

Parametric - Nature Obsession

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Abstract

This paper examines the basic application and usage of wood construction in landscape and tests the influence of the material's behavior on the structure of parametric elements. Over the years, nature has inspired artists and designers and is being reflected in many forms starting from wall paintings up to building facades. With the development in technology, it is important to understand how to use computer programs to portrait the elements of nature and integrate them in the design process. Designers favor parametric design due to its flexibility and its simplification to complex ideas by providing automated solutions, which led to the wide use of parametric design and the use of wooden materials in urban landscaping. The final exercise of the Parametric Design course at The University of Sharjah / Department of Architectural Engineering was to evaluate the students' understanding of the course learning outcomes and the skills developed, a system was to be designed to respond with material, function and location. For the sake of understanding the fabrication process, the students were required to fabricate their proposals using simple materials: Structure + Skin + Materials + Forces = System. Parametric algorithm was created to vary the fluidity of the shape, and optimization of material used. Benches and tables are CNC cut, fabricated out of 18mm thick wood slices. The Delonesk Table is one of the final built results that follows the strategy of non-overlapping yet contiguous triangles from a set of points. The Delaunay Triangulation is used in furniture production. Another built project by the students The RAK Coffee Table is inspired by the beauty that can be found in the United Arab Emirates. Extracted from the topographic map of the famous mountainous region of Jebel Jais and its roundabouts in Ras Al-Khaimah.

Index Terms— Digital Fabrication, Grasshopper, Nature, Parametric Design, Physical Fabrication, Rhinoceros 3D.

I. INTRODUCTION

Designers favor Parametric Design due to its flexibility, versatility, and relatability. With the recent development in technology, using programs such as Rhinoceros 3D to aid in generating designs became a common practice amongst designers. Nature has always been a source of inspiration for artists, scientists, and engineers and is being reflected in many forms starting from wall paintings up to building facades.

The RAK Coffee Table, one of the projects discussed in this paper, is inspired by the beauty in the mountainous region of Jebel Jais in Ras Al Khaimah.

The Delonesk Table is one of the final built results that follows the strategy of non-overlapping yet contiguous triangles from a set of points. It is designed by a set of triangles that guarantee one property: the circumcircle of each triangle includes only the vertices of the triangle; then, there are not any point of other triangle inside the circum-circle; this property makes the Delaunay triangulation unique. Taking advantage of the uniqueness, Delaunay Triangulation has been used in different fields such as furniture production. This triangulation was named after Boris Delaunay for his work on this topic from 1934.

II. MOTIVATION OF CONTRIBUTION

The discussed projects were designed by a group of undergraduate students who enrolled in the Parametric Design Course in the Architectural Engineering Department in the University of Sharjah. For the first time in the department, the students got the chance to design and fabricate furniture as the final project in the course. This conference gives us the opportunity to participate and exhibit our work.

III. OBJECTIVE

The main objective of the mentioned projects is to use nature-inspired designs and to reflect the students' understanding of the tools taught in the course.

The RAK Coffee Table was generated through a grasshopper program that outputs a unique design based on unique topographic sites. The beauty of Jebel Jais and its surroundings was one of the main reasons why its topographic map was selected to be showcased through the table.

The Delonesk Table was generated through the Rhinoceros 3D v6 plugin Grasshopper. Delaunay Triangulation has been used in different fields such as furniture production which encouraged us to use this form in our design.

IV. METHODS

As *The RAK Coffee Table* is based on a natural design, we need to use sophisticated programs to use the complex designs to generate data that can be visualized by the artist. In this instance, we have used a contour map from the Jabal Jais region to run it through a program to generate the table. The program was built by using the plugin for Rhinoceros 3D, grasshopper. The program was made by making a heightfield from image of the contour map. Afterwards, we use a box berp to take a box section of the heightfield map by splitting

and selecting everything inside the box then trimming the box. Then contouring the resulting berp and using the contour lines to be extruded. Finally, capping the holes of the extruded surfaces.

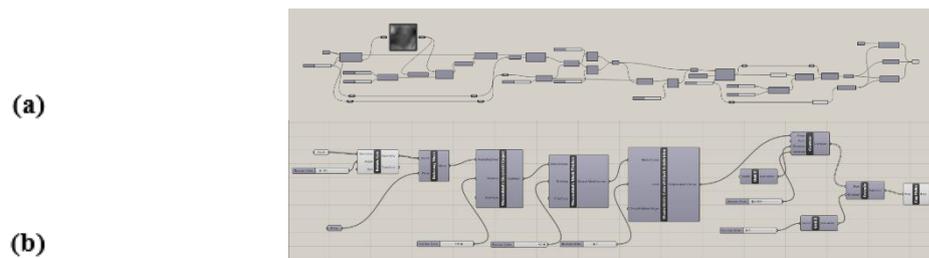


Fig. 1 (a) A screenshot of the grasshopper file for *The RAK Table* (b) A screenshot of the grasshopper file for *The Delonesk Table*

The Delonesk Table started by deciding the type of parametric structure we want to design and build. After doing some research we decided to create a desk table with Delaunay triangulation design. Then we started working on the Rhinoceros 3D v6 and Grasshopper plugin where participant learned how to design and manage parametric data, from basic to complex structures. Our purpose was to build a parametric desk table of 70 cm height and 40 cm depth in three weeks. Transferring the design from digital to realistic was very challenging for us as undergraduate students with no experience in that field, but we were motivated and excited throughout the entire process to reach our goal. After choosing the material, which is the MDF wood panels, we started cutting these panels using the Computerized Numerical Control (CNC) machine. Then we started to build the form piece by piece, then connecting them together using the solid aluminum rods.

V. RESULTS

The materials used in the fabrication of *The RAK Coffee Table* are Medium Density Fiberboard (MDF), glass, and adhesive to stack the table layers on top of one another. A Computer Numerical Control (CNC) machined the desired sections. The available CNC machine had a milling area of 40 cm x 60 cm while the area of *The RAK Coffee Table* is 100 cm x 100 cm. This means that the layers of the table should be cut into multiple smaller sections that would be stuck together. Due to human error, the table elevations were slightly inaccurate which led to discontinuity in the table faces. The weight of the MDF boards was also a major issue we faced. Even though this coffee table is meant for outdoor use, its heavyweight makes it immobile. The solutions to the issues faced in digital and physical fabrication are discussed in the conclusion.

Initially *the Delonesk Table* was designed to have a height of 70 centimeters, 2 meters long and 46 MDF wood panels. The challenges in fabricating this kind of project firstly was in the size limit of the cutting machine (CNC), this limits us in the possible height of our table, which is 70 centimeters height by 40 centimeters width. Moreover, reinforcing this 46 heavy weight panels all together using solid aluminum rods in order to stabilize it, was a challenging part where we should hide all these bars in between the panels without showing them in the openings. Before the fabrication process, the designation part took us 2 weeks in order to find the proper functional design shape of the table. After that, cutting these MDF wood boards took from us 2 days to be



Fig. 2 (a) an image of the finished RAK Table (b) an image of the finished Delonesk Table

done, and then we have started the fabrication that also took 2 days.

VI. DISCUSSION

This section discusses the mentioned projects in more details. Explaining the ideology and concept, materials used in the furniture construction and the digital and physical fabrication methods.

A. Concept

Geography could be defined as the science of understanding the physical features of the earth. This includes the beauty of natural elements such as water bodies, forests, deserts, and mountains. The nature in the United Arab Emirates hosts deserts, mountains, and waterbodies. *The RAK Coffee Table* reflects the beauty of the mountainous region of Ras Al Khaimah which houses one of the most famous mountains in the UAE, Jebel Jais. The design process started by extracting a topographic map of Jebel Jais and its surrounding with the goal of portraying the beauty of contour lines and integrating nature with furniture.

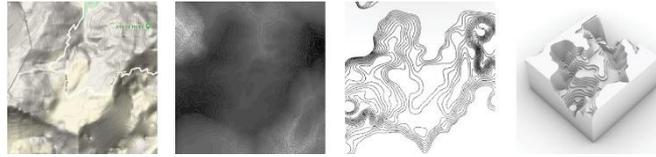


Fig. 3 The visualization of the concept development of The RAK Table

The 20th century witnessed the upsurge of the modernist style icons. This led to the thinning of the line which differentiates design from art. Everyday items were now claimed to be aesthetic factors, amongst those items came furniture which introduced the industrial sector to the definition of form through function, Delaunay Triangulation engagement was one of them. Delaunay triangulation is used in furniture production. Contouring the polygonal shapes that is generated from the triangulation and provide a compact and structure-aware representation are widely used or give an idea in furniture fabrication.

B. Materials

The initial contenders for materials to be used for *The RAK Table* were natural wood planks versus MDF boards, glue versus screws, and resin versus glass panel to top the table. Starting off with the material that the table is mainly comprised off, natural wooden planks vs MDF boards. The main deciding factor for this was the budget, since the university had a budget for the students, they could not use natural wood although it would have been much better. The next candidates that will be discussed is the joining material, were screws would have seemed to have a cleaner finish but the material needs to be prepared and threaded in the specified locations where the screws will go, but in this case we had the table to be with large surface areas that the adhesive can be spread on which is something that adhesive prefer to have a strong joining bond. The last materials to be discussed is the material to top the table. Although resin is a good material to finish the table with, it would add a lot of weight to the table which is heavy to start with. For that, a glass panel does not substantially increase the weight of the table and it allows for a small region under the glass panel to be treated as a storage area. Therefore, the materials that were decided on by the students were MDF boards to make up most of the table, glue as their form of joining the material for the MDF boards, and a glass panel to top it.

In *The Delonesk Table* project we have chosen the materials that are available in manufacturers, and easy to bring it to the university, also we looked to the materials that able to be fabricated and suitable to produce this design, and easy to handle and use. Those materials were MDF boards that look like the wood board, but it is lighter in weight and less expensive, also this material is structurally more stable. We also used solid aluminum rods, used to connect the MDF pieces with each other's to make it more stable, we faced problem with the diameter of the rods and how to locate the space for the rod in all boards but then we fixed this problem by choosing a rod with a small diameter, then we add the ring locks at the end it made of aluminum, all the materials that used in this project are easy to use and fit in our budget.

C. Fabrication Process

The fabrication process for *The RAK Table* started digitally by generating sections. The size of each section was limited by the size of the CNC milling area. After the sections were fabricated, the students worked on gluing the surfaces with their respective order and stacking them to dry. After the table was assembled it was spray painted and topped with a glass panel with rubber separator to keep the surfaces from being damaged.

the fabrication phase is the most important step in fabricating *The Delonesk Table*, it is what brings the project to reality. coming up with the fabrication process, we took the designed panels to be cut with the computer numerical control cutting machine (CNC), with numbering these panels in order to sit each one at its correct place and function. This process took from us 2 days to collect the panels from the industry place and double check them. After that we have started with the building phase, we sort all of these sections that are related to the top or bottom of the furniture and then prepare the Aluminum solid bars to reinforce it. one by one we finished the building phase, where the bars where locked from both sides to insure the stability of the furniture.

CONCLUSION

Through this learning experience, the students shared ideas and discussed the problems they faced throughout the design and fabrication process. This gave an insight on the common mistakes and allowed the students to develop an understanding on possible and efficient solutions regarding the digital fabrication, selection of materials physical fabrication.

The students who worked on *The RAK Coffee Table*, for example, understood that in order to make the table faces continuous, a CNC machine that has a milling bed of at least 100 cm x 100 cm should be used. In order to minimize human error, using aluminum rods to align the stacked sections and adhesive to press them together also ensures the continuity of the table faces. The other problem was the heavyweight of the table, to decrease it, using hollow sections for the layers in the middle would have had reduced the weight of the table drastically.

The students who worked on *The Delonesk Table* faced problem on how to hide all these bars in between the panels without showing them in the openings. Before the fabrication process, so this gave them a chance to think loud and together to get the perfect solution for these problems. So they solved it by have a perfect size that fit in the CNC machine, and they cover the bars with small pieces of wood.

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