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OPTIMIZING CAD-SIMULATION INTEGRATION: AN AUTOMATED FRAMEWORK FOR MODEL GENERATION

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ABSTRACT

The integration of Computer-Aided Design (CAD) models into discrete event simulation software is a critical requirement for many simulation projects, particularly those involving the movement of people or vehicles where spatial accuracy directly impacts study outcomes. While importing CAD files and configuring simulation elements is essential for system accuracy, this process is typically time-consuming, prone to errors, and involves substantial repetitive tasks. Although previous attempts have been made to automate this workflow, the wide variety of CAD formats and lack of standardization pose significant challenges. This paper presents novel approaches for automating CAD import processes, specifically focusing on 2D drawings using the ezdxf Python library and 3D models using Revit Python Shell. Our methods demonstrate potential time savings and error reduction in simulation model development while maintaining spatial accuracy.

1 INTRODUCTION

Companies develop sophisticated discrete event simulation models to optimize and predict performance across their global network. Given environments rapid changes and increasing complexity of operations, there is a critical need for accelerated analysis methodologies that maintain high precision. To address this challenge, we have developed an automated CAD-to-simulation conversion tool that significantly reduces model development time while preserving spatial accuracy. This innovation enables rapid deployment of simulation models across Amazon's diverse warehouse configurations, supporting data-driven decision-making in facility design and operations.

2 SOLUTION

Our research presents two complementary approaches for automated CAD-to-simulation conversion: one for 2D and another for 3D CAD drawings. Both solutions utilize Python scripts to extract geometric data and generate standardized text files that can be used to automatically construct conveyor system layouts in simulation software. For 2D designs, the ezdxf Python library (ezdxf nd) is used, selected for its robust capabilities in reading, extracting, and modifying DXF file information. The library's active development and comprehensive documentation make it particularly suitable for this application. Our algorithm follows the following approach. Initially it filters the drawing by target layers containing conveyor components. If blocks (reusable components made of a collection of geometric objects) are not correctly assigned to layers, it is possible to use other attributes, such as name, as a filter. If the filtered blocks contain attributes, such as width and length, those are extracted, if not, all the elements of the blocks are searched in order to create a coordinate mapping, such as a bounding box. Curves are handled differently and information such as radius and start/end angles are extracted. Directions can also be retrieved from drawing if there is standardization on the placement coordinate of the block. For 3D drawings, we developed an alternate solution using Revit Python Shell (revitpythonshell nd), addressing the limitations of DXF exports from 3D models where z-coordinates are lost or blocks are converted to 3DSolid entities and not much information can be extracted from those. The approch is similar in that it will extract attributes and coordinate mapping from family instances, which are comparable to blocks. If not enough information is found in the family, it is also possible to loop through geometry elements which is less preferred as it increases computational complexity. Both solutions significantly reduce model development time while maintaining spatial accuracy, though their effectiveness is enhanced when CAD files follow standardized conventions for component properties and placement. Research is ongoing, but we estimate a reduction of about 50% in the time taken to set up a simulation model.

3 DESIGN BEST PRACTICES FOR CAD IMPORT AUTOMATION

The disconnect between CAD designers and simulation engineers often creates challenges in efficiently translating designs into accurate simulation models. To bridge this gap and streamline the CAD-to-simulation workflow, we propose the following best practices for CAD design that can significantly enhance the automation process and improve simulation model accuracy:

- Standardized Layer Usage: Implement a consistent layering system to enable simulation engineers to efficiently filter and extract relevant information.
- Align Drawing and Flow Directions: Ensure that the drawing direction of linear elements (e.g., tracks, conveyors, roads) corresponds to the intended flow direction. While directional arrows are common visual indicators, they are challenging to interpret programmatically.
- Implement Standardized and Semantic Labeling: Utilize meaningful and consistent naming conventions for CAD elements. These labels can be easily extracted and interpreted to automatically populate simulation model parameters such as conveyor type, speed, and capacity. This practice eliminates manual data entry, reducing errors and significantly accelerating model development.
- Document CAD Standards: Develop and maintain a comprehensive guide detailing the CAD standards and best practices specific to simulation model creation. This documentation serves as a valuable resource for both CAD designers and simulation engineers, promoting consistency across projects and teams.

By adopting these practices, organizations can significantly reduce the time and effort required to translate CAD designs into simulation models, while simultaneously improving model accuracy and reliability. This approach fosters better collaboration between design and simulation teams, ultimately leading to more efficient and effective system analysis and optimization.

4 CHALLENGES AND FUTURE RESEARCH

A fundamental organizational challenge lies in the traditional separation between design and simulation teams. The lack of standardized practices and limited communication channels often results in redundant work and inefficient workflows. While establishing cross-functional standards and maintaining open communication can significantly improve team performance, there is an opportunity to evolve beyond simple collaboration. We envision a more integrated approach where simulation capabilities actively drive design decisions where simulation becomes an integral part of the early design process, incorporating established best practices and system knowledge.

Future research directions could explore bi-directional CAD-simulation integration. While this study focused on extracting CAD data and automatically generating simulation models, an interesting topic would be to automatically generate updated CAD drawings based on simulation results, which could accelerate the design-simulation cycle.

REFERENCES

ezdxf n.d.. “ezdxf Documentation”. https://ezdxf.readthedocs.io/en/stable/. Accessed: 2025-07-08.

revitpythonshell nd. “Revit Interactive Python Shell”. https://github.com/architecture-building-systems/revitpythonshell. Accessed: 2025-07-08.