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Virtual reality of water management in a big town

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ABSTRACT

This paper describes the development and the functions of a virtual reality tool (VRT) for the hydraulics simulation executed on high-performance computing infrastructure. The simulation process collaborates with the geographic information system environment in order to correct and prepare input data and visualize the simulation output. In Slovakia, we are using the system EPANET for the execution process of hydraulics simulation. We are able to port all the execution and simulation processes together with the EPANET system on high-performance computing infrastructure. All the execution results in the storage are visualized by the VRT. The paper describes the developed modules and its functionality.

Keywords: Virtual reality; Water management; Hydraulics simulation; High-performance computing infrastructure

1. Introduction

There are several problems with water losses, water flow, quality of water, water pressure in big town as is also Bratislava. For example relationships between distribution of available water resources that determine hydrogeological attributes of the town Bratislava, water service in concrete region. Therefore, several problems and questions its ensue. It is, for example, transport water over a long distance which is usually in big town and water pressure in big buildings or water flow in pipes. The analysis and calculations are necessary and technical and safety measures and investment spending too.

Water losses, water pressure, water flow are significant factors, which affects inefficient exploitation of quality water sources. Lot of cities have begun investing in new one technologies, which will help them better manage their water resources. New one technologies, sensors, data analystics, software can help. Important indicators of evaluation of water supply are not only financial indicators but also technical indicators; technical indicators characterize some technical condition of water pipelines, fault liability and with these related water losses [1].

Presented paper is focused on water consumption modelling and prediction, which could be applied in several tasks, for example, in hydrological scheduling system. To perform virtual reality visualization for water management in a big town is very challenging. The objective of our project is to develop a three-dimensional (3D) visualization system using the DHI Slovakia (Computer Related Service Companies – Bratislava – Slovakia) service. One area of water management involves handling the water in the natural environment and periodic simulation. Modem methods of benchmarking are starting to be used for the objective of evaluation of water supply level, these methods provide relative comparison of attained results of water companies. Possibilities for improvement of companies were created by comparison of selected indicators. Such way we can define situation of company considering other similar companies.

Management of water company needs to obtain information about selected indicators to can apply benchmarking methods. For that purpose benchmarking centres are starting

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to institute in the world. In this paper a new approach of evaluation of water losses indicators from point of view operator of water supply. There is described benchmarking method which can be used for evaluation of water supply systems oriented for water losses. This article presents results of evaluation of water supply systems in Slovakia [2].

For this, we adopted the EPANET system [4] which is a public domain software that models water distribution piping systems. EPANET performs extended periodic simulation of the water movement and quality behavior within pressurized pipe networks. The pipe networks consist of pipes, nodes (junctions), pumps, valves, and storage tanks or reservoirs. The package tracks contents, for example, the pressure at each node, the height of the water in each tank, the type of chemical concentration throughout the network during a simulation period, water age, source, and tracing.

Mathematical representation of the water supply network is the input for our simulation process [3]. The input data are stored in a text file which are organized in sections. Outputs are the simulation results that are written also to a text file. Simulation that we carried out took place both on the local clusters, then to the grid infrastructure, the EGI Federated Cloud in Slovakia.

The limitation of the EPANET display is that it only shown the results in a two-dimensional (2D) coordinate system. To overcome the problem, we designed a large 3D digital terrain model for the capital of Slovakia - Bratislava and its surroundings.

Visualization of large 3D model can be difficult. After study, we found that we can adopt some existing publicly available tools such as ArcGIS [5] and tune our tool to provide input for it. The ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications. It has a 3D analysis tool called ArcScene which is an application that displays and navigates data in 3D. Along this line, a 3D visualization tool has also been designed and developed to prepare the data for using the ArcScene tool. The calculations and simulations of the scenes are carried out by adopted EPANET. The animation is created by our 3D tool for displaying and working in the environment of ArcScene in the ArcGIS system.

2. Virtual reality tool

Our virtual reality tool is composed of five modules. Each module can work separately as an independent tool with functions as is receiving the third-dimension coordinates, creating 3D terrain, covering terrain by the ortho-photomaps, display the water pipe system, virtual reality of research results. Modules can work with other modules together as an integrated tool. In the ArcGIS environment from different shapefiles type (.dgn), thus obtained the thirds coordinate we have been able to receive the thirds coordinate. We have developed the module which converts 2D to 3D coordinate. We have obtained 3D data of water network, nodes, water towers, etc. Using these 3D data, we created a 3D surface, triangular irregular networks (TIN) surface. All data measured in the same water geothermal system. ArcGIS system allows you to display 2D data created TIN so that this data is associated with the third coordinate so that it loads from the surface.

It means that environment that provides sufficient information for 3D calculations and simulations in water management required to design a 3D virtual reality terrains of Bratislava. Module for receiving the thirds coordinate has converted 2D coordinates to 3D. When we obtained the thirds coordinate, we have been able to develop the substantial terrain TIN – 3D surface of Bratislava town terrain (Fig. 1).

On the resulting 3D terrain model, it is possible to plan the ortho-photomap (Fig. 2). The ortho-photomap we have

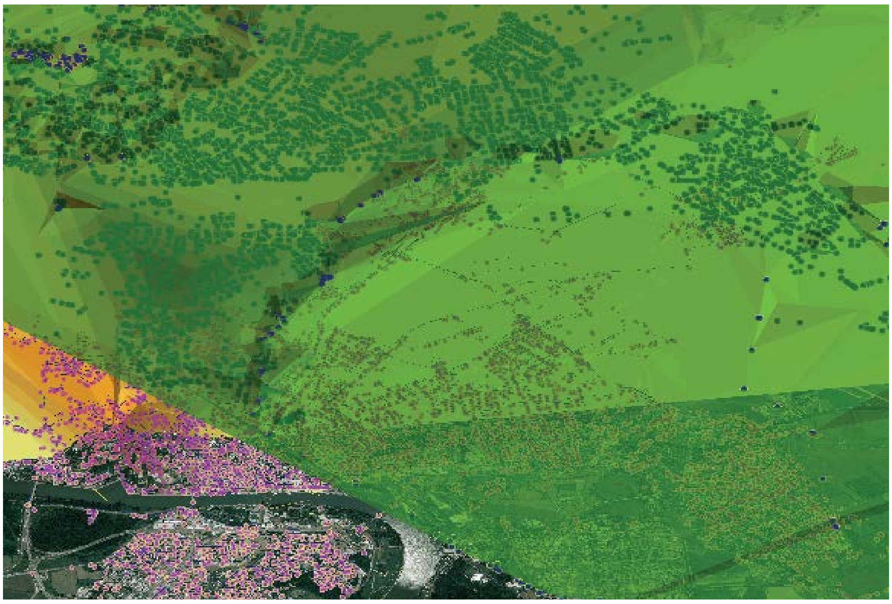


Fig. 1. 3D terrain model of town Bratislava and surrounding.

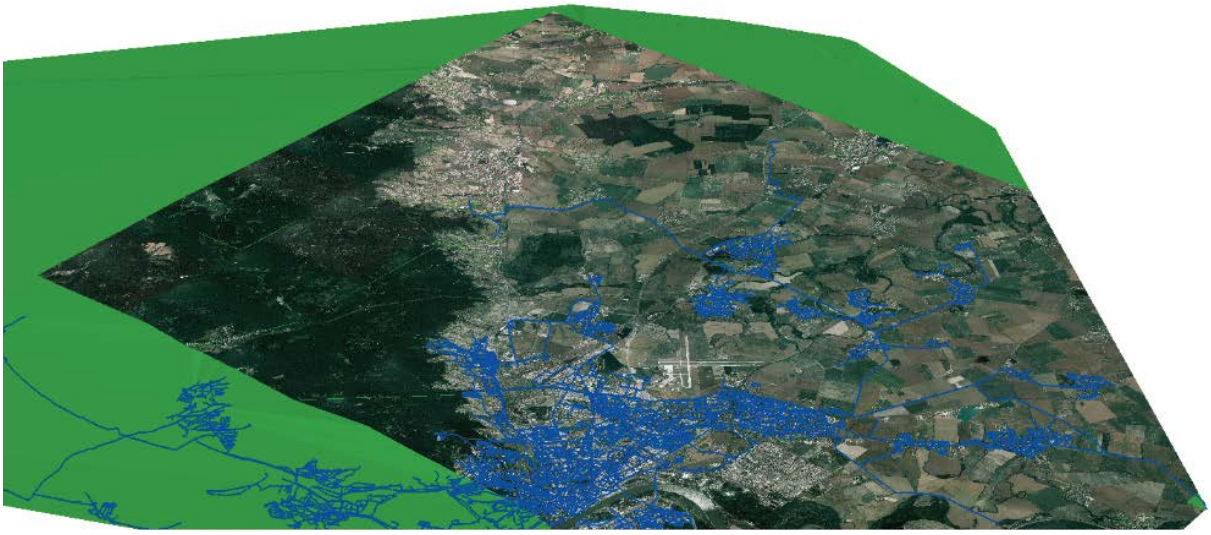


Fig. 2. 3D terrain model cover by ortho-photomap.

obtained was at a scale 25 m × 25 m. We have cut the terrain in the same parts. Each part of terrain we have covered by the appropriate part of the ortho-photomap. Once again, we have taken advantage of the capabilities of ArcGIS in the sense that when we covered part of the 3D terrain with the 2D ortho-photomap, again were the coordinates of ortho-photomap converted to 3D. The water supply pipes, water towers and 3D view nodes are second part of 3D digital environment of water management. We past the water system on the terrain prepared by us by the same

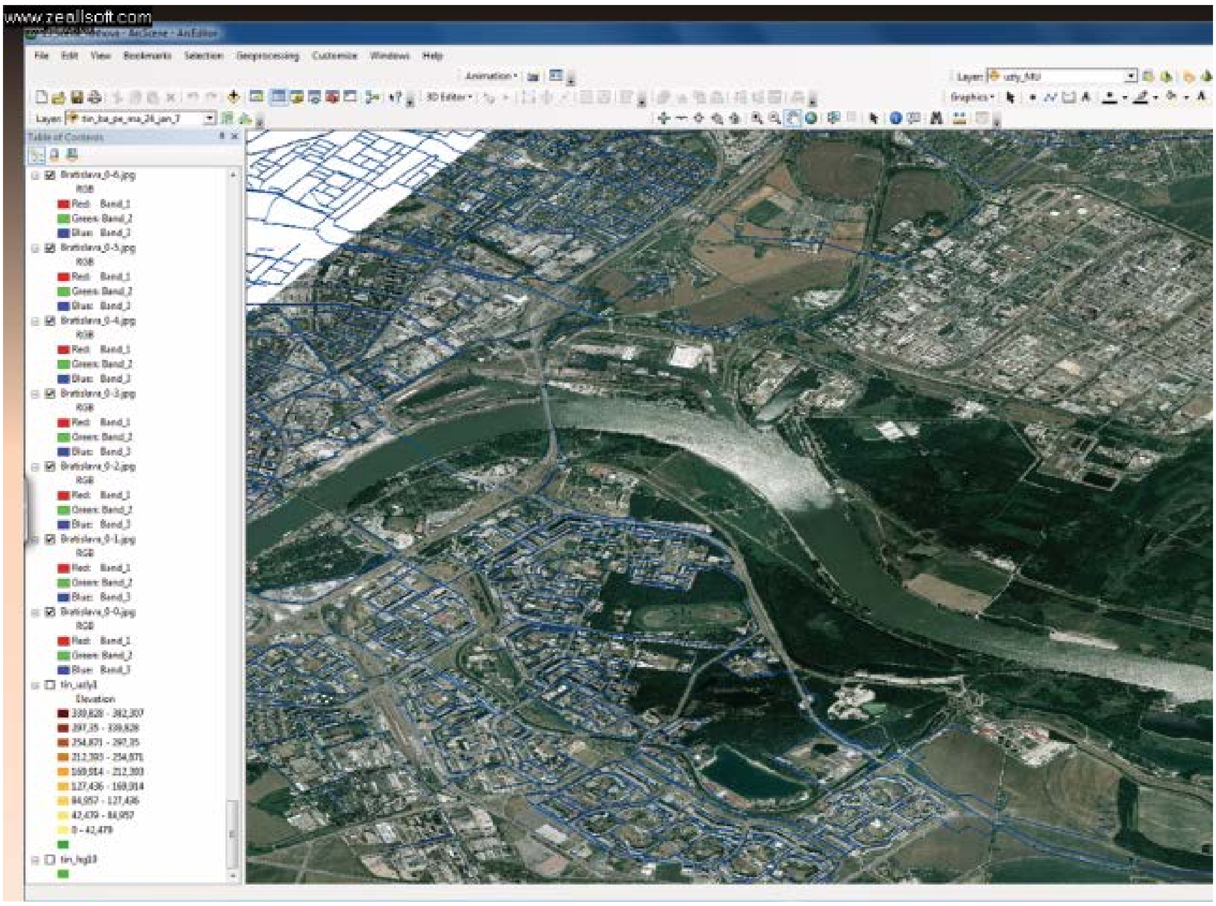


Fig. 3. 3D model with water pipes system.

system. Based on the knowledge of the water supply network, we know that it is located 2 m under the ground. We also have information about water pipes, nodes and so on. Water pipes are located 2 m under the ground. We are able to show it 2 m higher on the surface of the terrain for that reason than we want to see simulations process inside of water pipes. If we display it transparent blue, then it is possible to watch the research results of simulations. We are able to see the flow of water inside the transparent pipes (Fig. 3). Created a 3D digital model of terrain, water pipes, etc. allows us to display the results of simulations in water management. The advantage of 3D visualization is that pipes for the purpose of displaying the results of the simulations we can tap to display not just beneath the surface, where it is located but also on the surface of the ground in fact, where you can watch the results of the simulation Fig. 4 3D model of Bratislava. There is only for better monitoring of process inside.

2.1. Virtual reality of water managements

An important component for the display of water pressure and the flow rate of water loss is high-rise buildings. In order to make it easier to differentiate, the amount of buildings, so we knew on a virtual model of the building so that buildings appearing with one floor are displayed in a different color than the building with two floors and three floors, as well as other buildings, etc. So we have achieved a virtual model of the environment and the surroundings of Bratislava with water pipes, water – towers and nodes and also with the buildings, the amount of which is colorfully differentiated. This 3D virtual model is designed to provide an adequate environment for displaying the results of calculations already in the water economy (Fig. 5).

2.2. Virtual reality of the water pressure

In this environment, we are able through the proposed 3D model to display calculation results from the simulations which are calculated by the EPANET simulation program on the computer clusters. For example, to view a simulation of the water pressure within 24 h, we opted for 3D display using transparent 24 TIN models created from the simulations research results data. We use the same method like in terrain. We obtained 3D data of

Fig. 4. 3D model of Bratislava and surroundings with water pipes.

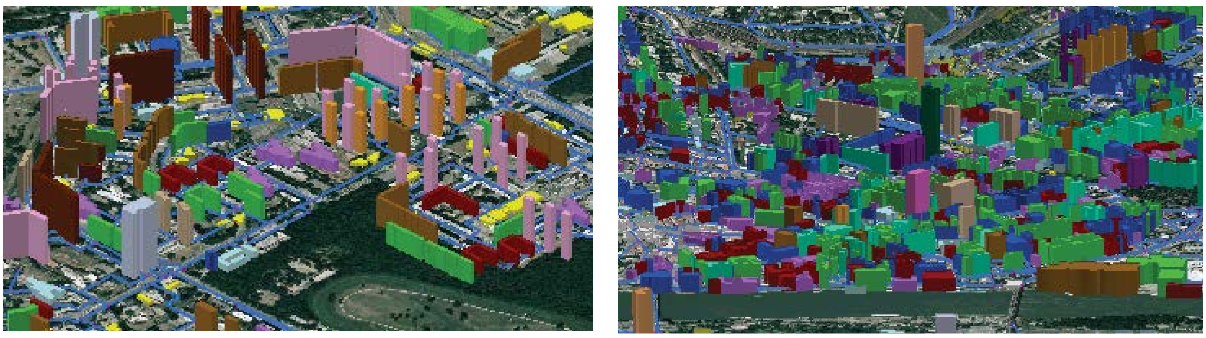


Fig. 5. Virtual model of Bratislava and surroundings with water pipes and buildings.

water pressure during 24 h. Water pressure differences in high building we are able display by using 3D data. Each TIN is the level of water pressure due to the high-rise. We decided to use the method of transparent TIN surface model. If any of the extra tall buildings overlap the transparent TIN, it means that its levels is over the normal water pressure (Fig. 6).

2.3. Virtual reality of the water flow

Water flow rates during 24 h we displayed from computed data using EPANET system which were ported to the grid environment. We have output data from simulation during 24 h. To view the flow of water during the 24 h, we selected one color scale. Within this color

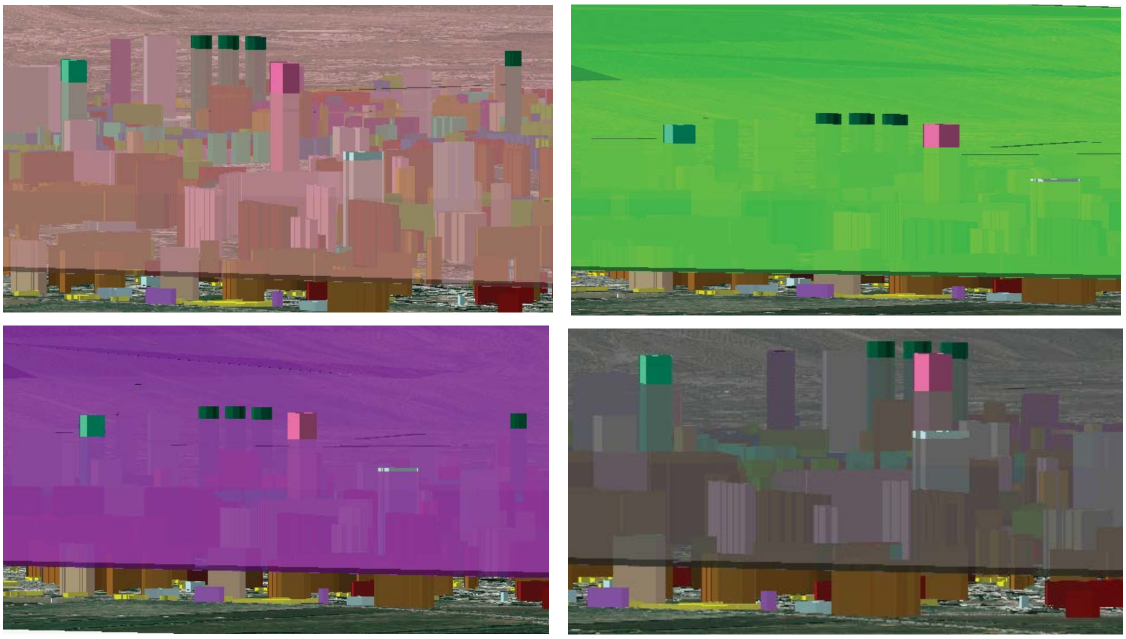
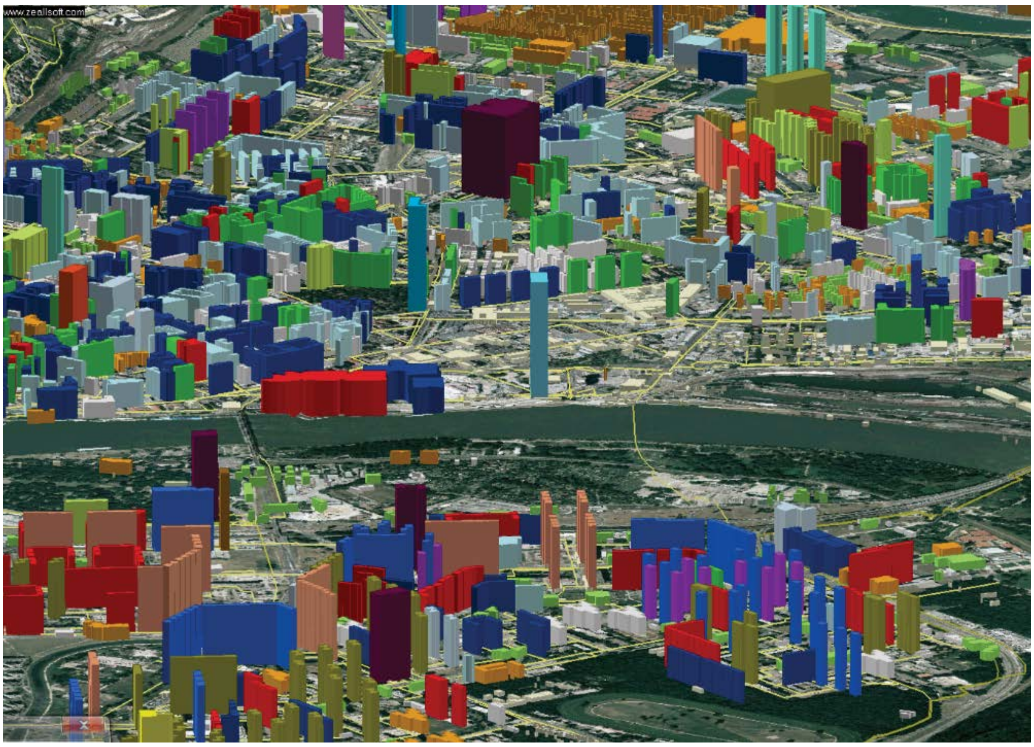


Fig. 6. Samples of 3D visualization of the simulation results computed by EPANET-water pressure during 24 h. First 4 h.



(Fig. 7. *Continued*)

Fig. 7. Examples showing the results of the simulation of water flow during the 24 h, calculated by the simulation program EPANET and computing on clusters.

scope, the water flow is graded from minus maximum value up to plus maximum value, there are in total eight color fields (Fig. 7).

3. Conclusion

The problem we have resolved is a great contribution for detecting emergency and critical problems in the water management. We used multiple scenarios necessary to detect problems. Our assumption is that the most important step was made by porting the calculations to the grid environment, virtual reality and 3D because this can greatly speed up the proper action to cope with problems in the water management. The 24 h data outputs tested for 3D viewing show very small differences which was also reflected on the display. In the future, we want to display multiple simulation outputs from EPANET and specify more time ranges. Also we will try to find the best form of 3D display and animation outputs. Currently our visualization system is tested by another organization in the scope of the project. Before, it was DHI Slovakia organization which tested our system. The future work in this field will depend on new requirements from the organizations their large data of the water management we have been computing.

Acknowledgments

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Software: Desktop Help 10.0 - ArcGIS tutorials - ArcGIS Resources This topic provides a set of links to a collection of various ArcGIS tutorials used to perform a number of common tasks in ArcGIS.