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Translating building legislation into a computer-executable format for evaluating building permit requirements

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ABSTRACT

In this paper, we describe an approach to translating the written content of the Korean Building Act into a computer-executable format for the purpose of evaluating building permit requirements. Among the various applications of building information modeling (BIM), we focus on automated design assessment and its rule-making process, which has been performed by both architects and software developers. Compared to the conventional rule-making approach, which is integrated with rule-checking software, our suggested mechanism (KBimLogic) of converting rule sentences from the Korean Building Act into computer-executable code (KBimCode) is a software-independent approach that separates the rule-making and rule-checking processes. We use the rule-making approach to translate the Korean Building Act into an explicit code that focuses on building permit requirements.

Building permit-related regulations are defined in the Korean Building Act, but some of the sentences are ambiguous, and some implicit definitions hinder translation into an explicitly defined computer-executable form. Some building permit-related requirements vary by building type, administrative district, permitted date, and as-built date; thus, it is critical to design computable rules independent of specific proprietary software. The building permit system in Korea changes (as it does in other countries), making it critical that code compliance rules be kept up-to-date. Our work is motivated by such fundamentals and suggests a logic rule-based mechanism for use by non-programmers and a user-friendly approach to the rule-making process.

The scope and major components of our research are as follows: (1) noun phrases classify building objects and associated properties from the Korean Building Act; (2) verb phrases derive high-level methods to construct the actual rule-checking body; and (3) the logic rule-based mechanism processes natural language sentences. In the actual implementation for translation, this approach has been demonstrated by each database and a GUI-based application named KBimLogic, for generating KBimCode. The KBimCode, which contains a set of specific building permit requirements translated from sentences, can be imported into our code-checking software (KBimAssess) using a specific file format.

1. Introduction

To qualify for building permits, architectural design firms must satisfy a series of requirements defined in the Korean Building Act, which contains design rules and regulations that are often interpreted in various ways by domain experts. The verification of multiple requirements with given building design models can be time consuming, and the results can be incomplete and arbitrary. The makers of various building information modeling (BIM) applications have attempted to reengineer natural language-based design regulations into machine-readable formats to improve the logical structure of the regulatory codes and thereby automate the design evaluation process [1].

BIM applications in the architecture, engineering, construction, and facility management industries support computer-interpretable and information-rich building models and automate some parts of the design assessment process. As has been demonstrated by some challenging projects using this approach, BIM reduces design errors and eventually improves the overall design quality [2,3]. Among the various tasks required to automate the design assessment process for acquiring building permits, this study focuses on the approach and mechanism for generating computer-readable explicit forms from the implicit natural language sentences specific to the Korea Building Act [4].

The scope of this study is to describe major findings and distinguished features developed to translate sentences from the Korean Building Act into computer-executable forms that can be directly used in a rule-checking application. To design the logical rule-based mechanism, we refined the objects/properties and predicates of sentences from the Korean Building Act into a database called the “logic meta

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database." Initially, the logic meta-database contained more than 15,000 building permit-related sentences (e.g., 12 types of higher-level laws including content, such as required specifications for elevators, fire-retarding divisions, and evacuation facilities, and 49 types of related lower articles or standards). The logic rule-based mechanism, shown in Fig. 1, is as follows: (1) classify each object and its related properties in the Korean Building Act, rather than using a standard BIM model such as IFC or the Revit schema; (2) classify a method for verifying the objects and properties of the target building; and (3) translate the natural language sentences in the Korean Building Act according to a logical process. Through a logical rule-based mechanism, sentences are stored in the logic meta-database as intermediate code, called "KBimCode," which is reusable and executable according to the purposes of the Korean Building Act [5]. The KBimCode is managed in a web-based database interface. An application for generating and managing KBimCode is also implemented as "KBimLogic." Exported KBimCode can be used in a BIM assessment tool called "KBimAssess" to check designs against building permit requirements in Korea. Using this series of application systems, this study focuses on the translation mechanism, including the logic meta-databases. Actual building permit-related code compliance verification is demonstrated using the suggested mechanism and KBimAssess applications with existing building models. (See Fig.1.) (See Fig. 2.)

2. Background and research motivation

From the perspective of facilitating computer-executable rules from natural language regulations (a so-called rule-making process), several parties have explored various applications of automated design reviews on actual projects.

1. CORENET (2005)
   The Construction and Real Estate Network (CORENET) is Singapore's major IT initiative, led by the Ministry of National Development and driven by the Building and Construction Authority [6,7]. It aims to streamline the business processes of the construction industry in order to improve turnaround time, productivity, and quality [8]. Among its functionalities, the e-PlanCheck module performs automated checks against Singapore codes on building control, barrier-free access, fire prevention, environmental health, households, public housing, and vehicle parking. It consists of an e-submission system and integrated review of plans for IFC-based files. The e-PlanCheck module is a cutting-edge system that integrates expert knowledge in regulations, artificial intelligence, and BIM technologies [9,10]. To verify code compliance, this project developed the FORNAX platform to calculate each required condition. The FORNAX platform is an object library programmed in C++ language [11]. Each FORNAX object contains hard-coded rules that assess themselves.
2. Statsbygg Project (2009)
   Norway undertook several projects for automated code checks. CORENET's e-PlanCheck was adopted and tested in the Selvaag Group's "Munkerud" housing project and the Akershus University Hospital project [12]. The HITOS (Tromsø University College) project driven by Statsbygg (Norwegian Directorate of Public Construction and Property) performed spatial requirement and accessibility checks using dRofus software [13] and the Solibri Model Checker (SMC) [14]. Although those projects demonstrated the increasing feasibility of BIM-based code checking, it remains a "black-box" process in terms of how commercial software implements related codes, standards, and regulations for computable rules. The Statsbygg project developed methods to translate and transform building-related codes in standard documents, national codes, and regulations for

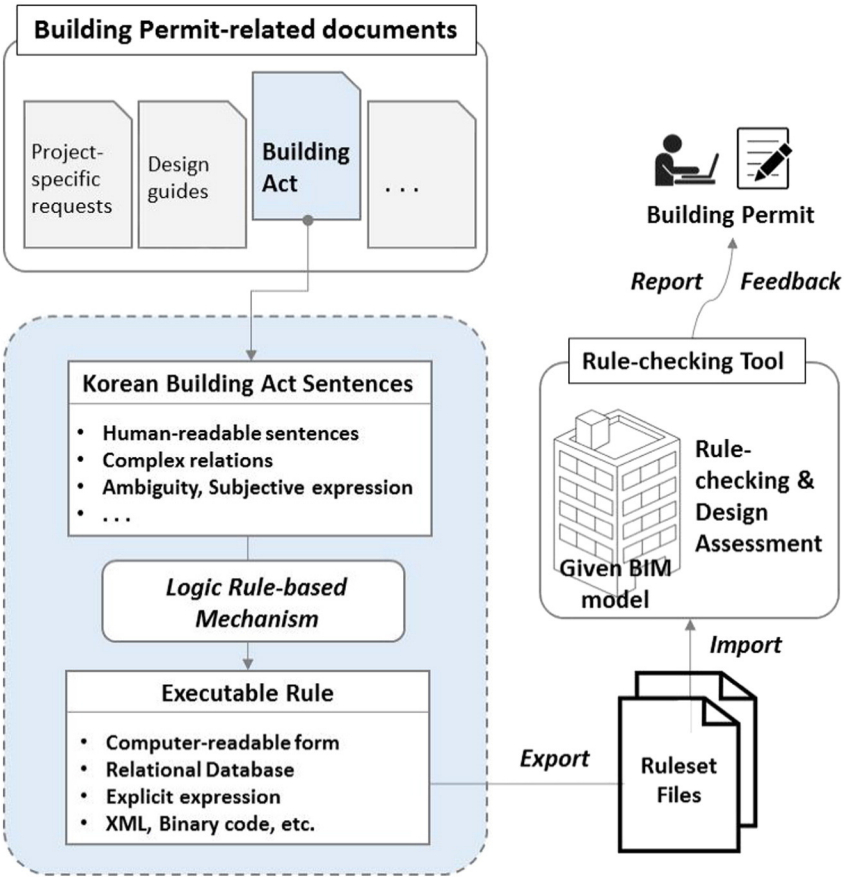

Fig. 1. Overview diagram of the research scope and flow: an approach to translating Building Permit-related documents into a computer-executable format.

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