Rule-based Security Planning System for Practical Application

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Abstract. Security planning is a vital part of the operation and management phase in a building’s life cycle. Ideally, this will be addressed during the building design phase. However, reality often differs from this ideal. In the real world, information such as floor plans tend to insufficiently describe or imperfectly match physical buildings, and must be surveyed and re-worked during security planning. Because of this, security companies require two kinds of staff: those in the security business and those in charge of planning, including floor plan verification. This research focused on creating an efficient way to help staff in this work environment develop a system of security planning for buildings and facilities using a rule-based approach in a tailor-made CAD system. In this research, we developed a new 3D CAD system for desktops and mobile devices, which specializes in security planning using a game-engine. To avoid errors during security planning, a rule-based check system was developed and integrated into the CAD system. The rule-set of this rule base was built from the security planning manual, including guidelines on equipment layout and wiring in various situations, which could then be used in the development of an automated check. This research describes the method of system development and final results.

Keywords: Security Planning, Operation and Management, Rule Base, BIM, CAD

1 Introduction

The Computer Aided Architectural Design (CAAD) research domain has focused on catering to well-trained and educated users in industries such as architecture, engineering, and construction (A/E/C) since these studies started. Situational applications of Computer Aided Design (CAD) have therefore been well adapted to, and widely adopted in, the design and construction fields; however, operation and management areas are quite different during early steps in the building life cycle, as workers in these areas do not receive any formal A/E/C-related training or education. In summary, employees in these fields complain of the inconveniences and
difficulties of using CAD due to complexities and excessive functions not used in their work. The security planning area in particular presents a more serious situation than other operation and management domains because of their work and business environment. By common convention, security planning is part of the building operation and management phase of the building life cycle. Ideally, security planning is done concurrently with the building design stage; however, reality is consistently different from the ideal. In practice, security planning is frequently started later in a project, sometimes not even until after the operation and management phase has begun. Because of this, security companies are required to employ two kinds of workforce: those performing security functions and those laying out security planning. The difficulty for security employees tasked with planning is that they don’t have architectural expertise, such as drawing up and interpreting building floor plans. Furthermore, expertise is required to avoid errors when using floor plans for some aspects of security planning such as the layout of alarm equipment and wiring. Security companies have developed a security planning manual, giving their staff a solution to these problems in the format of a book. Unfortunately, this manual has proven insufficient for resolving the problem.

Given the ongoing nature of the problem, this research focuses on developing a rule-based system to assist in security planning for buildings and facilities using a tailor-made CAD system developed during research. The proposed security planning system was developed to overcome common security problems by converting the security planning manual into a rule base for an automation planning system and game engine. This development opens use of the tailor made CAD system to nonprofessionals who lack training or expertise in using architectural floor plans and layouts for alarm placement.

2 Related Research

2.1 Rule-Based Solution for CAD, BIM, and Security Planning

A bright vision of future applications for engineering knowledge, specifically to CAD environments, has been set forth by Gero [1], and past results have shown the value of CAD related knowledge in adapting and evaluating building design [2]. A rule-based system can store this type of knowledge and experience to make practical judgments in real-world situations.

Since a rule-based system was introduced by Hayes-Roth [3], many studies have been conducted using a rule-based system in CAD research. Recently, these have focused on adapting from 2D CAD to Building Information Modeling (BIM) [4, 5]. Since the BIM concept was introduced, it has been shown a rule-based system can successfully be applied to BIM. A prototype rule-based system, called Green Building Design Assistant (GBDA), has been developed for automatically checking green building design [6]. The system integrates BIM, rule-based reasoning, and virtual reality to help designers by automatically checking green building design codes and presenting real-time visual feedback from this checking. Additional research using
rule-based systems has been performed to solve safety issues in design and construction. Zhang [7] demonstrates an automated checking system using rule-based applies the Solibri Model Checker (SMC) as a rule-based engine for safety planning and simulation uses. This system can be described an automated, table-based safety rule translation prototype based on Occupational Safety and Health Administration (OSHA) standards and construction safety best practices.

All the researchers mentioned above focused on design applications. Conversely, research conducted by SECOM Intelligent system laboratory (a Japanese security company) is investigating security planning using rule-based systems. Their research presents an expert system dedicated to security planning called ESSPL, which generates security plans for alarm systems using the rule-based system. The system consists of several subsystems including data management, zone planning, sensor planning, and control equipment planning [8]. SECOM argues that in order to provide a high-quality alarm system, it is crucial to optimize the remote sensors and equipment layout in a building. The results of their research aim to satisfy the requirements. One obstacle they have faced during research and field tests was obtaining building plan data for their models. Because of this, 95% of time during field testing was allocated for designing an accurate building plan model.

2.2 Tailor-Made CAD for System Integration

In this research, “tailor-made CAD system” refers to a drawing and modeling system specialized for a particular field in the building design life cycles such as operation and management (O&M) or facility and asset management (FM&AM). These are typically performed by laymen without training or expertise in the commercial CAD systems used by architectural designers and construction engineers. The space management system in place at the Incheon International Airport is one existing example of an in-house, tailor-made CAD system formatted as an intuitive 3D model viewer, which was developed using a game engine. However, this tailor-made CAD system still encounters usability issues between the complex 3D viewer interface and end user. Because of this, the airport has decided only few authorized users who have taken a special training program are allowed to run the program [9]. There are several additional reasons to further the development of tailor-made CAD systems: commercial BIM tools are exceptionally complex for end-users, lack sufficient Software Development Kit (SDK) support for developing specialized requirement functions [10], and have prohibitively high licensing costs. Further contributing to the complexity issues of commercial BIM software, most organizations require only the CAD system for their work, not the additional functions included in the license.
3 Rule-based Security Planning System

3.1 Background of the System

The company, which ordered this system, was the first company to provide on-line security service, dominating market shares in Korea. The company has established an Information Technology (IT) infrastructure for successful and efficient business. This IT infrastructure has been applied new technologies such as 2D CAD, a mobile viewer for field workers, and enterprise resource planning (ERP). New technologies introduced in the field are quick to adopt the IT infrastructure.

The company has recognized that 3D mobile CAD may be combined with engineering knowledge such as rule-based system development and adapted for their business. These technologies, now mature and stable, are ready for business applications. Hence, they have decided to upgrade their current system using this technology. This research is on the process of adapting such technology to security planning. The requirements and expectations were defined prior to starting the project using current system parameters and feedback from a field employee in the targeted field. The requirements and expectations were separated into five categories: easy to draw, estimation, customer relationship, security planning rule, and efficiently of operation. The detail is described in Table 1.

3.2 System Configuration with IT Infrastructure

The Rule-based security planning system (the new CAD remains under a codename in the company at this time) is a part of IT infrastructure in the aforementioned company. This infrastructure serves enterprise data from ERP to the system, and the system serves visual data to the central control and operation management systems. Here, the visual data is a 3D spatial model including property data for the surveilled space. Each system is connected through intranet as well as the internet. The Rule-based planning system consists of two CAD programs working on both a PC and a mobile platform (Android based Tablet). Although the CAD programs function on different platforms, the user interface is unchanged to avoid confusion in non-expert end users. The system configuration is illustrated in Fig. 1.

3.3 Tailor-Made CAD for Security Planning

CAD serves multiple required functions in the system, including provision of a precise and simple drawing method, 2D and 3D view support, and multiple platform support (desktop and mobile). However, CAD requirements are often prohibitive for users without professional architectural or engineering knowledge. It was decided a game engine would be used to meet these requirements in this research. The game engine Unity 3D was chosen because it supports multiple platforms, including Windows and Android, using the same source code. As the source code remains the same, the time and cost of multiple platform development is reduced. Thus, the
proposed tailor-made CAD, supported simultaneously in 2D and 3D on desktop and mobile platforms, was developed in limited time.

**Table 1.** Company requirements and expectations for the system

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Expectations</th>
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| Easy to draw | • No system specific preexisting knowledge required for drawing  
• Precise and simplified drawing | • Increased production in drawing work  
• Eliminate the possibility of transcription errors  
• Create potential to unify communication based on precise drawings |
| Estimation | • Support automated and manual estimation  
• Support partially automated, partially manual estimation in variable situations  
• Support recording precise elevation of device installation | • Reduce estimation errors  
• Eliminate gaps between design and construction estimations |
| Customer relations | • Enable customers in the field to create drawings using mobile CAD.  
• Help customers understand proposals with 3D views. | • Reduce lead time  
• Easily convey use to customers with 3D dynamic viewer |
| Security Planning rules | • Automated installation when control units and sensors are drawn  
• Reflect interrelation among equipment, checking installation regulations for numbers and equipment | • Prevent human errors using automated installation  
• Enable security planning: final confirmation of missing equipment done by automated regulation check of Security planning possible |
| Efficiency of operation | • Propose company recommend equipment  
• Enable a stock check for equipment availability  
• Automatically verify risk elements | • Simplify inventory management for company supply policies  
• Enable checks in the instance of uncertain handling procedures or equipment availability |
The user interface is also considered to be a crucial element in achieving the required user-friendliness of this CAD. Many ready-to-use CAD systems on the market have complex user interfaces with too many buttons, causing delays in learning and mastering the CAD system, which naturally lead to user frustration and complaints.

The proposed CAD uses the design philosophy that the simpler things are, the better. Fig. 2 shows the final product of these ideas. The number of buttons is minimized, and the design remains the same between desktop and the mobile platforms.

The ability to use CAD in a mobile environment was one of the core requirements for this project, due to the nature of security service and planning. A businessperson in the company’s employ must visit the site upon customer request. Using the current system, they must survey the building for accuracy to the current drawing, return to the office to correct discrepancies and create a final drawing, and then again the site and meet customer for a second time. This is a time-consuming task, and the businessperson surveyed requested a way to streamline the process, surveying the building and drawing a floor plan simultaneously in the field. Further improvements to the process were requested in the form of real-time estimations and equipment stock checks.

Developing a mobile CAD interface is not an easy task. The integrated space management system of Incheon International Airport is one of good examples of a successful implementation [9]. When the airport developed their CAD system, the 3D viewer worked properly and satisfied their requirements; however, the mobile CAD was different in this case because their mobile platform is still a Windows-based mobile computer (using the same operating system and computing power as desktop computer). For the proposed system, the tailor-made CAD and 3D viewer will be used in two different development environments: a Windows-based program and the previously described game engine.

In this research, the development environment was unified to the game engine with satisfactory results. Under this solution, the mobile CAD works on both Android-based tablets and pads. Fig. 3 shows a demonstration of the mobile CAD interface.

3.4 Rule Base for the System

The Rule-based system consists of the user interface, model controller, space model, rule engine, and rule database. This architecture is illustrated in Fig. 4. The architecture has two core parts: the model controller (shown in 2) and rule engine (shown in 4). The model controller handles space models using the model checker and layout system. The model checker analyzes features of the model against the rule engine to display information and adapt the features to applicable rules. The layout system automatically installs security devices such as sensors as directed by the rule engine. The inventory check system, a part of the model controller, verifies equipment stocks using ERP data. The rule engine handles the rule database and controls the model controller via the query interface and rule-set manager. The user interface activates the rule engine with queries and returns results and actions. Results are displayed as missing items and/or a violations list, giving users a chance to check and resolve mistakes.
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The documentation-based security planning manual is converted into the database as a set of rules, and the rule database stores this as the official rule-set. The security planning rule set consists of types of business categorized by the level of security or risk, the type of space, the type of property in the space, the type of windows and doors, the type of security equipment, and the method of arrangement applied to security equipment.
The first information that runs through a rule-based system is the type of business. The rule-set used defines four types are defined as follows: 12–business common, 9–high risk common, 11–high risk business, and 10–significant business. An example of rule-set application can be shown through the process of checking whether or not a wall vibration sensor is required. First, the system checks whether or not the business type is defined as high risk. If the business type is high risk, such as a jewelry shop, the system checks if the shop has lightweight wall. In this case, a lightweight wall would be a built-in environmental risk to the jewelry shop and the system would instruct the user to install a vibration sensor on the wall. The rule can be represented in prolog style as shown below:

```prolog
required_vibration_sensor(X):-
    business_type1(X, high_risk),
    space_type(X, jewelry_shop),
    wall_type(X, lightweight).
```

The rule application process in the system has several steps. First, the building or space model is prepared either by constructing a tailor-made CAD from scratch or converting an existing 2D CAD drawing using the converting tool. When the model is ready, the system requires the user to enter information on the model, such as the type of business and type of space. The system analyzes the model and information using the model controller and rule engine. During this analysis phase, the system checks the size of the space or room and what type of doors, windows, walls, and properties are installed. After analyzing the space, the system selects the required equipment as determined by the rules-set under the given analysis results. The system then checks the ERP information relating to the selected equipment to determine if it is in stock. Finally, the system designs a layout of the required controller and sensors in their correct positions in the model.

The system provides further regulation of the company’s designed security by checking relationships between the central control device and sensors, and then reporting any missing equipment or violations. Any problems, which the system finds, must be solved, by one of the two methods provided by the system. The first method is to accept the problem, at which time an automation solution will be provided for use. In some cases, however, the system is unable to check all aspects of the situation, and the user will need to ignore the violation. To ensure maximum security and avoid errors, a single user cannot override a violation even if the situation calls for a given rule to be disregarded. For this, users must receive confirmation from the operation center to avoid critical problems. Hence, the second method is the service to request solution from the operation center. Both methods in this process are illustrated in Fig. 5.
4 Conclusion

The primary aim of this research was to increase the utility of a CAD system in security planning during the operation and management phase of a building’s lifecycle. In the security planning phase, a 2D CAD system typically used for sales and security purposes, as businesspeople in these roles tend not to have the extensive engineering or architectural knowledge required for CAD system use. This situation may be resolved with a 3D CAD system, which is easy to use, automatically corrects errors, provides intuitive visual information, and functions on a mobile platform. The requirements are a result of the unique working environment in which salespeople must respond to clients’ requirements promptly in a mobile environment. This research designed a CAD system development strategy to satisfy the field requirements. The first issue was how to develop a 3D CAD system for desktop and mobile platforms with an intuitive viewer and user interface in limited time. To do this, the Unity 3D game engine was used, chosen because it is supported across platforms including Windows for desktop and Android for mobile devices. Additionally, the game engine easily implements an intuitive user interface and 3D viewer. The second issue was how to avoid errors during security planning, such as regulatory violations regarding equipment installation and wiring. For this requirement, the security planning guidebook was converted into the rule-set for the rule-base.

The rule-base was integrated into the CAD system developed in this research so that the user can automatically check their work for errors. Furthermore, whenever a
security planning rule is changed, the alteration is spread to all of staff members effectively in real-time and effectively because the system works in the company’s existing IT infrastructure. As a result of this feature, issues have arisen with rule version control and change management. Regulation changes are difficult and often delayed, resulting in confusion in the field.

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