Airport terminal design using parametric architectural trend: From design to manufacturing

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Abstract The process of parametric design is considered one of the newest trends in the architecture field that can be obviously recognized in airports' terminals design. The process of decision-making is supported during the early stage of the conceptual design process. Yet, many design alternatives are being introduced to choose the fittest design concept. During that process, the airport design depends on many parameters that should be considered before taking design decisions. Furthermore, creating the desired model is assisted by using a computerized stage for digital fabrication through several mock-ups of different fabricated scales to allow the process of design decisions. The workflow for the process of parametric design is being spotlighted in this paper for a pavilion that is designed in an airport from the conceptual design stage (with the assistance of Grasshopper "Plugin for Rhinoceros) to the fabrication stage (with the assistance of Slicer Fusion) that is used for preparing the mock-ups for the digitally fabricated process using the CNC router.

Keywords: Parametric design, Digital Fabrication, Grasshopper, Slicer Fusion.

1. Introduction

1.1. Parametric design and its applications in airports

Parametric design for architecture is described as a method of algorithmic thinking and mathematical equations to result in a set of optimized solutions for the problem of design through certain parameters, which together support and describe the relation between architecture design goals.[1] Airports are considered iconic establishments that reflect the heritage and development of the country where they exist. Hence, airport design requires an innovative architectural trend, which can be accomplished using architectural parametric design the architecture design for airports has a set of parameters that should be considered before making decisions like runways that are paved land strips on which landing and take-off operations of aircraft takes place that has different runways patterns such as single runways, two runways, and hexagonal runways, taxiways that are paths to connect each end of the runway with other sectors of the airport, apron which is a place used as parking place for aircraft, a terminal building where the administration facilities, pre-journey, post-journey, and lounges are found, control tower that controls whether aircraft are in land or air and finally the hanger builder where the services for the aircraft take place.

Many designers use parametric design for airport design in which the concept, the relation with surrounding contexts, spaces distribution, and materials used are the main principles for their conceptual stage such as Harbin airport T3 designed by MAD architects.

It's an airport with a snowflake-like shape that blends with the chilly surroundings. MAD designed a terminal building that mirrors the features of Harbin's geography and environment by alluding to the gentle slopes of China's huge Northern plains and the area's tremendous snow and ice. It generates architectural poetry that blends into its surroundings like a snowflake that has gently dropped to the ground while also expressing itself as a fantastical, intergalactic environment for future air travel.Using Fabricated materials on specific panels to form the shape and the design of the green landscapes play important role in the design.

Also the parametric design for Jewel Changi Airport by Safdie Architects is seen clear. The design of the oculus in the top of the glass dome for the inspiration of rain that matches with Singapore climate, the presence of greenery walls in the gate of 80 foot tall that acts as “mythical garden”, the using of the smart glass façade that allow eduquate amount of daylighting to enter the space for the visual comfort of the users indoor. It also has additional attractions that resemble follies, such a set of misty bowls and a run of sculptural mirror slides. , all are designed using parametric archietcure to be homogenous with the surroundings.

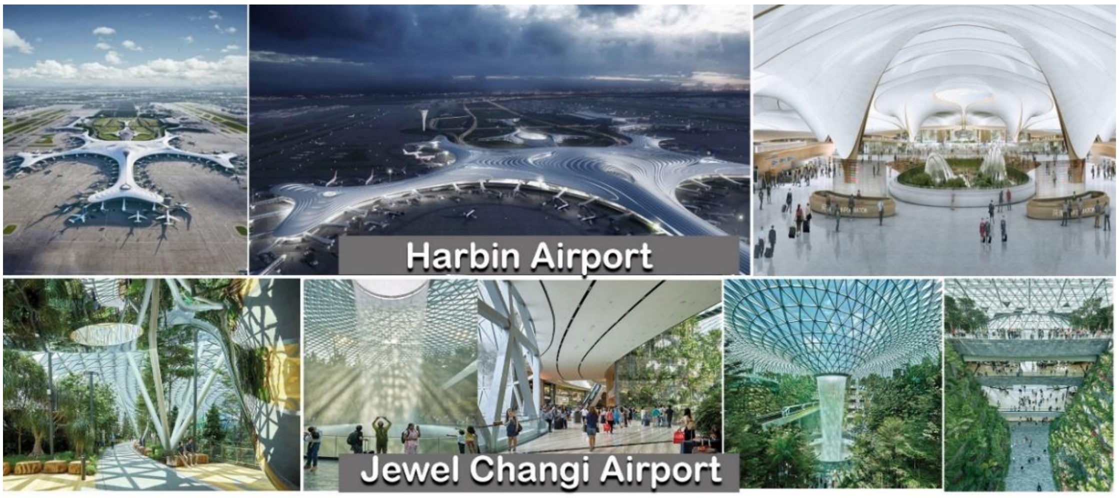

Figure 1. Harbin Airport T3 by MAD architects Jewel Changi Airport by Safdie Architects

1.2. Digital Fabrication

Early in the 19th century, Henry Ford, the creator of the Passage Engine Company, established a mass generation that was the beginning of manufacturing technology. [2]. The distance between idea and generation has been closed through digital fabrication. Making use of computer numerically controlled (CNC) manufacturing to create the coordination that connects "file-to-factory" [3]. Prototyping tools like laser cutters and 3D printers saw considerable price drops in the early 2000s, and Open-Source equipment advancements shared these advancements. Computerized manufacturing is a way of thinking that combines transdisciplinary information with the use of 2D plans, 3D plans, and machines and tools. Advanced invention originates with CAD (computer-aided design), which is then converted to CAM (computer-aided manufacturing) software. The output of CAM is ready for fabrication to a specific equipment, such as a 3D printer or CNC processing device.

The first digital fabrication labs were established in architectural schools in the late 1990s as a consequence of a collaboration between architecture and mechanical engineering laboratories[4]. The most important tools for creating models in engineering were CNC routers and rapid prototyping.

Techniques and procedures have quickly advanced throughout the years. The first three phases for advanced manufacturing tasks are as follows: [5]

- Phase of digital design: Using CAD software, a virtual model is produced in this initial phase. The 3D model was surfaced or exported as triangulated mesh. .
- Phase of preparation: Creating a CAM file, which is subsequently sent to the machine, is the first step in configuring the production parameters and fabrication-specific parameters.
- Fabricate phase: create components using an analogous production process based on the CAM data with little to no human involvement. Before the produced pieces are ready for use, they may need to be assembled to attain their final characteristics and appearance.

The fabrication phase also emphasises:
1) Putting thoughts and concepts into mockups, prototypes, and finished goods.
2) Choose the digital tools and technologies required to turn ideas into prototypes and finished products.
3) working imaginatively and attempting to investigate building using various fabrication processes.
4) Variously visualise and depict artefacts while continually modifying [6].

This research seeks to demonstrate the parametric design workflow, starting from the architectural design idea through the execution process, based on the preceding introduction and background. The introduction to this study includes a brief status report on the manufacturing and parametric design procedures. In addition, the research's methodology will be described before the procedure is described. And last, the final thought.

2. Methodology

Using grasshopper to establish the preliminary parametric design concept, which offers a variety of design options, is the first step in the parametric design workflow. According to [7] this procedure, there are several actions that may be taken, including:

- Pools of options and solutions
- Form Exploration
- Form Evaluation
- Form Refinement
- Form Optimization

3. Case study application

A case study model of a pavilion in an airport with a set of wooden ribs was created. Scripting is done on the grasshopper canvas by building a digital model based on a set of pre-programmed rules or algorithms known as 'parameters,' as illustrated in Fig.1.

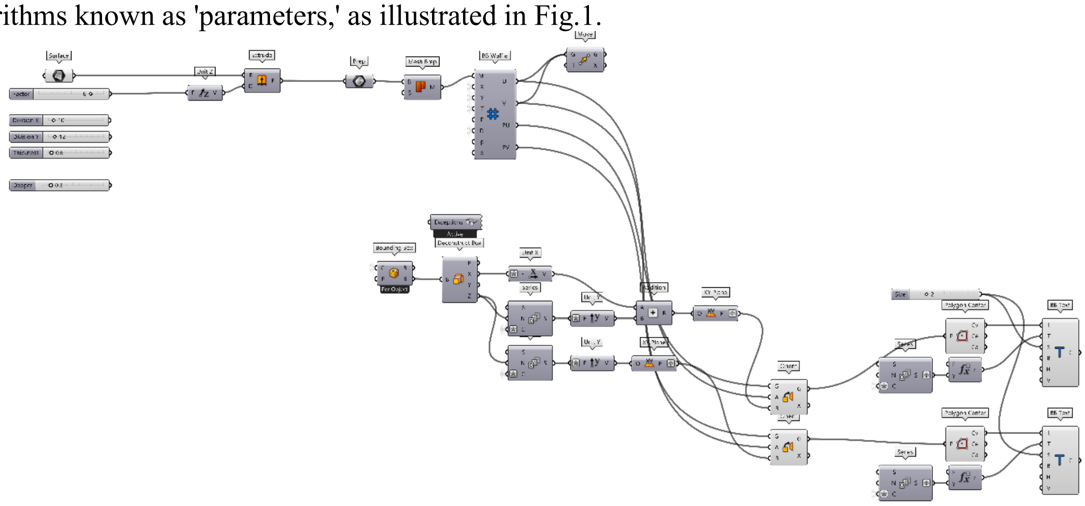

Figure 2. The Scripting of a mathematical equation and algorithmic relation in Grasshopper

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In order to extract the model from the Rhinoceros, the scripting is being interfaced. Scripting deals with algorithmic computations that must be performed in the right order to obtain the desired model. It was created using Grasshopper's mathematical computations. The finished model is then interfaced to Rhinoceros for baking.

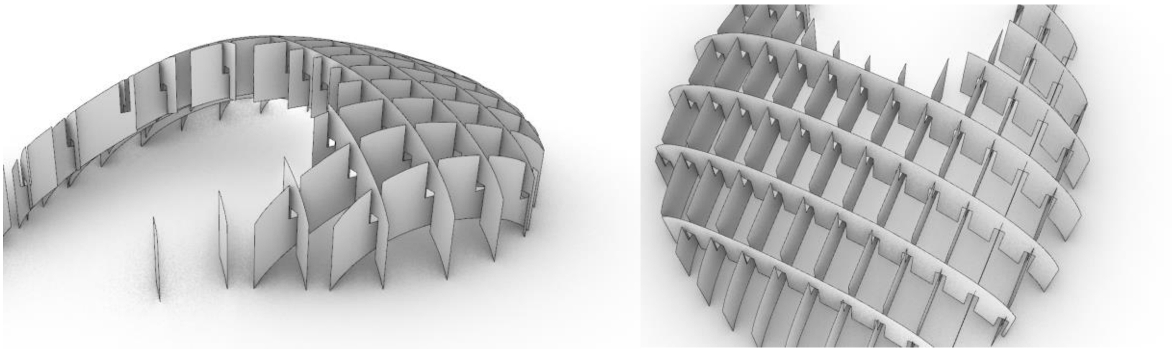

Figure 3. The model generated by grasshopper in the Rhino interface

Secondly, The file is then imported into Slicer Fusion 3D, a tool for preparing for digital fabrication, when the final model idea for the grasshopper is complete in order to obtain the plans that will be produced using a CNC router. The application was used to coordinate the plans' numbers, which would be used in the mock-up phase's design. Additionally, it is employed in cost and time estimation. After multiple fabrications of porotypes at various sizes, the final model, in which the cladding and elevation patterns are made, is made at scale 1:1.

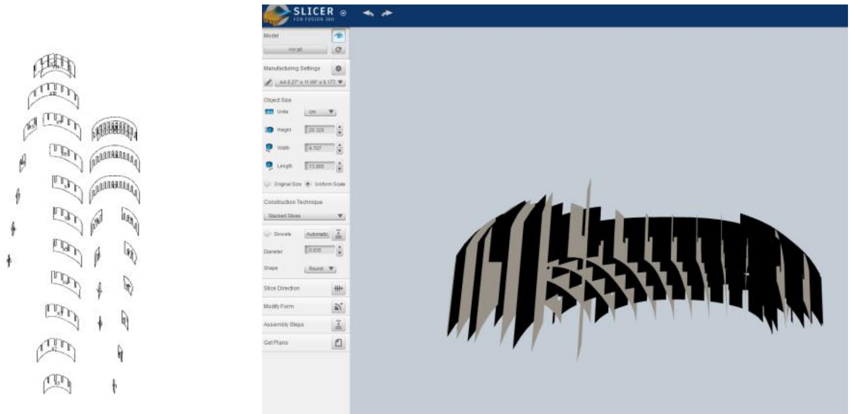

Figure 4. The plans that are being exported by the slicer fusion program for the CNC router

The preceding step is regarded as a preparation for the fabrication process since following the construction of the model mock-up, the building is prepared to be constructed at scale 1:1 on the site after finishing the working drawings and simulation for the civil drawings.

4. Conclusion

This paper is regarded as an illustration of how the workflow for parametric design, in which the design is created via Grasshopper. The model is then baked to Rhinoceros to be edited and reformed. The design is then converted to STL or ObJ file for fabrication preparation and mock-ups in various scales for plan slicing for digitally fabricated using the Slicer Fusion software to obtain plans for CNC router. The model is then developed to be prepared for actual success on the site after being optimized for architecture,civil and environmental simulation to give the optimized model.

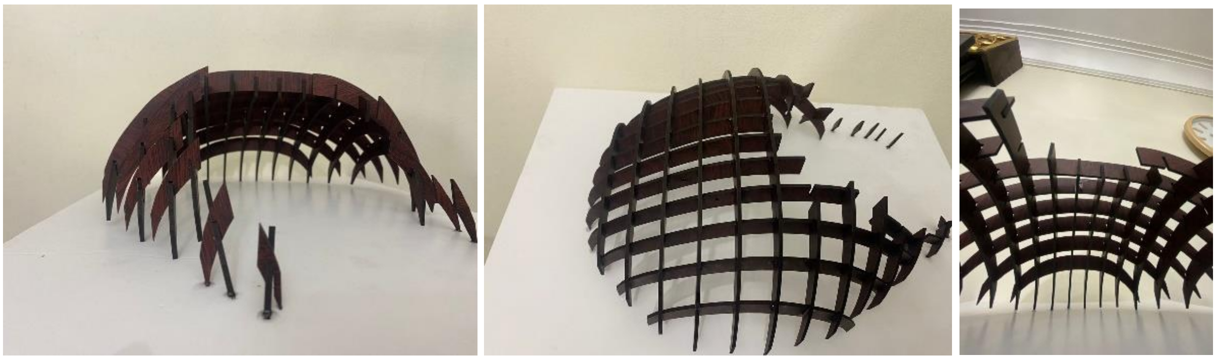

Figure 5. The final mock up after being installed after fabrication

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