APPLY BIM COORDINATE ON NON-UNIFORM BUILDINGS AND STRUCUTURES

Exploring Revit and Dynamo as a method

HAOTONG BU ,
University of New South Wales, Sydney, China
Email address: z5158047@ad.unsw.edu.au

HAOTONG BU

Abstract

Nowadays, BIM collaboration technology is widely used in a variety of engineering and design practice, providing technical support for project completion and accuracy. But now BIM Technology also has some technical bottlenecks and limitations, such as the application of complex special-shaped structure. Due to the gradual change of the aesthetic trend of designers, more and more irregular design forms appear in the architectural structure design. This limitation of BIM collaboration is becoming obvious.

In detail, many special-shaped structures have twisted or irregular curved walls, external curtain walls and structural systems. This is difficult for every major in BIM collaboration. From the point of view of structural design, it may not be difficult to complete the structural model in this special-shaped structure. It is difficult to transform this part of the model into a shared platform for BIM collaboration. As different disciplines may share different BIM platforms, this also leads to differences in data standards. However, the initial models of professional collaboration are basically NURBS 3D data. Therefore, I hope that through the relevant algorithm and logic language, we can find that the NURBS 3D data can be transformed into the relevant BIM platform data. Finally, this algorithm hopes to develop into a general use package, which can adapt to the use of a variety of BIM platforms. And it can ensure the accuracy of the model. This algorithm is mainly through Python or Java language, binary model data and BIM platform data conversion. Form a platform interface for complex surface structure. And grevit and provingground could potential be the API that connects the convert the complicated model to the BIM data, which are the plugins based on grasshopper. However, some researches about these APIs show that they also have some limitations for the complicated surfaces or structure and the transferring process is not convenient. But the basic logic of the APIs is converting NURBS 3D data into binary data and using the web port to pass data to BIM platform. Specifically, the APIs are subdividing the surface into controlling points and extract the coordinates of the points which could be transform into binary data read by BIM platform. And the basic language was Python. So, a python script could be potentially developed to solve the problem.

At the same time, the algorithm can also consider the unified standard. Because each specialty has its own independent evaluation system and technical standards, there will be inconsistent standards in cooperation. Through the research of each standard system, the differences are combined into the algorithm to solve.

Keywords.

BIM Coordinates, Disciplinary Standards, Transforming API, NURBS

1. Introduction: (Research context and motivations)

With the increasing complexity of irregular building modelling, the amount of information attached to the building is also increasing. The traditional modelling method can not solve the problem of irregular surface shape creation and repetitive modelling. How to quickly and accurately establish the model and manage the model information has become an urgent problem. Parametric technology provides a flexible modelling method for the generation of geometric shape, and BIM platform can effectively integrate the information of the whole life cycle of the building. Therefore, it is of great significance to study how to use BIM parametric technology to realize the rapid creation of irregular surface and component information management.

The purpose of this paper is to solve the problem of complex curved surface modelling, many kinds of components and information, and low efficiency of traditional modelling method. Based on the platform of Revit and its plug-in dynamo, this paper mainly studies the parametric modelling, information data exchange and transmission of irregular building surface The modelling logic of typical special-shaped surface is summarized. Reasonable modelling ideas are proposed for different surface types, and dynamo Revit is constructed The model information management system is used for parametric modelling of special-shaped buildings to improve the modelling efficiency and reduce the repetitive work, so as to realize the model information transfer process of "logic parameter model information", and provide technical reserves and experience for similar surface modelling in the future

1. Theoretical research, through the current BIM Technology, parametric design technology theory and status quo research, clear research methods and content, provide theoretical basis and method guidance for this paper.

2. This paper analyzes the BIM Technology and the theoretical basis of parametric modelling, explains its technical core features, application principles and methods, describes the current BIM based parametric modelling method for special-shaped buildings, summarizes the commonly used interactive data formats and interactive software platforms, and determines the software used in this paper.

3. Based on the comparison of typical special-shaped building parametric design cases, this paper summarizes the main generating methods and logic of curved surface shape, combs the thinking of parametric modelling of special-shaped surface, puts forward reasonable modelling scheme for different surface types, and uses

dynamo The parametric control of the surface is realized, and the generated surface is meshed. The adaptive node package is developed for meshing. The dynamo program is used to drive the Revit to quickly generate the surface model.

4. Aiming at the data transmission and processing of special-shaped building components, the dynamo Revit model information management system is constructed, and the systematic parametric management technology solution of irregular building component data is proposed, which is divided into three parts: "basic database data processing platform information output platform" Language development can realize the algorithm of rapid model creation and automatic layout, batch generation and modification of components, as well as rapid generation and output of positioning data. Accurate and reliable data can be output through parametric program, which can realize smooth information exchange between upstream and downstream, and simplify the tedious work of previous manual processing.

2. Research Aims

In the research stage :

I was aimed to figure out a methodology that could solve the problem when applying BIM Coordinates to some complex buildings or model.

And also I hope to find out a solution to unify the standards of multiple disciplinaries.

3. Research Question(s)

Revise the research question submitted from Assignment 1b:

1. What are the platforms for BIM collaboration?
2. What are the difficult parts for the BIM techniques in distorted surface or structures?
3. And how could I separate the workflow of BIM in distorted surface or structures?
4. What are the definitions for distorted surface or structures?
5. How could I realize the data visualization in BIM Technology? In what platforms and programming language?

Based on the issues outlined in the introduction and the derived aims, the question the research this project investigates is:

How the technical problems could be solve when BIM Coordinates is applied to some complex building or structure?

And there could be some risks during the practicing process. How we could avoid or solve the risks?

* How the technical problems could be solve when BIM Coordinates is applied to some complex building or structure?*

4. Methodology

(1) Literature research method
This paper deeply understands the research status of BIM Technology and parametric modelling technology, systematically arranges and analyzes relevant theories, studies the principle of BIM parametric modelling and its related knowledge, summarizes its application difficulties, and the current combination of the two in special-shaped buildings, as the theoretical basis and method guidance of BIM based parametric modelling of special-shaped buildings.

(2) Comparative analysis
This paper analyzes the classic cases of parametric design of typical irregular buildings, summarizes the generation methods of typical curved surfaces, and compares the common points and key points in the cases, as the basis for proposing the framework and method of surface modelling in the study.

(3) Case analysis
Combined with practical engineering cases, the application effect of the proposed modelling method and model information management system is verified, and the key problems of BIM parametric technology in the application of special-shaped buildings are summarized. The practice and related theories are combined to provide reference for the implementation of BIM parametric modelling technology in special-shaped building projects in the future.

(4) Software modelling method
Through the comparison of various modelling software, dynamo + Revit is selected as the modelling software in this paper. Using Python language and design script language built in dynamo, the parametric generation of irregular surface and the management of model data information are carried out.

5. Background Research/Literature review

Introduction of BIM Technology: Generally, Building Information Modelling (BIM) is a kind of coordinate technology and process that combine serval disciplinaries and software to form a guidance for the building design and construction (Hardin, Brad & McCool, Dave 2015). It was a short period form the beginning of BIM to the implementation. BIM technique was transformed from the parametric modelling

research conducted in USA and Europe in late 1970s and early 1980s. And the implementation in real projects started from the mid-2000s. The BIM technique was gradually becoming one of the core techniques in AEC (Architecture Engineering-Construction) in the last decades (Khemlani, L., Papamichael, K., and Harfmann 2009). From a technical point of view, BIM is a kind of project simulation, which consists of threedimensional models of project components including structures, detail piece, pipe ways and etc. And the information extracted from the simulation would be linked to building planning, design, construction and operation (Azhar, Salman, Khalfan, Malik & Maqsood, Tayyab 2012). A constructing model would be built precisely and visualized digitally in the platform of BIM, which could be disassemble into pieces to instructed the constructing process (Azhar 2011). After the model is built, collaborators from multiple disciplinaries would adjust and improve the model in their own field based on the project specifications and design changes to avoid the conflicts between serval disciplinaries. The process is to guarantee the practicability of the constructing project. (Carmona, J., and Irwin 2007). BIM could also visualize the data or constructing model in a digital platform. And the visualization could indicate the potential design, construction or operational problems in a simulation environment. BIM represents a new paradigm in AEC that encourages the integration of the roles of all stakeholders in a project. But now BIM Technology also encountered a corresponding technical bottleneck. That is, how to use BIM Technology well in complex structural environment.

Reasearch Questions: As the new trend of aesthetics in design or architecture field, lots of complex and distorted structures or buildings are been built or designed. And these kinds of modern and historic buildings that are design with distorted surfaces, complex morphological and typological variables could be a technical difficulty in BIM. Generation of complex parametric models needs new scientific knowledge concerning new digital technologies (Banfi, F, Fai, S & Brumana 2017). With the development of software and techniques, diverse modeling tool was invented such as McNeel® Rhinoceros Grasshopper, Autodesk®Maya, Autodesk® Autocad. These applications realize the three-dimensional modelling, simulation, rendering and animation (Piegl, L. A., Tiller, W 1997). However, the parametric design tool currently could not combine with BIM perfectly, without the application interfaces. Potentially, there is solution for the API. As majority of these 3D modelling

application share the same inner algorithm for digital object, a programming language could be developed to simulate the algorithm and convert it into BIM platform data. In detail, the mathematical logic for the applications are building Non-uniform Rational Basis splines (NURBS) in 3D space and transform them into graphics to represent complex 3D elements (Brumana, R., Oreni, D., Cuca, B., Binda, L., Condoleo, P., Triggiani 2014). The improvement of coordination and production in the Architecture, Engineering and Construction industry (AEC) needs new approaches and methodologies to increase the flexibility of modelling for complexity of the 3D distorting surfaces (Barazzetti L., Banfi F., Brumana R., Previtali 2015). Specific conversion tools or languages need to be developed to handle the conversion of NURBS surfaces in specific application scenarios. It may be able to convert formats, or model algorithms, or model languages, etc(Banfi, F, Fai, S & Brumana 2017). So, the primary work for the API was to convert NURBS into BIM data. But, the collaboration could be difficult in those complex structure. And this is the question to be solved in the future. Generally speaking, through some researches, I have found that BIM Technology has some technical limitation when it is applied to complex structures or complex surfaces. However, these limitations could be solved by some methods.

Risks: The first technology-related risk is lack of BIM standards for model integration and management by multidisciplinary teams. In the process of design and construction, each specialty has its own independent standards and technical system. To combine the information together, every team member should access to the BIM model. This needs to establish a unified language and programming system in the BIM platform at the establishment stage of the project. At the moment, since there are no standard protocols available, each firm adopts its own standards (Weygant 2011). This leads to the problem of management confusion when BIM collaboration technology is interdisciplinary. However, this problem often occurs in practical projects Another risk in the application of BIM Technology is who should control the entry of data and be responsible for inaccurate data. Although BIM Technology can save a lot of time and labour costs for construction projects. However, once the data is not accurate, it will lead to the overall construction project can not be promoted, and even need to trace back to the design step to start again. Compared with traditional methods, the problem of data accuracy is one of the risks that needs

to be consider in BIM technology. Thus, Before BIM Technology is fully applied, these risks and their costs should be fully considered (Thompson, D. B., and Miner, R. G. 2007).

Conclusion: The primary goal of the proposed modelling technology applied to BIM in the future is to manage the complex shape and large amount of material information by implementing the BIM platform to the structure and architectural design of the special-shaped surface (Volk, Rebekka, Stengel, Julian & Schultmann, Frank 2014). During the BIM constructing process improvement of the proposed approach and its interoperability should be done to facilitate the proposed new paradigm of modelling automation. Additionally, the risks should be avoided during the BIM process. In BIM Technology, there will inevitably be interdisciplinary work. Therefore, there should be a unified standard among disciplines, which will be transformed into the language of BIM platform. At the same time, the data verification system needs to be established to verify the accuracy of the data.

6. Case Study (Your Project work)

Parameterization is a core concept in BIM Technology. The parameters here are not only the geometric parameters of the model, but also a series of non geometric parameters such as material, model and cost associated with the geometric model. Different from the two-dimensional modeling method, parameters and models are interrelated in the process of modeling based on BIM. When the parameters are modified, the model will change. Correspondingly, if the model changes, the relevant parameter values will also change.

In the application of BIM in special-shaped buildings, compared with conventional buildings, irregular buildings have many nonstandard components, which carry a lot of information. In the process of modeling, it is necessary to manually create and modify the component parameter information, and the workload is complex, and in the input process, it is easy to enter information wrong or missing. Therefore, the data can be processed automatically and automatically from the data modeling platform to the manual data processing platform.

Rhino+Grasshopper+Revit
Using rhino and grasshopper plug-ins to create the model, in essence, only the information controlling the geometric parameters of the model is generated, but the non geometric information that can be used for construction, such as component

properties and functions, is not included. It is impossible to manage the parameter information directly, so it is necessary to import the established parametric model into BIM software and improve it later. Its essence is parametric modeling software rather than BIM model. Rhino software has many interfaces to transfer and transform with other BIM software. Through format transformation, rhino software can realize the transmission work with BIM software. In the aspect of special-shaped building modeling, rhino and Revit are usually combined for information management. Through rhino, the model file is exported in sat format, and then imported into Revit for the next step of work, adding components and corresponding attribute information for the generated entity, and analyzing the model information. However, the rhino model imported from Revit only contains the geometry information of the generated curves and surfaces, and does not contain the logical data of the generated model. If you want to modify the model, you must edit it in rhino and re import it into Revit. The process is complicated and inefficient. In the process of docking with the deepening design software, a large number of model information may be lost.

Revit + Dynamo

It is more suitable for the modeling of conventional buildings, but it is difficult to use it for surface modeling. Therefore, Autodesk has launched dynamo, a visual programming plug-in based on Revit, to carry out parametric modeling. Dynamo is an add-on to Revit that can be run directly from the Revit environment. It can also run independently to realize complex logic operation. Its biggest feature is the visual programming language, which controls the generation of graphics by program code, without complicated programming logic. Parametric programming can be realized through the connection of its own arithmetic unit. Using this method to model the complex special-shaped surface, we can directly control the shape through the logic language, and can directly control the family parameters, and drive Revit to complete the creation of adaptive components, and then create the whole model. As a parametric modeling software, dynamo based on the Revit platform is different from grasshopper, which is a plug-in of rhino platform. With the powerful data information management ability of Revit, it can obtain the geometric information of the model more conveniently and flexibly, and has the building information creation and management functions that grasshopper can not provide, so as to realize the transmission and management of model information more effectively. In addition, python language and design script language are built in dynamo, which can help it to carry out more complex logic programming work, and realize the flexible creation and control of shape.

Dynamo is a parametric modeling software based on "generative algorithms", which is oriented to programming design and building information model. Its operation mechanism is based on the Autodesk platform, and gives full play to its visual

programming ability. Through simulation calculation, parametric programming, automatic data processing and other technologies, it can control the generation of geometric parameters, improve data processing, and then generate models. Visual programming in dynamo is completed in graphical operation interface. Its principle is to extract the built-in algorithm in the software, process and store the data by using the software integration function, package the data into independent arithmetic units with different functions, use the predefined arithmetic unit to replace the program code writing, and automatically process the source data for a specific modeling goal, so as to realize the model creation and data storage management. The arithmetic unit that interacts in dynamo is called "node". Each node has multiple inputs and outputs. The corresponding connection order is set by logic programming. By connecting the same type of ports through model lines, these connected nodes together create a "workflow", which runs in the order from left to right, and builds different logical networks through the input, processing and output of different parameters, so as to obtain different target results and realize the flow and transmission of data.(Talbe1)

For the complex surface which can not be expressed by function analysis and can not be obtained by combining simple foundation control surfaces, it is necessary to approximate discrete points and fit them to generate surfaces. This method is a general method to control nonlinear problems. Whether on dynamo parametric platform or grasshopper software, its core principle is to use NURBS to describe curves and surfaces. The main idea of using NURBS curve to model in dynamo is to extract a series of positioning points as reference points, so that the spline curve can pass through the reference point as much as possible, and then convert the curve into a surface by fitting. Through stretching and clipping, the generated surface can be as close to the positioning point as possible to generate the final surface.

1. Coordinate point positioning

As the intersection point of line and line, line and surface, the point takes the role of positioning. It is used as the basic control point to assist in the generation of curve and surface, and can also locate the components in the later stage. There are many ways to generate points in dynamo, which can quickly realize the creation of coordinate points through the position of points (x, y, z). The common codes are as follows:

Point.ByCoordinates (x, y, z)

Point.ByCartesianCoordinates (CoordinateSystem.ByOrigin (0, 0, 0), x, y, z)

2. Basic control line generation

In the surface modeling software, structural lines are used to describe the trend of curved surface itself, i.e. u and V curves. Through the control of function language, we can connect the points in different ways to produce curves, control the shape of u

and V structural lines, and further control the form of building surface. Commonly used NurbsCurve.ByPoints To create a spline curve, the code generated in code block is as follows:

```
arr = { Point.ByCoordinates (x1,y1,z1),
Point.ByCoordinates (x2,y2,z2),
Point.ByCoordinates (x3,y3,z3)};
nurbsCurve = NurbsCurve. ByPoints (arr)；
```

The control points are used to determine the spline curve, and the shape of the spline curve is changed by changing the position and degree of the control points. The code generated in code block is as follows:

```
arr = { Point.ByCoordinates (x1,y1,z1),
Point.ByCoordinates (x2,y2,z2),
Point.ByCoordinates (x3,y3,z3),
Point.ByCoordinates (x4,y4,z4)};
nurbsCurve = NurbsCurve.ByControlPoints (arr)；
```

You can also directly use the nodes under the nurbscurve branch of the geometry directory to create curves, input the control points into the list list and store them, and then select the corresponding nodes to create curves.

3. Foundation control surface generation

The surface is generated based on the created surface. The commonly used nodes are nurbssurface (non rational spline curve) and polysurface. Compared with the traditional modeling method, NURBS can control the curvature of the surface better and create a more reasonable and realistic surface model. Usually, a set of coordinate points is given first, and then the surface is generated by inputting degree u and v. the surface will pass through each point of the coordinate point set.

```
surf = NurbsSurface.ByPoints (python_ points_ 1)
```

After the single curve generation method is established, the panel family is customized in Revit and loaded into the project to realize the automatic creation of panels based on adaptive points. The core node in dynamo is AdaptiveCpmpoment.By Points。 Input points connect the two-dimensional array of anchor points, and familytype connects the adaptive family category to be arranged. In the points array (list) above, each element is a small list, and each small list contains multiple points. These points are the coordinate points needed for generating an adaptive component. In this array, the key point of input information is the point order, that is, the generation rules of components. When using dynamo to place the correct adaptive family, we must ensure that the input point order is correct. The points of 2D mesh are transformed into a set of 4 points. Each set generates an adaptive component corresponding to the control, and the intersection points on the grid correspond to the nodes of the adaptive component. As shown in

the Figure1, the order of adaptive points is 1, 2, 3 and 4, so it is necessary to sort the points on the grid by 0, 1, 2 and 3 anticlockwise.

Here, the sorting of grid points can not be solved only by using dynamo's own nodes. Python script nodes are provided in dynamo, and some new nodes are developed through ironpython to call revitapi and. Net library to process some more complex data operations. Here, python script script is used to write code, which can realize the sorting of coordinate points more quickly. In order to obtain two adjacent lines, the points to be extracted are all on the line. Each point is extracted in sequence and loaded in a list list, which loads the coordinate positioning points in order. After processing, the python script node will output the coordinate value of each point. (Figure 2)The main code is as follows:

```
Import clr
clr.AddReference('ProtoGeometry')
from Autodesk.DesignScript.Geometry import*
dataEnteringNode = IN
data = IN[0]
point =list()
for i in range(len(data) -1):
line1= data[i]
line2= data[i +1]
for k in range(len(line1) -1):
node =list()
node.append(line1[k])
node.append(line2[k])
node.append(line2[k +1])
node.append(line1[k +1])
point.append(node)
OUT = point
```

At this point, we have successfully combined dynamo and python in Revit, and input the irregular surface by controllable and adjustable means, and can give the attribute. However, there are still some deficiencies in the current research projects. At present, only simple single surface has been tested, and many types of complex surface have not been tested. The generality of this methodology cannot be determined. This may be one of the biggest limitations of the study so far.

7. Discussion (evaluation and significance)

Aiming at the problems of complex form, various components and low modelling efficiency, based on the BIM modelling core software platform Revit and its plug-in dynamo, this paper proposes a parametric generation method of irregular building surface, and constructs dynamo Revit Based on the model information management system, the corresponding program of rapid common and layout of components is developed, and it is applied to the actual modelling process of special-shaped curtain

wall to realize the parametric data interaction and coordination of "logic parameter model information". The main results of this paper are summarized as follows:

1. Summed up the current BIM Technology Applied to the modelling of special-shaped buildings and the problems encountered in the application of parameterization: parametric software is usually used to generate shapes in the early conceptual design stage of special-shaped buildings. When BIM software is imported for further design in the later stage, the logic parameters controlling the shape generation are not imported into BIM software, which could not realize real-time modification.

2. Summarize the idea of parametric modelling of special-shaped surface, and put forward the method of surface generation based on dynamo. Firstly, the surface of special-shaped building is classified, and the logical framework and method of modelling special-shaped surface by using dynamo parametric program can quickly create and locate space points, lines and surfaces, and complete the creation of special-shaped surface. According to the principle of meshing, a method of Meshing Based on the width and number of meshes is proposed. The user-defined node package is developed, which can quickly modify and update the design in dynamo model, and directly drive Revit to generate new models.

3. Try to realize the dynamo Revit model information management system, and realize the rapid and accurate processing of component information. According to the analysis of the data transmission and processing requirements of special-shaped building components, the model information management system based on dynamo Revit is proposed, which is divided into three parts: "basic database data operation platform data output platform", which is based on dynamo and combined with Python Language developed a program to realize the rapid layout and modification of components, which can process information data quickly and output accurate and reliable data.

However, due to the limited research time and ability, there are still some deficiencies in the completed achievements, which need further research and improvement

1. In this study, we propose a logical modelling method based on dynamo for the parametric generation of special-shaped building surface. In the future, we should strengthen and improve the function of dynamo surface modelling for a variety of special-shaped building surface forms, and propose a more complete solution for the forward design of special-shaped buildings;

2. This paper combines dynamo and Revit to connect the model information and data flow from the design stage to the processing stage, but the function is relatively single. In the future, we can further add various information data, strengthen the data processing method, and establish a more complete model information management system.

3. It is necessary to further strengthen the learning of Python language, combine with the secondary development of Revit, realize data coordination with more software, and further improve the application scope of dynamo and the interaction ability of other software.

[FIGURE]

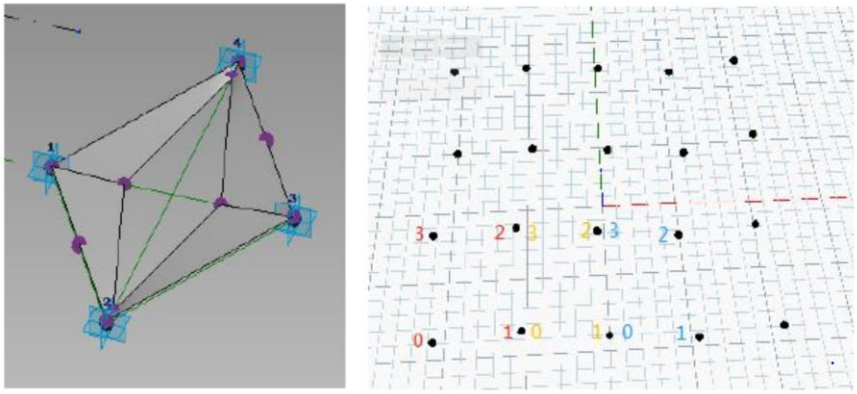

Figure 1. Revit Family Points In Dynamo

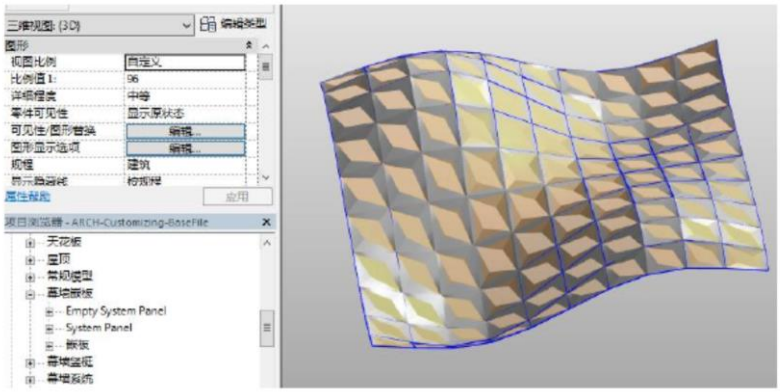

Figure 2.Completed Non-uniform Surface in Revit

8. Conclusion

This paper aims at the problems of complex form, various components and low modeling efficiency of the special-shaped surface. Based on the BIM modeling core software platform Revit and its plug-in dynamo, the parametric generation method of irregular building surface is proposed, and the dynamo Revit model information management system is constructed to realize the parametric data interaction and coordination of "logic parameter model information". The main results of this paper are summarized as follows

This paper summarizes the idea of parametric modeling of special-shaped surface, and puts forward the method of surface generation based on dynamo. Firstly, the surface of special-shaped building is classified, and the idea of parametric modeling of special-shaped surface is summarized. In this paper, a logical framework and method for the modeling of special-shaped surface with dynamo parametric program is proposed, which can quickly create and locate space points, lines and surfaces, and complete the creation of special-shaped surfaces. According to the principle of meshing, a method of Meshing Based on the width and number of meshes is proposed, and the user-defined node package is developed, which can quickly modify and update the design of dynamo model, and directly drive Revit to generate a new model.

Compared with the traditional BIM modeling method, the proposed dynamo based parametric modeling process and program can realize the logical parameter modeling of the surface, reduce the repetitive work in the modeling process, improve the modeling efficiency, and realize the parametric data interaction and coordination of "logic parameter model information", which has certain practical application value.

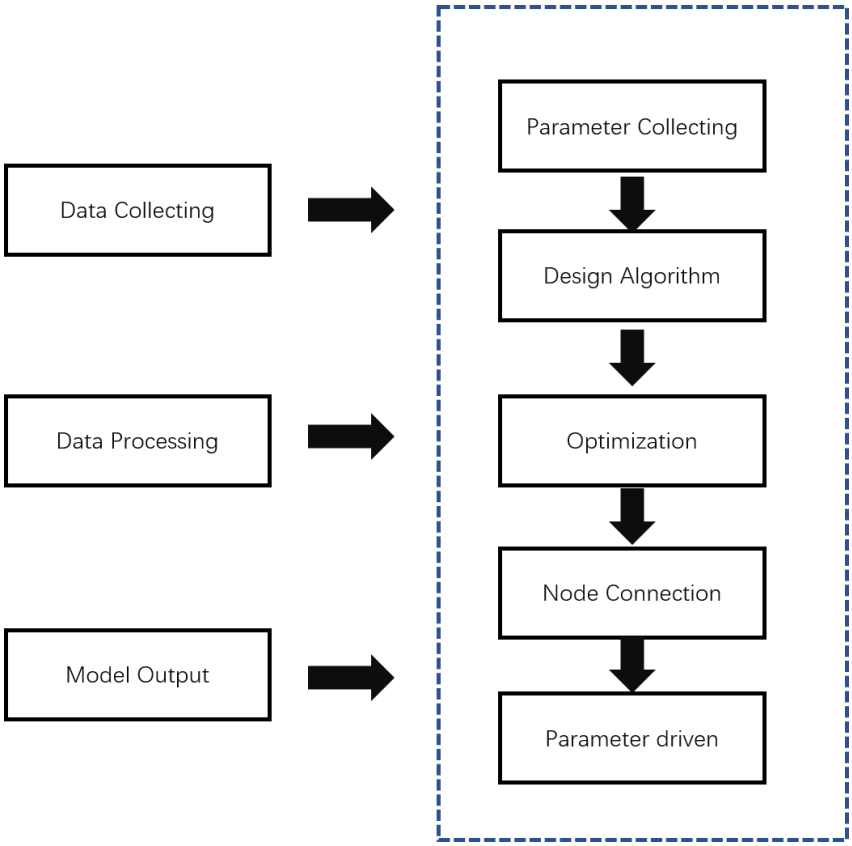

TABLE 1. Working Process in Dynamo

[TABLE]

Acknowledgements

First of all, I would like to thank my mentor Professor Nicole Gardner for his guidance and supervision in the whole process of topic selection, promotion and writing. With foresight and gentle and patient words, he pointed out the direction for me, guided me to complete the thesis writing successfully, and provided me with many learning and training opportunities in the three years of knowledge seeking, which made me benefit a lot, which will also become the precious wealth of my life. At the same time, I would like to thank Professor hank for his valuable suggestions and guidance in the process of writing the paper. Professor Hank's scientific and rigorous academic attitude has deeply influenced me.

Thank you for the company of my friends in the past three years. The pictures of learning and entertainment can be vividly seen. Thank you for spending this special and unforgettable time with me. Thank you for all the people you met in the past three years. Meeting is fate. Experience makes people grow up. Parting is not the end, but a new beginning. I wish you all the best in the future.

References

Azhar, S 2011, 'Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry', Leadership and Management in Engineering, vol. 11, no. 3, pp. 241–252.

Azhar, Salman, Khalfan, Malik & Maqsood, Tayyab 2012, 'Building Information Modeling (BIM): Now and beyond', The Australasian journal of construction economics and building, vol. 12, no. 4, pp. 15–28.

Banfi, F, Fai, S & Brumana, R 2017, 'BIM AUTOMATION: ADVANCED MODELING GENERATIVE PROCESS FORv COMPLEX STRUCTURES', ISPRS annals of the photogrammetry, remote sensing and spatial information sciences, vol. IV-2/W2, pp. 9–16.

Barazzetti L., Banfi F., Brumana R., Previtali M., 2015. Creation of Parametric BIM Objects from Point Clouds Using Nurbs. The Photogrammetric Records, 30, 152. pp. 339-362

Brumana, R., Oreni, D., Cuca, B., Binda, L., Condoleo, P., Triggiani, M., 2014. Strategy for integrated surveyingtechniques finalized to interpretive models in a byzantine church, Mesopotam, Albania. International Journal of Architectural Heritage, pp. 886–924

Carmona, J., and Irwin, K. (2007). "BIM: Who, what, how and why." Building Operating Management. ⟨http://www.facilitiesnet.com/software/article/ BIM-Who-What-How-andWhy–7546⟩ (August 21, 2009).

Della Torre S., 2015. Shaping Tools for Built Heritage Conservation: from Architectural Design to Program and Management. Learning from 'Distretti culturali'. Community Involvement in Heritage. Garant. pp. 93-102

Hardin, Brad & McCool, Dave 2015, BIM and Construction Management, John Wiley & Sons, Incorporated, New York.

Khemlani, L., Papamichael, K., and Harfmann, A. (2006). "The potential of digital building modeling." ⟨http://www.aia.org/SiteObjects/files/ potentialofdigital.pdf⟩ (August 11, 2009).

N Kasim, N A Zainal Abidin, R Zainal, et al. Best practices of Building Information Modelling (BIM) implementation in design phase for construction project [J]. IOP Conference Series: Materials Science and Engineering, 2017,271(1).

Piegl, L. A., Tiller, W., 1997, 'The NURBS Book', Computer aided design, vol. 28, no. 8, pp. 665–666.

Sebastiano Maltese,Lavinia C. Tagliabue, Fulvio Re Cecconi, et al. Sustainability Assessment through Green BIM for Environmental, Social and Economic Efficiency [J]. Procedia Engineering, 2017,180:520-530.

Thompson, D. B., and Miner, R. G. (2007). "Building information modeling—BIM: Contractual risks are changing with technology." ⟨http://www .aepronet.org/ge/no35.html⟩ (August 22, 2009).

Vanlande R,Nicolle C,Cruz C,IFC and building lifecyclemanagement [J]. Automation I nconstruction, 2008,18(1) : 70-78

Volk, Rebekka, Stengel, Julian & Schultmann, Frank 2014, 'Building Information Modeling (BIM) for existing buildings — Literature review and future needs', Automation in construction, vol. 38, pp. 109–127.

Weygant, R.S. (2011) BIM Content Development: Standards, Strategies and Best Practices, NJ: John Wiley and Sons