Combining semantic 3D GIS with numerical simulation for assessing the impact of blasts in urban environments

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ABSTRACT

Numerical simulation of physical effects and phenomena requires specialized software that has been developed for engineering tasks. Computer Aided Engineering (CAE) is well integrated with Computer Aided Design (CAD), enabling seamless workflows for designing and optimizing products digitally. Urban simulation requires data sets such as detailed 3D city models that are managed in specialized Geographic Information Systems (GIS). The interoperability between GIS and CAE worlds is still very limited due to different approaches on how to capture, represent, exchange, and process data. The presented work enables a seamless integration of numerical simulation and management systems for 3D city models with a focus on the simulation of blasts in urban environments that may be caused by unexploded bombs from WW2 or terrorist attacks. In Germany, many unexploded bombs are still buried in the ground being a potential threat both for human beings and the built environment. They are frequently found on new construction sites. A detailed physical simulation of the expected detonation can help police and emergency forces tasked with setting up evacuation zones and other measures for protecting the local residents. The requirements in this scenario are very high. The data exchange from GIS to CAE must be fully automated so that the numerical simulation process can be started immediately on request without extensive manual adaptions. Information on the semantics and structure of buildings must be maintained in order to assess potential damages. Visualization and presentation of simulation results must be prepared in a meaningful fashion in non-expert systems and available from anywhere. The overall processing time must be sufficiently short in order to support decision makers. In our solution, we use a virtualcityDATABASE for storing CityGML data sets representing 3D city models, and ANSYS numerical simulation software with an integrated explicit AUTODYN solver for simulating the propagation of shock waves. Both systems are bridged by a conversion and healing tool that prepares CityGML so that it can be loaded by ANSYS. For exchanging data we rely on the ISO 10303 international standard (known as STEP). The automatic healing process fixes inconsistencies in 3D model geometry and topology that often occur in spatial data sets. In ANSYS, an Euler space is set up automatically with adequate cell sizes representing the air. The result of the simulation is processed as 3D voxel space containing pressure values, either at a specific point in time or maximized over the complete time span. For visualization purposes, the voxel space is merged with the 3D city model in order to display damage zones or raw pressure values on the building structures. The system is available through an online web portal that can be used to browse through the 3D city model and for setting up simulation parameters relevant for our scenario. The resulting framework has been successfully tested on a real world data set that was already integrated in a Spatial Data Infrastructure, consisting of more than 200000 buildings with roof shapes, partly extended to include façade details. Although the overall processing time still exceeds the required response times of decision makers, the other requirements could be met by this approach.

REFERENCES

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