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Breaking into BIM: Performing static and dynamic security analysis with the aid of BIM ☆

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ABSTRACT

The design and construction industry is moving towards Building Information Models (BIM) that provide all of the strengths of traditional 3D CAD with an added layer of data allowing new and powerful applications. We investigate the concept of using the data within BIM to better explore security design and considerations. We achieve this by first graphing the physical entities of BIM to capture their relational representation as nodes and links. This graph representation will facilitate the use of graph theory or agent-based simulation to assist in the analysis of the static and dynamic behaviour of the environment around the BIM. We also demonstrate an application of graphing by investigating the use of BIM to explore automated infrastructure security design and consideration via red-teaming. The intent is to make security analysis easier and a process that can be carried out during the design phase of a project, even by non-expert users.

1. Introduction

Physical Security Assessment is the process of examining a facility and establishing the risk of it being penetrated without detection or appropriate response. To achieve this process one traditionally requires a security expert, highly valuable individuals whose knowledge and experience carry a representative cost. This can lead to security considerations becoming almost an afterthought in many cases, implemented as needed with experts often consulted late in a project lifecycle.

Researchers have looked at using computer simulation to assist security practitioners. However, these attempts have often faced problems with the knowledge required by a user to setup and operate the software often impeding the usefulness of the system [19]. In this paper we demonstrate a proof of concept computer aided security simulation tool designed to alleviate these problems by applying known security modelling methods and heuristics to the information contained within a Building Information Model (BIM).

BIM is a 3D modelling paradigm that extends the capabilities of "dumb" modelling applications like traditional 3D Computer Aided Design (CAD) by adding a layer of associated information. By leveraging this information layer it is possible to perform deeper analysis of a facility, such as simulating elements like construction cost and time. In our research we look to provide tools that open up Physical Security as a simulation option.

In this article we will discuss some of the advantages of BIM and existing research on Security Simulation. We will then introduce the process we use to go from BIM to simulation, followed by the static and dynamic simulation applications we have developed to date. Finally we will present the results of our work and discuss where we see it leading in the future.

2. Background

In this section we will address, in part, the history of BIM and Infrastructure Security. We will also discuss some of the background of Intelligent Agents, which can be used to further explore the models we create.

2.1. Background—BIM

BIM is an evolving standard for the collaboration and design of facilities. We are increasingly seeing its uptake, with many multi-million dollar projects utilising it [7]. In Australia, the federal and state governments are increasingly requiring the use of BIM for public works

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projects. Many of the organisations using it however are not taking full advantage of its potential.

A common advantage of BIM over traditional CAD is that BIM can perform automatic conflict detection, saving time and money during the design stage. However, Gao and Fischer [7] found only 14 of the 32 projects they examined took advantage of this feature. Azhar et al. [2] demonstrated that the returns on investment for BIM from activities such as automatic collision detection are well worth the cost to organisations.

Cheng & Wang [3] discussed how BIM allows for any changes that need to be made to be implemented more cheaply than in traditional 3D CAD or 2D design methods. One example of this is moving a support beam; in traditional CAD a designer typically needs to move the beam, then any supports, bolts and foundation individually. In BIM these objects can all be grouped, allowing the software to move the associated components with the beam, saving the designer time and effort.

BIM is not without criticism, though this criticism typically lies more with the implementations than the concept. Coates et al. [4] stated "BIM represents the digital Lego, not the digital clay" referring in part to the inflexibility of current software to accommodate different design methodologies. In their paper, they comment that BIM currently has no real support for free form sketching and other early design techniques. Alternatives are suggested, such as Onuma Planning System, though as BIM continues to mature we will most likely see software vendors attempt to address these issues.

Smith [17] found a great deal of power in the ability of BIM to help plan and design a facility. They suggested that by better planning how a facility will be used, ensuring loud machinery is away from quiet work areas and so on, the efficiency of a facility can be increased. They go on to state that if the efficiency of a facility can be improved as little as 3.8%, that improvement will pay for the entire facility over its lifetime.

As BIM becomes widely accepted in architectural business, providing tools that make it quick and easy for an architect to receive feedback on their design and bring their attention to areas they may want to adjust will allow for cheap and effective modifications. By building on existing BIM software we intend to make security analysis another tool at the designer's disposal, allowing for easy early consideration and changes to help improve facility integrity. Our tools will not replace security experts but we aim to make some of their knowledge easily accessible, to allow for earlier incorporation of security considerations during the vital design phases when change is easiest to bring about.

2.2. Background—Infrastructure Security

Infrastructure Security is an expansive field in its own right, so here we will look primarily at areas that have influenced our own work. We will first address existing infrastructure security simulation systems. After this, we will provide some background on the security heuristics we have elected to use.

Tarr and Peaty [19–21] examined the use of computational modelling of security. Their approach examined the use of modelling to assist in the design of prison facilities. To achieve this, a simulation would be setup by modelling all barriers along a given path with relative material strength, which was then analysed to establish if it provided sufficient Delay and Detection.

They found computer-aided simulation to be a beneficial approach, with one of the main limitations being the need for expert users to input data and setup the simulation. A lot of their effort between their original publication and the last was spent on refining the tools to reduce the cost of modelling a facility, but as of last publication it was still a problem. With our system, we have successfully minimised the negative impact of these problems through leveraging BIM.

Others have also used BIM for facility analysis with some also analysing security concerns. In *Automated Assessment of Early Concept Designs* [6], the author describes the work undertaken by their team to create an extension of the Solibri Model Checker. Their extension is reminiscent of an expert system, assessing the BIM design for conformity to various regulations and providing feedback to the designer, reducing the knowledge burden on designers less experienced in dealing with Courthouse design.

Garcia [8] described the EASI model, which allows an expert user to calculate the delay along a single path through a facility. Similar to the work by Tarr and Peaty [21], both the reliance on an expert user and the single path calculation can make this process slow and costly. A point of concern for us is that single path modelling presented in the above systems may lead to the oversight of exploitable attack vectors.

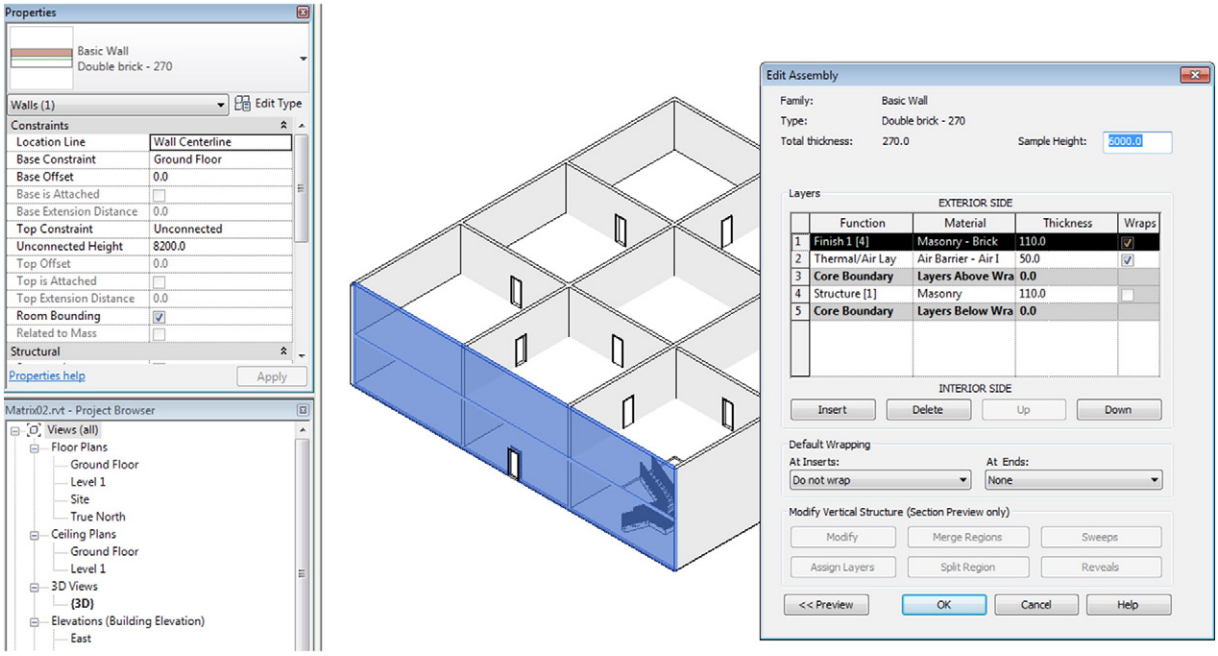

Fig. 1. A simple BIM represented in 3D, with the front wall selected.