GeoTime 2.0: a Network Geoinformation Technology for Exploration of Spatiotemporal Processes

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INTRODUCTION

GIS GeoTime (version 2.0 http://www.geo.iitp.ru/geotime/all.htm) develops the ideas of the former desktop version (Gitis, 1994a; Gitis, 1994b). It is oriented on visual representation, simulation and forecasting of spatiotemporal processes which are described by the models with local interaction. There are many natural and technogenic processes corresponding to these models, such as seismotectonic interactions, propagation of a surface flow and pollution distribution, preparation of natural disasters and some of the social and economic processes.

Problem orientation of the system concerns three directions: detection of earthquake precursors and earthquake prediction research, seismotectonic zonation based on the dynamic properties of the geological environment and simulation of spatiotemporal processes.

We outline basic principles of the system and consider three examples of application.

GEOTIME

GIS GeoTime 2.0 is implemented as a Java application loaded via Java Web Start. It can integrate dynamically loaded data and plug-ins distributed on network servers as well as on a user computer. The system supports the parallel multithreaded data processing on multiprocessor/multicore systems.

GIS GeoTime 2.0 consists of the *data storage*, *data processing* and *visualization* subsystems (Fig.1).

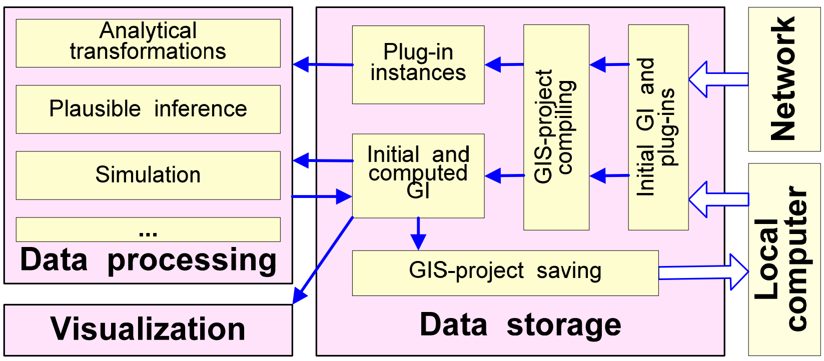


Figure 1: GIS GeoTime 2.0 diagram.

The part *Initial and computed GI* is responsible for storing the 2D, 3D and 4D grid-based and vector data. *GIS-project compiling* interprets configuration metadata XML-file of the project and supports dynamical downloading of the data and plug-ins. The *visualization* subsystem supports interactive visualization management of 2D, 3D, and 4D grid-based and vector layers, animated representation of 3D and 4D vector and grid-based layers as dynamical sequences of frames in standard 2D projections (Fig. 2), measurements of the grid-based values etc.

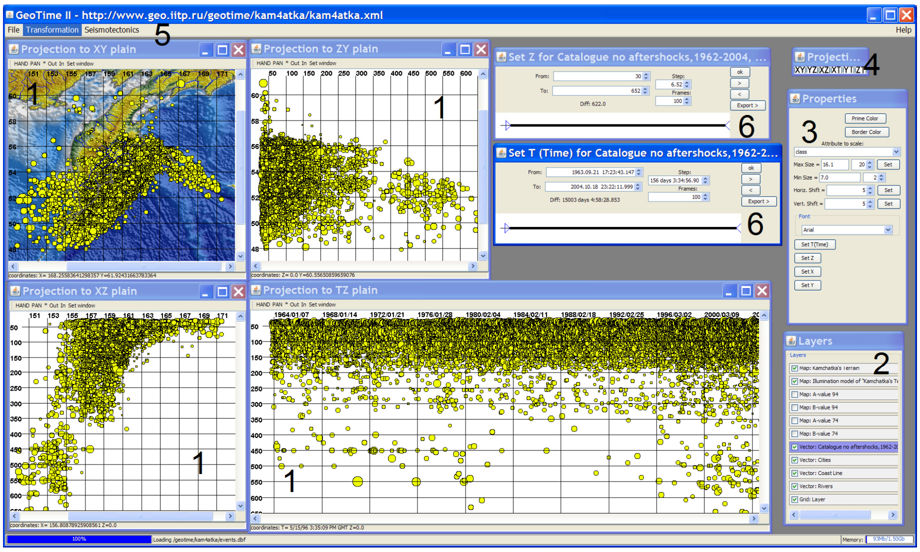


Figure 2: Representation of Kamchatka 4D earthquake catalogue: 1 are earthquakes in projections XY, XZ, YZ, ZT, where X is longitude, Y is latitude, Z is depth, T is time; 2 is the layer window; 3 is the attribute window; 4 is the panel of the plane projections; 5 is the operation management panel; 6 are the windows of animated visualization management.

Data processing subsystem allows estimating properties of spatiotemporal data in the form of 2D, 3D, 4D grid-based layers, *analyzing* and detecting the anomalies preceding the earthquakes. Consider an example of spatiotemporal anomaly that precedes the Tangshan earthquake 28.07.1976, M=7.9. Initial data are 10 time series. The time series are transformed in 3D grid-based layer, in which the earthquake precursor is detected by the use of statistic testing method. Besides the earthquake precursor there are the regional seasonal anomalies visible on XT and YT planes.

Let us consider two GeoTime plug-ins.

Earthquake clustering plug-in is applied to seismic flow research. Formation of earthquake clusters in seismic flow is explained by unstable-avalanche fault forming model (IPE Model) (Sobolev, 1993). The model supposes that preparation of a strong earthquake is attended with the clusters of dependent events specifying an area of creation of expected big earth crust rupture. Therefore the clusters of earthquakes can be used for earthquake prediction.

Applying the plug-in for Kamchatka and Central Asia regions allows finding one of the peculiarities of seismic process. The dependence between a number of clusters and a number of events in clusters (size of the cluster) for Kamchatka Region is shown on Fig. 4. The dependence is bilogarithmic:

$$\lg N(n) = u - v \lg n ,$$

where n is the size of cluster, $N(n)$ is a number of cluster with size n. For original catalogue coefficient of incline v_e=3.98 is smaller than for artificial v_r=10.42. It is clear that a number of clusters in real seismic flow is noticeably bigger than a number of clusters in artificial Poisson flow with same seismic activity. The dependency confirms IPE model and this result can be used in investigation on seismic flow cluster and on earthquake prediction research.

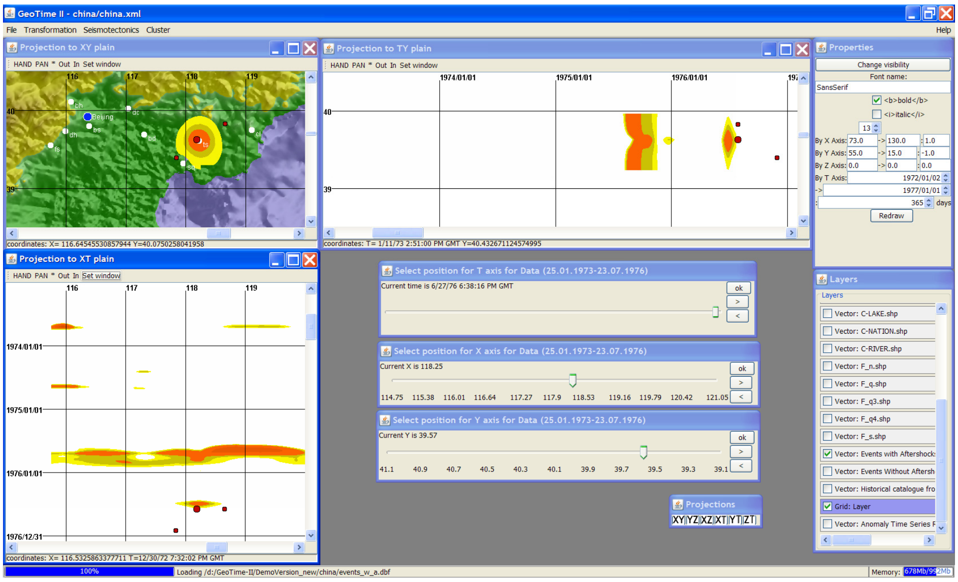


Figure 3: The pattern of Tangshan earthquake precursor. White circles are geomonitoring stations. Red circles are earthquakes with $M \geq 6.8$.

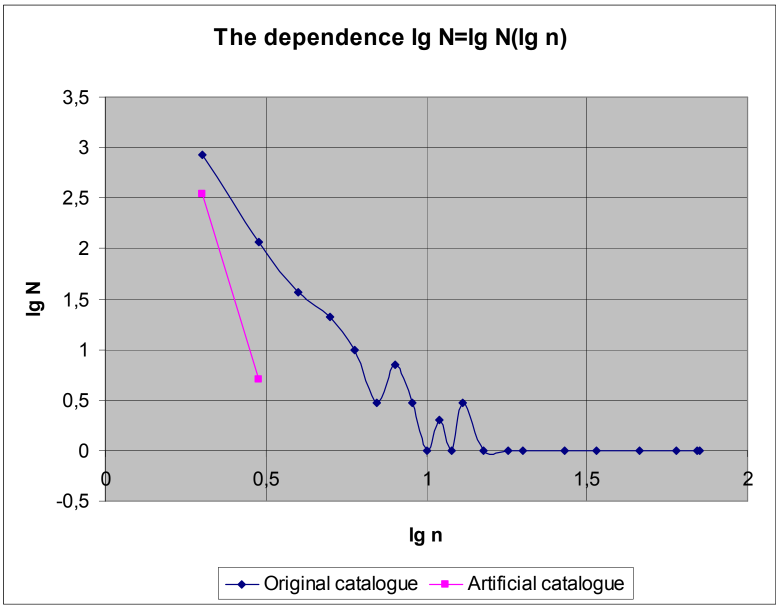
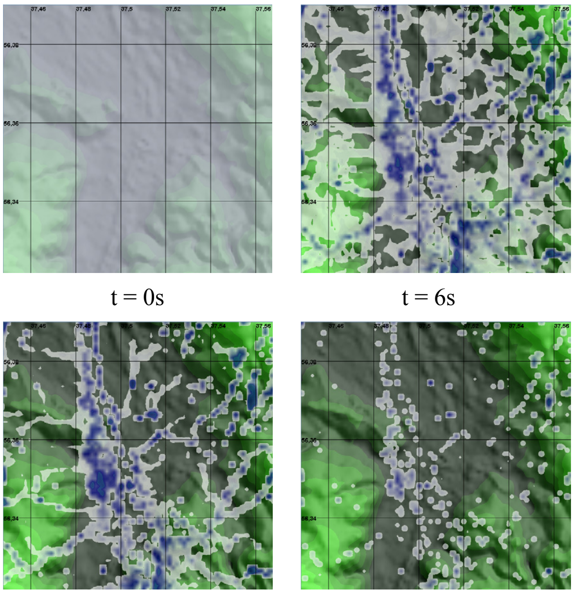


Figure 4: The dependence between a number of clusters and cluster size for Kamchatka Region.

The second plug-in performs the simulation of a surface flow. Nowadays in geo-hydrology there are highly developed empirical methods of calculation of integral index that refers to the water flowing from the territory being examined and falling into a river within a month for example. However, these methods are not able to estimate how much water ran through the local part of the territory being examined, how much water infiltrated there and where the water accumulated. Our model is based on generalization of the solution for the problem of viscous liquid layer movement on inclined plane (Landau, 1988) to case of an arbitrary relief.

The plug-in was used for simulating the surface flow in the Dmitrov district of Moscow region. As input data we used the initial uniform layer of liquid 20cm high. Results of the simulation are presented on Fig.5 and Fig.6.



t = 0s t = 6s

t = 24s t = 192s

Figure 5: Water layer height dynamics over the relief as background.

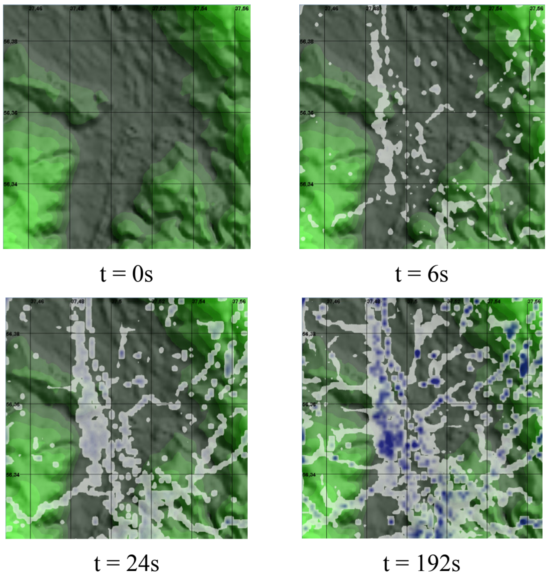


Figure 6: Infiltered water dynamics over the relief as background.

CONCLUSION

GIS GeoTime 2.0 is intended for geoinformational research of spatiotemporal processes which supports a solution of sophisticated fundamental and applied problems in a subject domain field. It is possible to mark the following GeoTime 2.0 peculiarities: implementation on the basis of Java Web Start technology, integration of the data and plug-ins distributed on network servers as well as on a user computer, support of parallel multithreaded data processing on multiprocessor/multicore systems. Testing of the system on real tasks, such as exploration and detection of earthquake precursors, distribution of a surface water flow and pollution, analysis of natural catastrophe preparation etc. manifested high efficiency of the system.

ACKNOWLEDGEMENTS

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