**buildingSMART International (2022)**
451-STUDENT Student Research using openBIM

oNlgqeQJ

# Developing an automated information inquiry framework for 4D BIM

## Entrant details

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|---|---|
| Role or Job Title on the Project | Researcher, Programmer |
| Employer | |
| Ramaji, Issa | |
| Employer Role | Academic or Research Institution |
| Are you or your employer a member of buildingSMART? | No |

## Entry details

## Entry Details

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| By checking this box I understand and acknowledge that this awards program is to assess information about openBIM, and that openBIM is not only about the use of solutions. openBIM is about setting up an environment where every party in a team can work in the optimal way ("how they prefer") without putting limitations on others. It is about freedom to take control over your data and workflows, while keeping that freedom for others as well. Full use of open standards is not mandatory for this mission. | ✓ |

Location

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Submitting Party and Stakeholder Logos (compiled into one .ppt/pptx file for upload)

| PPTX | contributors to the proje... (37 KiB download) |
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Entry Description

About the Project
This project was on the development of an automated information inquiry framework for 4D BIM. The project's goals are to accelerate information retrieval from BIM models and enable non-technical users to have access to the information. The framework and its software implementation create a Siri-like experience in which the user asks questions in a natural language and receives the answers in a few seconds.
The authors used ifcOWL- a web ontology language presentation of the IFC schema- to semantically understand the input questions and their parameters.

Core Objective
To facilitate accessing information in BIM models since accessing this information could be tedious and time-consuming for non-technical users, who might have limited or no knowledge of working with BIM software. Especially, the project seeks to provide a user-friendly environment for Navisworks software. Also, since lack of BIM expertise is one of the barrios to adopting BIM in construction projects, This project aims to remove any need for skill to access information on BIM models.

Scope
This project focuses on 4D BIM information that are important and common in the construction phase. This project is also applicable to all BIM models. It is developing to make a BIM assistant available for all the BIM models, which can automatically answer any users' questions during the construction phase.

Results
The proposed framework facilitates and accelerates accessing information in BIM models during the construction phase of the building project by automating the information query process. The evaluation of the platform shows that the voice assistant facilitates information retrieval from the BIM model, outperforming manual methods in five out of six questions investigated in the case study. The results illustrate that the platform can correctly recognize the type of users' questions. It can also understand the user's exact purpose utilizing NLP and ifcOWL ontology and return the related elements or requirements from the model. Its accuracy and precision in answering are considerably high. Another point of the platform is the speed of answering. In five of six question types, the speed is two to five times faster than manual QTO in Navisworks.

What stage of completion is the entry content representing? | Initial Development

Stakeholder Statements

Navisworks software users

Upload a 2 minute video to show the scope of the entry.

| MP4 | Q1.mp4 (3.1 MiB download) |
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Problem Statement

Building Information Modeling (BIM) is a trending technology in the building industry that can increase efficiency throughout the construction process. Various practical information can be obtained from BIM models during the project life cycle. However, accessing this information could be tedious and time-consuming for non-technical users, who might have limited or no knowledge of working with BIM software. Automating the information inquiry process can potentially address this need. This research proposes an Artificial Intelligence-based framework to facilitate accessing information in BIM models. there are some challenges, and some of these are as follows:
• Automating information inquiry related to the most practical and needed information in the construction phase is a challenge and requires more considers.
• Keyword-based search is unable to consider semantic complexities and syntax variations.
• Text-based answers to users' questions may sometimes not be enough. Visualizing the responses (e.g., showing the items mentioned in the users' question, showing tables) will help the user better understand the answer.

Previous efforts and limitations

Many types of research tried to facilitate access to information of BIM models; however, no research has done the information extraction process to facilitate accessing 4D BIM information. They mostly are keyword-based, and as a result, the accuracy of answering is low. Understanding the user's purpose from their question can potentially solve this problem. Utilizing ontologies can improve semantic reasoning and understanding, facilitate sharing information, be effective and practical for information retrieval and extraction, etc. This project takes advantage of the semantic understanding of sentences from ontology. Therefore a domain ontology named IfcOWL) are used to increase the accuracy in understanding users require.

Research method

The project framework includes the following steps:
• Step 1: the user's question type is determined through a Support Vector Machine (SVM) algorithm. Various functions are provided to be activated based on the user's question type and search the model for an answer. Therefore, determining the question type of users is essential in the first step.

- Step 2: the question is analyzed with a Natural Language Processing (NLP) algorithm to extract keywords. NLP is used for the syntactic understanding of the user's question.
  • Step 3: Understanding the user's purpose is critical for the question answering system. Keywords of the question alone cannot achieve the user's purpose and are not ready to be directly searched because a keyword may be just one form of a different term representing the same meaning. Additional terms have the same meaning and various forms of a term, such as abbreviations. Therefore, corresponding synonyms and other forms of keywords must be collected and used to search in the database. So, the keywords extracted from the last step are expanded through a domain ontology and a general ontology. The expansion method has two parts: 1) using Wordnet, a general ontology, the query's keywords will be expanded with their general synonyms, and 2) Several semantic resources have been developed, such as ISO 12006-2, Uniclass, OmniClass, Industrial Foundation Classes (IFC). In this research, IFC specification, a semantic foundation, is used for ontology foundation because of its wide range of definitions of various terms. Instead of creating a new ontology, ifcOWL, which provides a web ontology language representation of the IFC schema, is employed. Therefore, utilizing ifcOWL, specialized semantic concepts related to the construction industry will be added to the user's query by utilizing the relationships between concepts in ifcOWL for a more accurate search. Accordingly, a final query is formed based on keywords and their expanded concepts.

• Step 4: the identified keywords and expanded terms are mapped to lists of objects, materials, and tasks in the BIM model. The components or tasks the user wants are picked as the target term if they exist in the lists of the BIM model.
• Step 5: an API is called to employ the identified question type and the target terms, find the answer in the BIM and display them to the users. Also, to create a more user-friendly environment, "Google web speech API" is used so that the users can interact with the platform through their voice, talk with the platform and hear the answers. Doing so is inspired by similar platforms such as Google Assistant, Siri, Alexa, etc.

Findings/Validation

A standard BIM model was chosen to evaluate the platform, and BIM experts and non-experts were recruited to ask the platform some questions from each query type. Four principles were considered to assess the performance of this platform: • Query classification, • Parameters recognition (purpose of the user), • Answer checking, and • Response speed.
The results for each principle are as follows:
• Query classification: 116 of the 120 question types were correctly recognized by the platform, resulting in 96.66% accuracy in the case of query classifying.
• Parameters recognition (purpose of the user): most of the parameters found from users' queries were the exact purpose of them, and the platform considerably recognized their needs and found them from the model. Therefore, 91.66% of accuracy was also achieved for this case.
• Answer checking: every answer found by the platform was equal to the answer that Navisworks QTO achieved. It should be noted that for some elements in the model, the value of properties was not defined. For instance, the area of "Travertine for Ramp" was not specified. This platform found and highlighted this element but returned zero as the value, which was reasonable. Therefore, for this principle, an accuracy of 100% was achieved.
• Response speed: in conclusion, this platform is 2 to 5 times faster in answering rather than manual search and using Navisworks quantity take-off.

Conclusion/Contributions/Limitations

There is essential information in a BIM model needed by stakeholders of a project during the construction phase. Access to this information is especially tedious and time-consuming for non-expert BIM users, which could lead to a lower BIM adoption rate in construction projects. To address this issue, this research has introduced a question answering platform that understands the vocal natural language question of the user and returns the answers through an automated information retrieval from 4D BIM.
The proposed framework facilitates and accelerates accessing information in BIM models during the construction phase of the building project by automating the information query process. The evaluation of the platform shows that the voice assistant facilitates information retrieval from the BIM model, outperforming manual methods in five out of six questions investigated in the case study. The results illustrate that the platform can correctly recognize the type of users' questions. It can also understand the user's exact purpose and return the related elements or requirements from the model. Its accuracy and precision in answering are considerably high. Another point of the platform is the speed of answering. The speed was two to five times faster than manual QTO in Navisworks in five of six question types. For one question type (list of tasks that must be finished in a specific timeline), the speed of answering equals the manual searching. One significant advantage of this platform is that anyone can ask their questions and achieve responses directly, regardless of the users' BIM skills. The platform enables non-technical users to benefit from BIM without intermediaries.
The platform can be extended for the automation of other information retrievals from BIM models. Additionally, enriching ontologies for a better understanding of the user's purpose can be potentially led to enhancing the performance of the proposed voice assistant. Implementation of the platform on the web will increase the accessibility and versatility of the platform.
The platform has some limitations that can be addressed in the future: 1) IfcOWL, which is used as a domain ontology, has not enough terms of materials and objects, so it needs to be combined with other existing AEC ontologies such as Uniclass or OmniClass, 2) the user can't ask about the quantity of more than one material in a question; however, it is possible to ask for one material in several objects within one question, 3) the user can't ask for two different quantities (such as Area and Volume) in one question, 4) grammar used for analyzing questions and finding noun phrases is not specialized for each question type. Using specific grammar for each question type can improve understanding of the user's purpose, 5) for question one (finding the quantity of material in a specific location), the location is limited to stories named layers in this research. To better answer this question, it is needed to consider the particular location users want and answer them based on that location. It most likely can be done by determining the location's X, Y, and Z boundaries and searching all objects and material within the specific boundary.

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## openBIM Evidence

Software Ecosystem Map

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| PDF | 3.pdf (5 KiB download) |

Process Maps

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| PDF | 4.pdf (237 KiB download) |

openBIM Data Metrics Summary

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| Upload .ifc file(s) or other technical files to support validation of the research results. | https://1drv.ms/u/s!AiseELu7YPcZqA9Dtk02mtBr97RE?e=Ut9SKG |

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## Use Cases

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| BIM Uses were defined on the project | ✓ |
| BIM Uses formed an integral part to how the project was delivered | ✓ |

Documentation on use case(s) as a single file upload

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| PDF | 6.pdf (290 KiB download) |

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