BIM-based immersive indoor graph networks for emergency situations in buildings

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In the last decade, the significance of the emergency management in public infrastructures has increased due to changed security conditions worldwide which has led to the necessity of computer-aided emergency assessment process for extreme situations. The evacuation and rescue of endangered people are of highest priority for the rescue team. The rescue mission is influenced by various parameters like building elements, the spread of fire and smoke and the behavior of endangered people. Each of these parameters can be simulated based on different computer methods, but cannot be considered independent from each other.

Conventionally, the emergency assessment is usually a paper-based process regarding official fire safety regulations and relevant guidelines. In order to ensure these regulations, normally a general building safety concept has to be verified and, depending on the use of the building, additional regulations could be necessary to observe. At this step of the assessment process, nowadays computer simulations are still unusual and they are only necessary as an additional survey in cases of very special facilities with uncommon architectures (“Sonderbauwerk”). The increasing significance of the emergency management in public infrastructures leads to the demand of a computer-aided emergency assessment in terms of higher quality of the individual building safety and a better decision support for the engineering process. Especially the use of computer models for surveying fire protection design and modelling the evacuation process is of special importance. For the visualisation the use of virtual reality leads to a better understanding for the involved engineers.

The challenges here are, firstly, to develop an unique building information platform, secondly, to realize the virtual environment based on geometrical and material boundary conditions of building, thirdly, to generate the potential escape routes of endangered people in these virtual environment and, finally, to have a realistic visualization of the results which can make a visual evaluation for safety engineers suitable and supports the coordination process with the involved engineers (Rüppel and Abolghasemzadeh, 2009).

BIM is the process of generating, managing and using building data during its life cycle (Holness, 2008). It is a new Computer Aided Design (CAD) paradigm that employs intelligent graphic and data modeling software and creates optimized solutions for building design problems. Especially for the demands of indoor-routing (process of calculating a way from a defined starting point to a defined endpoint) be BIM is a suitable modeling platform. Mathematically a path can be defined as a sequence of differentiable pieces. The basis of route calculation is a graph with possible paths. As people walk inside of rooms bordered by walls and doors the graph has to cover only accessible areas. To generate a graph out of a BIM, building elements need to be extracted to determine rooms, walls and doors in order to create polygons with accessible areas. Therefore, the basis of the presented approach is to develop indoor graph and routing generators with the BIM platform.
Regarding to the room polygons which are produced by a new developed BIM interface, specific methods are used to generate the needed routing graphs. As manual methods are not feasible for complex buildings, automatic methods like quadtrees, meshes and straight skeletons have been analyzed for usage in the case of indoor-routing (Rüppel and Stübbe, 2009). The new BIM-interface includes a routing generator based on different automatic methods and integrates the results into the Autodesk Revit which is a BIM-platform and presents the developed models in the immersive virtual environment at the Darmstadt Civil, Environmental and Safety Engineering Lab (CES-Lab) (see Figure 1). This newly developed system is called “Immersive Safety Engineering Environment (ISEE)”. With ISEE the safety engineer will be able to obtain more realistic visualizations of models in the immersive environment, to modify his concept more effectively, to walk through the escape ways in virtual reality and to evaluate them visually. Especially observing the movement of endangered people according to the generated routes in an emergency scenario is considered in this new approach. In this way the safety engineer is able to run the required simulation models with different egress scenarios based on various routing networks to verify the maximum escape time. With ISEE indoor routing is possible on the BIM platform „Autodesk Revit Architecture“ (by Autodesk) in combination with the immersive methods of the CES-Lab. ISEE can also give the rescue staff the opportunity to perform and evaluate emergency situations in a virtual training.

The paper presents in section 2 the approach to set up ISEE to model emergency situations in public infrastructures supports the immersive experience of these situations from endangered people's perspective. Escape routes for endangered people can be calculated depending on the building conditions and the evacuation process can be visually evaluated. In section 3 the definition and advantages of building information modeling in terms of building safety (fire protection) are presented. The calculation process of indoor routing are explained in section 4. In section 5 adequate methods for the generation of indoor routing graphs are analyzed. In section 6 the common routing algorithms are introduced and in section 7 a short description of the virtual reality possibilities of the Darmstadt CES-Lab are given. Finally, in section 8 a summary and an outlook are presented.

Figure 1. Generating graph networks and routings from BIM and visualization of results in ISEE

References