio Max, ArcGIS and MicroStation. These systems also enables export to VRML language for virtual reality on Internet.

5. Conclusion

Dynamical modeling means an innovative approach and technology in cartography and geoinformatics. Object oriented approach to system modelling with the use of capability of the object to store its own behaviour can be used in dynamic modelling.

This approach is reflected in further technologies used in computer graphic and internet. Technologies based on XML and VRML are only one of many examples. Dynamic mapping capabilities provide potential for spatial data visualizing.

In this paper was mentioned technologies which must be accepted during creation of geoinformatic models. System approach to analysis and design of system model and digital technologies of data acquisition, data organization, data generalization and data visualization are used in geoinformatic models creation. Key problem is that of data organization in correspondence with requirement to visualization-invariant models. The visualization-invariant model created can be implemented to particular software system to visualize, animate, analyze. Not only GIS systems are available to create dynamic models or dynamic visualizations. In many cases the professional graphic and CAD systems must be used to create professional dynamic visualization and animation of geoinformatic model.

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