CONFLICT IMPACT ASSESSMENT BETWEEN OBJECTS IN A BIM SYSTEM

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ABSTRACT

Mechanical/Electrical/Piping (MEP) systems, due to their complexity and diversity, are the most intricate part of building construction. This being the case, Combined Services Drawings (CSD) and Structure, Electric and Mechanic(SEM) drawings can ensure that all coordination issues are resolved prior to construction. Construction companies attempt to apply Building Information Modeling (BIM) to manage and integrate engineering information and solutions efficiently into the CSD and SEM processes to enhance the accuracy of design and the efficiency of review. There are several powerful commercial tools, such as Bentley Navigator, Autodesk Navisworks, and Tekla BIMsight, that can review the integrated BIM model and detect conflicts in systems, and allow planners to correct the conflict issues one at a time. However, for increasing numbers of conflicts, this may be inefficient, and requires them to be arranged in a list according to impact and seriousness before solving them. For this reason, this research implements a module for conflict impact assessment based on rule-based reasoning to classify and weigh conflict impact and seriousness, and highlight the conflicted objects in the BIM system in different colors depending on their conflict type and seriousness during the analysis. This system not only detects and lists possible conflicts and errors, but also sorts them according to the severity of impact and conflict type. Planners can effectively modify the BIM models according to these conflicts as they are listed and visualized in the BIM system. If these conflicts, such as pipeline interference and problems of insufficient space, can be avoided in the early stages of planning, it facilitates the achievement of project objectives in quality, scheduling, and cost.

KEYWORDS

BIM, CSD, SEM, Conflict Detection, Impact Assessment

INTRODUCTION

Integrated building design is a process of design in which multiple disciplines and seemingly unrelated aspects of a project's design are integrated in a manner that permits synergistic benefits to be realized. However, design conflicts still occur due to various dependencies (Klein *et al.*, 1989; Hellmund *et al.*, 2008; Wall *et al.*, 1995). Therefore, management of these design conflicts is critical to the success of the design. Therefore, it is necessary to have a methodology to describe, understand, and evaluate the relationship between the design process and the design conflicts in collaborative design (Ceroni *et al.*, 2003; Lu *et al.*, 2000; He *et al.*, 2012). Wu *et al.* (2010) propose a research about a 4D workspace conflict detection and analysis system for solving space issues in construction sites. The realization of conflict detection technology has also been greatly accelerated by the availability of powerful commercial design review and analysis software for integrated design processes, such as Autodesk Navisworks, Bentley AECOsim Building Designer, Bentley Navigator, Tekla BIMsight, *etc*. All of these are able to display conflicts found in conflict checks and mark these with different colors to represent various statuses. However, issues occur when the system generates a large number of conflicts, and it is difficult to identify which are more important and urgent. This research seeks to implement a module for building information modeling (BIM) for conflict impact assessment based on rule-based reasoning to classify and weigh conflict impact and seriousness in order to facilitate modifying the integrated BIM model effectively and efficiently.

CONFLICT IMPACT ASSESSMENT

This study defines four major conflict types between different BIM objects in the system, as shown in Table 1. This research also includes an extra time-space conflict between the project architecture and large equipment to prevent occurrences of dynamic conflicts during construction, as shown in Table 2. Conflict rules were developed according to the results of industry interviews investigating conflict evaluation and conflict seriousness during the integrated design process, as shown in Table 3.

Table 1 – Design conflict types between different BIM objects.

	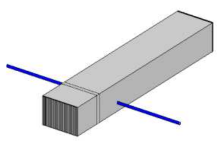	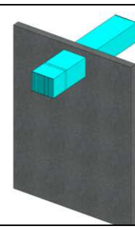	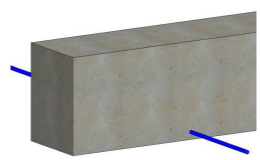
Type 1	Type 2	Type 3	Type 4
Structure vs. Architecture	MEP vs. MEP	Architecture vs. MEP	Structure vs. MEP

Table 2 – Possible time-space conflicts between architecture and large equipment.

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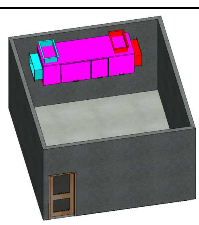
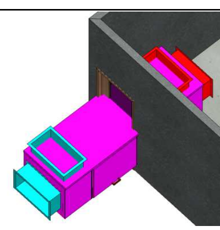
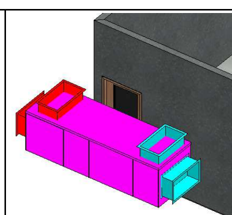
<tr><td></td><td></td><td></td></tr>
<tr><td>Design conflict between large equipment and architecture object.</td><td colspan="2">Opening is too small to move large equipment into the room space after installing the wall.</td></tr>
</table>

Table 3 – Conflict rules for the integrated design process.

Priority	Type	Color	Code	Rule
P1 Serious Design Conflict	Architecture vs. Structure	Red	1201	Conflicts between columns and beams.
			1202	Conflicts between beams and slabs.
			1203	Conflicts between stairs and columns.
			1204	Conflicts between stairs and beams.
			1205	Conflicts between walls and columns.
			1206	Conflicts between walls and beams.
			1207	Conflicts between walls and slabs.
P2 Minor Design Conflict	MEP vs. MEP	Orange	3301	Conflicts between air conditioning pipelines and power pipelines.
			3302	Conflicts between power pipelines and weak current pipelines.
			3303	Conflicts between feed pipes and sewage pipes.
			3304	Conflicts between sewage pipes and drain pipes.
			3305	Conflicts between drain pipes and rain pipes.
P3 Time-space Dynamic Conflict	Architecture vs. Space	Purple	1401	Conflicts between Architecture and Space.
P4 Ordinary design Conflict	MEP vs. Architecture	Yellow	1301	The diameter of pipeline is the larger than the thickness of the wall.
			1302	Conflicts between walls and power pipelines.
			1303	Conflicts between walls and weak current pipelines.
			1304	Conflicts between walls and power pipelines.
P4 Ordinary Design Conflict	MEP vs. Structure	Yellow	2301	Conflicts between vertical pipelines and column objects.
			2302	Conflicts between vertical pipelines and beam objects.
			2303	Conflicts between vertical pipelines and slab objects.
			2304	Conflicts between horizontal pipelines and column objects.
			2305	Conflicts between horizontal pipelines and beam objects.
			2306	Conflicts between horizontal pipelines and slab objects.

VISUAL TIME-SPACE CONFLICTS DETECTION MODULE

Figure 1 depicts the basic framework of the system's design. This study takes advantage of BIM technology to integrate the project's architecture, structure, and its mechanical/electrical/piping (MEP) model. Furthermore, this study considers time and model to develops a visual time-space conflict detection module based on Bentley Navigator to analyze, evaluate, and display conflicts. Three easy-to-use modules are developed to provide the core services of conflict impact assessment, as discussed in the following sections.

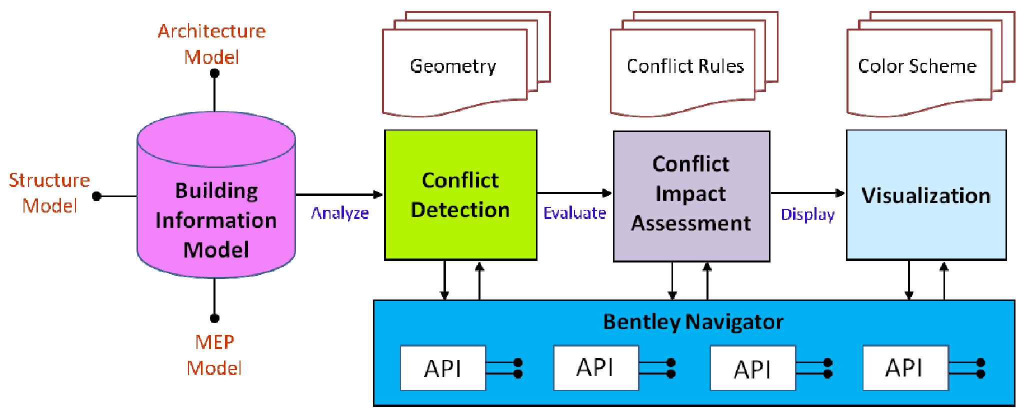


Figure 1 – System framework.

Conflict Detection

This system can detect two different categories of conflict: "Design Conflict" and "Time-Space Dynamic Conflict". The conflicts represent a mathematical intersection. The intersection of O_a and O_b is written as $O_a \cap O_b$ and formally as:

$$O_a \cap O_b = \{x: x \in O_a \wedge x \in O_b\}. \quad (1)$$

That is, $x \in O_a \cap O_b$, if and only if $x \in O_a$ and $x \in O_b$.

This formula is implemented into the system to detect conflicts between objects.

This research also binds 3D models with their corresponding construction schedules to simulate time-space conflicts before actual construction commences for preventing damage conflict. An example of this is if a worker wants to set up equipment in the correct position and the exit is too narrow or small, they must then remove the door for handling equipment.

Conflict Impact Assessment

After the conflict detection phase, the system will list all conflicts. Then, the system will evaluate the seriousness of these conflicts based on the proposed conflict rules. Finally, the system will rearrange the conflict list in order to assist the construction-planning engineer in detecting conflicts and correcting them effectively and efficiently.

Visualization

During the simulation, the 3D objects in the construction BIM model are highlighted in different colors depending on their conflict types. Table 3 shows the color scheme implemented with examples of the kind of BIM objects that would raise these specific conflicts.

DEMONSTRATION

A dormitory engineering project in the Yanchao campus at the National Kaohsiung University of Applied Sciences, completed in 2010, was used as a test case. This project was divided into three seven-floor buildings. This study focused on the jointed basement due to it having complete architecture, structure, and MEP BIM objects, as shown in Figure 2.

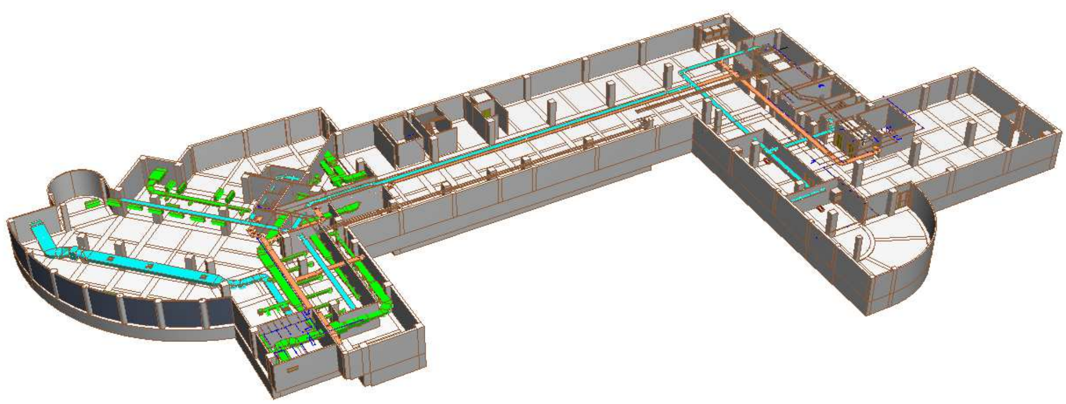


Figure 2 – Example engineering project.

The system provided user-friendly interfaces for construction planning in grouping architectural, structural, and MEP BIM objects into item sets, as shown in Figure 3. Figure 4 shows the user interface for the conflict analysis. The left window (as indicated by Frame A) was used to set up the abovementioned conflict rules for conflict analysis, and the right window (as indicated by Frame B) was used to display the results of the conflict analysis between the architectural, structural, and MEP BIM objects, while the bottom window (as indicated by Frame C) was used to show related information for the objects in conflict. Finally, the conflict objects in the BIM system were highlighted in different colors depending on their conflict type and seriousness during the analysis, as shown in Figure 5.

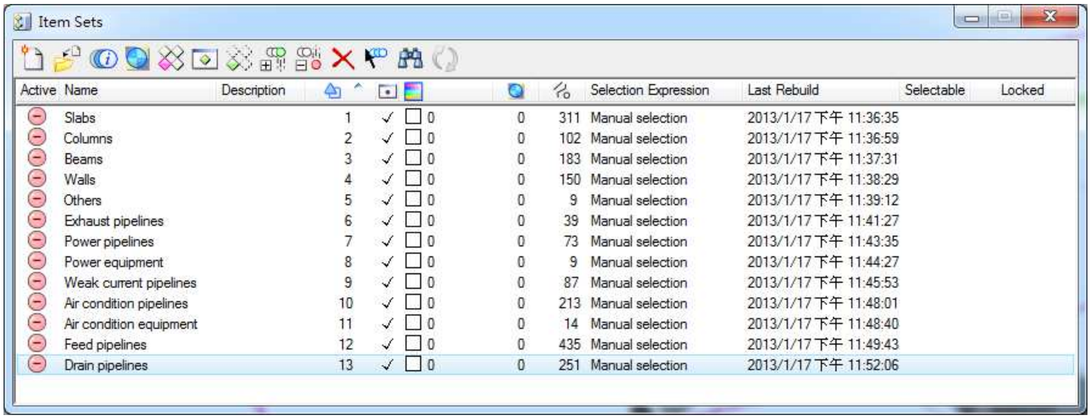


Figure 3 – BIM objects grouped by Item Sets in the BIM system.

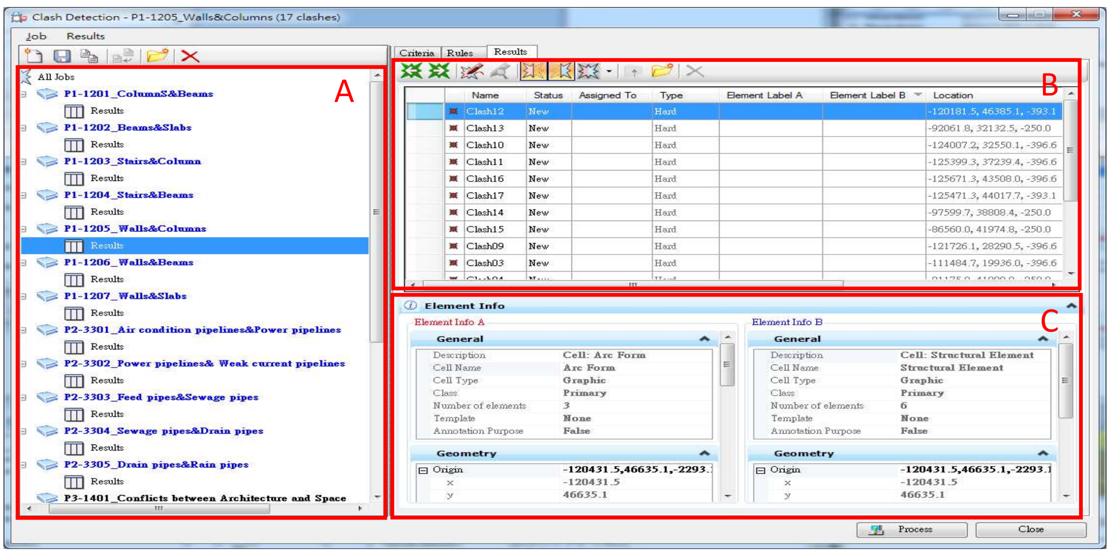


Figure 4 – Conflict analysis according conflict rules.

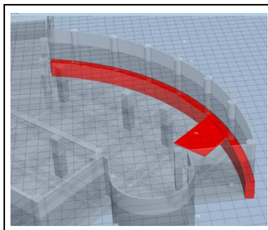
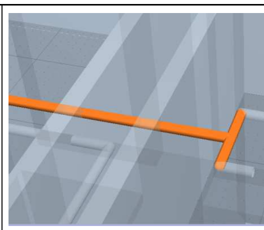
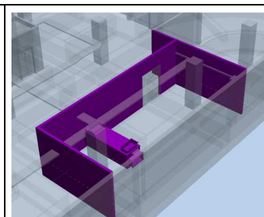
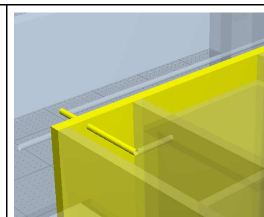
			
Structure vs. Architecture	MEP vs. MEP	Architecture vs. MEP	Structure vs. MEP

Figure 5 – Conflict visualization in the BIM system.

CONCLUSION

Integrated design with Building Information Modeling (BIM) is distinguished from conventional design by its use of a highly collaborative project team from a greater number of professions. Therefore, it is a more effective and efficient method than traditional 2D design for fulfilling specific project requirements. However, a precondition to this is solving all conflicts during the integrated design process. Although existing software is able to detect design conflicts, it fails to classify and weigh the conflict impact and seriousness.

Thus, this research implemented a module for conflict impact assessment based on rule-based reasoning to analyze conflict impact and seriousness, highlighting the conflicted objects in the BIM system in different colors depending on their conflict type and seriousness. This method reduces the time taken to solve design conflicts, simplifies the process of the integrated design, as well as minimizing design time and errors.

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