

Deep auto Modeller

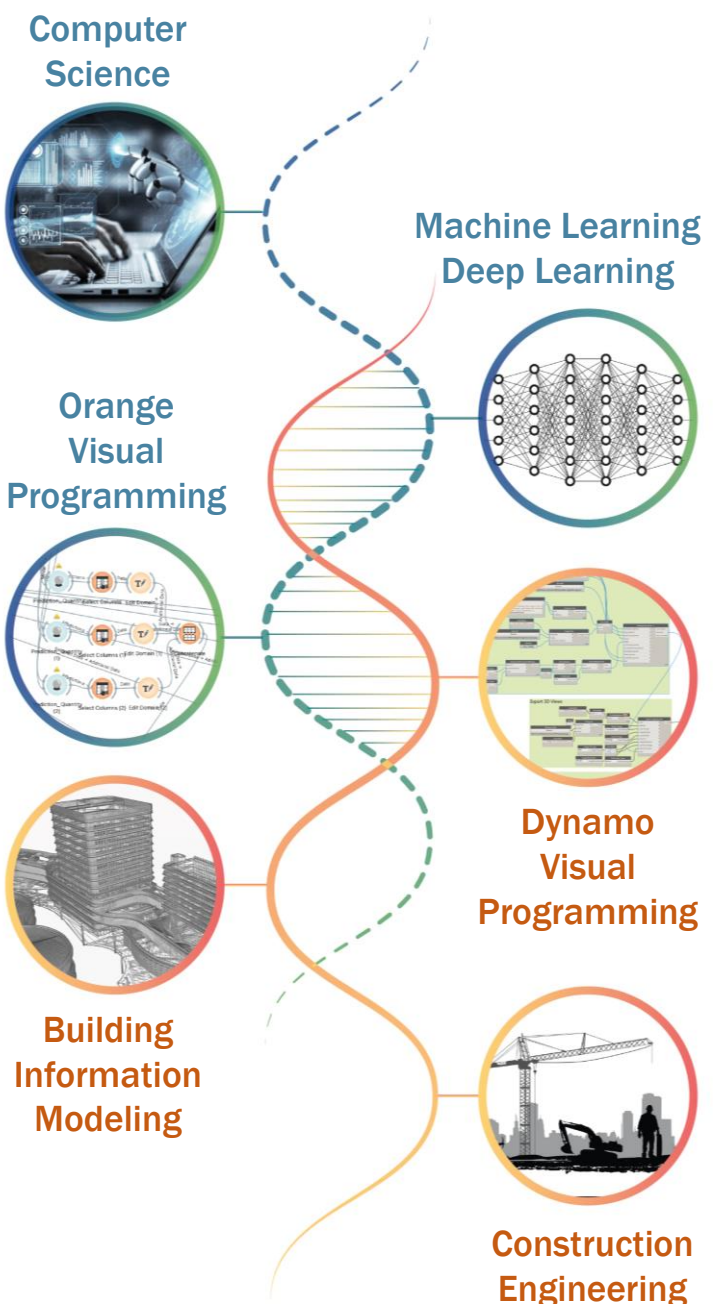
A cross-visual programming tool for BIM data and deep learning

Construction digitalization is increasingly significant in the Architecture, Engineering, Construction, and Operations (AECO) industry due to the urgent need for efficient information sharing, smart planning, design and construction, and sustainable asset and facility management. As a process of digitalizing the built assets into a management system, Building Information Modeling (BIM) can improve the sharing efficiency and accuracy of the information and help decision-making. To advance construction digitalization in Hong Kong, the information on public and private construction projects has been required to be updated into BIM models across the whole project life cycle. For example, HKSARG has mandated the utilization of BIM on all capital works projects with a budget of HK\$ 30 million or more since 2017 (DevB 2019), while all private works with a budget of HK\$ 300 million or more are required to adopt BIM for construction management by 2026 (CIC 2022).

With the release of BIM Standards - General (Version 2 - December 2020) (CIC 2020), the applications and implementations of BIM have been widely discussed and explored by both the industry and academia. Among various BIM uses, the concept of the Digital Twin has attracted great attention due to its potential ability to represent reality through a virtual model. However, the success of BIM uses and applications rely heavily on the BIM data quality and quantity. The insufficient level of detail (LOD) of BIM can lead to the failure of performing various BIM uses, such as analysis and simulation.

BIM detailing refers to the process of increasing the LOD for construction projects. Currently, this process is labor-intensive and time-consuming as it requires lots of BIMers and BIM Modellers to manually and constantly increase the amount of data throughout the project. While construction projects in HK are getting more difficult and complex, the importance of information depth becomes crucial and leverages the consequences of information loss. However, due to the low added value of manually created high LOD of BIM objects, many BIM objects might not have adequate components of information needed in the digital twin applications. Therefore, an efficient method for automatic BIM detailing should be developed.

Background



Challenge of Achieving

Under the need for a more efficient way to increase the LOD and alleviate the workload for BIMers and BIM Modellers, during our product development process, we adopt the knowledge from the computer science discipline to develop our Deep auto Modeller. During the product development period, we mainly focus on solving the following difficulties:

➤ How to assist dynamic projects with BIM detailing?

As construction projects by nature are dynamic and contain lots of variables and uncertainties. The detail of the model is critical to the successful implementation of BIM in managing dynamic projects. A higher LOD of BIM enables different applications to perform more dynamically and store more semantic information in the models, which can further affect and assist stakeholders in the decision-making process. However, as BIM detailing is time-consuming and requires interdisciplinary engineers to create detailed components and collaborate throughout the project, an appropriate LOD of BIM would be preferred and suggested based on the different stages of the project.

➤ How to auto-create BIM with the assistance of machine learning (ML) and deep learning (DL)?

Although BIM has already been considered a centralized information hub for storing various types of geometric and non-geometric data, the native BIM-format data cannot be directly used by the ML and DL. Therefore, an appropriate data exchange method and process, from native BIM-format data to ML readable data, should be developed.

➤ How to deliver the final product integration?

As for the innovative application of BIM, how to fully deliver the automatic BIM detailing process is significant, including extracting existing BIM data, adopting ML models for predicting missing BIM components, and using parametric design to detail the missing components automatically. Therefore, how to deliver the final product integration is the third challenge.

Breakthrough

As the adoption of BIM increases in the AECO sector, various BIM uses have been explored and adopted rapidly, including the digital twin of the project. However, the current industrial practice requires great resources to achieve a higher LOD of BIM to perform dynamic and accurate project status. Meanwhile, the rapid development and application of deep learning technologies in BIM have proven to be effective in facilitating BIM-related works. This product will utilize deep learning to fill in the missing motion components in BIM objects to increase the interactive and dynamic performance of BIM applications. The productivity and applicability of current systems directly influence the convenience of BIM detailing in HK.

Innovation Highlights

In short, there are three highlights of our product:

1

Automatically extracting/writing data with Dynamo

- Automatically extracting the standard parameter value and the 3D view for DL.
- Automatically run Python script inside Dynamo to operate difficult and customized code.
- Automatically create the BIM elements by using the prediction results.

2

Linking BIM and ML

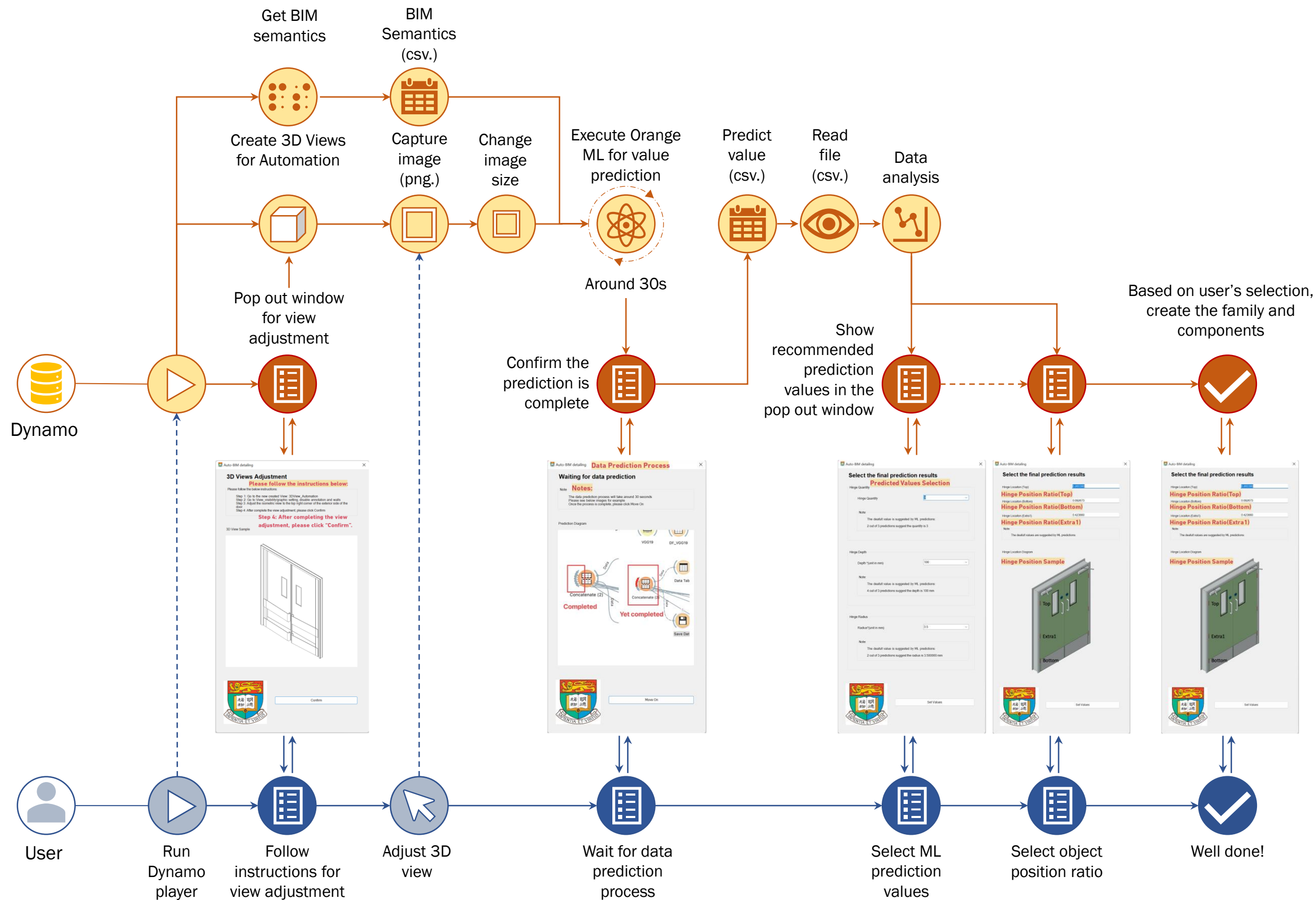
- Training data collection from the NBS library with high-quality & high-standardized data.
- Adopting the DL to increase the accuracy of prediction.

3

Integrated product delivery

- Proactively utilizing a single Dynamo script to conduct all the automation (ready-to-used).
- User-friendly UI with clear illustrational images to guide the user.
- Enable users to select/input other values.

Product workflow



Enhancement in productivity

The proposed BIM detailing product provides a feasible and efficient tool for automatic BIM detailing design, which will promote the BIM application in the field of digital twin by creating high-level detailed BIM models in terms of four aspects:

- (1) **Cost-effective:** Fewer requirements of supporting documents (e.g., detail drawings) and design experiences of users;
- (2) **Qualified detailed results:** Higher rate of consistent with AEC industry that reduces an average of 47.4% (up to 58.7%) of design error;
- (3) **Time-efficient:** The automatic generating of detailed components cost in minutes level (about 2 minutes for the whole process, while ML takes around 30 seconds);
- (4) **User-friendly:** BIM modelers can focus on the general designs, while the detailed BIM components, even the invisible ones, can be created automatically.

Enhancement in quality

The enhancement in quality is summarized in two aspects, the quality of the product and the corresponding enhancement in BIM detailing quality.

(1) Quality of the BIM detailing product:

- **Robust:** The BIM detailing product for Revit is developed based on Dynamo, a stable product for Revit that provides a graphical interface for users to perform parametric-related functions of BIM objects.
- **Satisfaction:** The development foundation of the BIM detailing product involves three tools, Autodesk Revit (Version 2022), Dynamo for Revit (Version 2.12), and Orange data mining (Version 3.31), which guarantee the satisfaction of the BIM detailing product. Because all the foundation tools are widely used in the AECO industry.
- **Price:** At present, the product is free for use and open-source for future development.

(2) Quality of the BIM detailing output:

- **Error-eliminated:** By utilizing the deep features of BIM components, the generated components are actually verified by “thousands of training examples” that guarantee the alignment of design criteria and BIM semantic schema. An average of 47.4% (up to 58.7%) of design error is eliminated.
- **Time-efficient:** The automatic generating of detailed components cost in minutes level (about 5 minutes to generate detailed components).
- **Effective decision-making:** Suggested BIM detailing design is provided by the product, which enables designers to make an efficient decision for different purposes.

Achievement of the Breakthrough

Published paper:

Chen, S. H., & Xue, F. (2023). Automatic BIM detailing using deep features of 3D views. *Automation in Construction*, 148, 104780. doi: <https://doi.org/10.1016/j.autcon.2023.104780>

Reference:

CIC. (2022). CIC-BIM Network Sharing Session. Hong Kong: CIC-BIM. Hong Kong: Construction Industry Council.

DevB. (2018). Construction 2.0: Time to change. Hong Kong: Development Bureau, Government of Hong Kong SAR.

CIC. (2020). BIM Standards - General (Version 2 - December 2020). Hong Kong: CIC-BIM. Hong Kong: Construction Industry Council.