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Robots Challenge

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Abstract

Robots are taking over the world from more than a century ago, and are making radical changes to concepts and humans expectations about things. The challenge was: Will robots replace humans? With its capabilities in 2019, the new challenge is: Can we make what the robot cannot do? KUKA is a robotic arm that can construct any structure with any shape or size with high precision. The idea started at the workshop that I directed and organized at the university of Sharjah depending on my previously worked on similar artworks. 22 hardworking students accepted the challenge and decided to work with maximum capacity to make it happen. It finally took place in the Architectural Engineering department main lobby for a period of two weeks. The produced wall is 2.2 m high, and 7.1 m long, constituted from 1430 blocks. The process started with trying to produce a model that answers questions like: How will we design? How will we fabricate? What material can humans use to challenge robots?; The wall developed into an interactive learning experience from day 1 when students had questions in their heads until today, not just for the working team, but also to other students by asking questions, taking pictures, touching, and observing. The program used to design was Rhinoceros 3D v6, a 3D computer graphics software, with a scripting plugin called BrickDesign. The design was produced by trial-and-error using attraction points. For the materials, Styrofoam was used because of its cheap, light, and easy to handle, and wooden skewers were used to nail the blocks together. To fabricate the design, sections were taken from the design, printed, and used as a reference for the Styrofoam blocks.

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

I. INTRODUCTION

Robots applications are taking over the world from more than a century ago, and are making radical changes to concepts and humans expectations about things. In the fields of architecture and building construction, they can do what a group of human workers can do with less time, less errors, and less cost! Any shape or concept can be turned to reality in a matter of days or even hours of work. The challenge was: Will robots replace humans?, with its capabilities in 2019 we decided to flip the arrow, and ask humans to challenge today's robots. So our new challenge is Can we make what the robot cannot do?

The initiative to challenge robots is the originality and human error that adds value to an art work. Perhaps another reason is not having a robot in the university won't stop us from making what it can do. A video of KUKA showed how it can make a high wall when programmed to the coordinates of the location of each brick to form a certain design. We are challenging KUKA, a robotic arm that can construct any structure with any shape or size with high precision, with the potential of 22 hardworking students. The idea started from the workshop supervisor that has previously worked on similar art works around the world; it was the first of its kind in this university or the United Arab Emirates to be built by undergraduate students. Students accepted the challenge and decided to work with maximum capacity to make it happen. It finally took place in the Architectural Engineering department main lobby for a period of two weeks.

The process started with trying to produce a model that answers questions like: what significance will the art work give to this void? How will we design? How will we fabricate? What material can humans use to challenge robots?, it developed into an interactive learning experience from day 1 when we had

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questions in our heads until today. Not just that it was an interactive experience for the working team, but also to other students by asking questions, taking pictures, interacting with, and observing.

II. MOTIVATION OF CONTRIBUTION

For a project that was made for the first time in the United Arab Emirates by undergraduate students, we wanted to present and expose our work as much as possible. For a conference of this size it would be a great opportunity to show off this work to the world.

III. METHODS

The workshop was structured by introducing the students to parametric design techniques as a part of architectural design. Starting by doing some research about large-scale installations and its structure then getting some ideas about what design would this parametric wall have. After that we started to design throughout the use of scripting plugins with Rhinoceros 3D v6 where participants learned how to build and manage parametric data structure, from the very basic to a complex modeling and to develop data driven responsive geometries and envelope. Our goal was to build a parametric wall of 3.5 meters height and 7 meters long in a week and transferring it from a digital to realistic design, even though this was the biggest challenge for us as students with no experience, we all were motivated and excited to be a part of it.

We started to build sections of the bricks we had, one by one, then sticking them together until we reached the height of 2.2 meters.

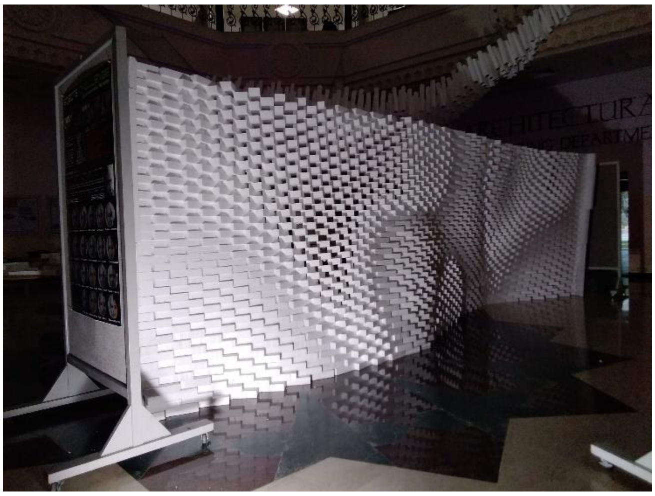

Fig. 1 The finial product.

IV. RESULTS

Initially the project was designed to have a height of 3.5 meters, 7.1 meters long and 2275 bricks. However, we ended up with 2.2 meters high, 7.1 meters long and 1430 bricks. The challenge was that the project should be developed by the students themselves in a short period of time of one week, but the workshop ended up extending the process by one more week. The fabrication process started slowly in the first week because the process was foreign, new and we had no experience. It took so long to assemble the sections and putting them on top of each other to build the wall. Though, in week two the process started picking up and building the sections and the wall was way faster, however not fast enough to be done in just two weeks. When we reached 1.5 meter the wall started to shake when applying any force that was not vertical to the wall. Supporting frames were added to stabilize the structure. With the supporting frame, reaching 2.2 meters we realized that going higher became a bigger risk since it started shaking again.

V. DISCUSSION

A. Concept

A concept usually comes from a glimpse about the added value of the art work to a place, and the effect it poses on people, from that we thought of options related to what people in the architecture

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department admire the most like inspirational characters, famous quotes, abstract art, and logos. The trial and error process started with tracing ready made photos of abstract art and characters, these and the following trials were reflected using the variation of brick angle and the shadow it creates, increasing the rotation also changed how the outcome looked like. More trials were created using another method: forces, that act like a point that exerts force on the surface, what we decided to create with forces trials was an exceptional interactive experience that people would be curious to know how the final result will be during fabrication and take as many pictures in the interesting corners it creates.

No more than six forces were used to create the shape, from different directions, different intensities, and exerted on different surfaces; Each force played an role in making more edges, they affected each other from two sides resulting in unexpected connections.

Four trials with forces resulted in the final one, adding more or changing any intensity would have made it look odd or structurally unstable, so that was the end point. The resulted design had corners for people to look at closely and interact with. However, the initial trials with forces and photos were discarded because of their lacking an added value, and the desire to create something original and genuine.

B. Materials

With all the limitations that we had to choose a material that is available, cheap, and easy to handle and link together. The material we had to build with had to be something that could be cut easily since the pieces were so close or touching and sometimes overlapping, the blocks should be improvised to fit the printed section. Another point to keep into consideration since students are building this wall, the material should be light enough for any of the students to be able to carry the blocks. In addition to that, having a light material will make the wall lighter, therefore less structurally challenging, and the fabrication process a lot safer on the builders. Having all the requirements put into consideration, bricks were out of the question since they are not cheap enough to fit in our budget, heavy, and hard to handle, so we moved on to wooden block. Wooden blocks are light and easy to handle, but they are not cheap enough to fit our budget still. The last material we had in mind is styrofoam, styrofoam is lighter than the wooden blocks, easy to handle, and very cheap. So, it seemed that styrofoam is the material that fits the job best. As for the material to hold the blocks together, a material that doesn't take much time and is strong since we had a short period of time to build this wall and couldn't wait for it to dry. The quick dry adhesives on the market usually would damage or melt the foam, and the ones that don't are available and/or hard to handle. Adhesives are not the only way we can hold these blocks together; we can use nails. Of course, steel nails are heavy and might cause the foam to fail, so we used wooden skewers to nail every two blocks together. Wooden skewers are fast, available, and simple to use

C. Fabrication process

The fabrication process is the most important step in the project, it is what brings the project to reality. Coming up with the fabrication process, we had to think of what resources we have which were 22 workaholic students, an expert, a short amount of time, and a0 paper printer, and a handful of construction toolboxes.

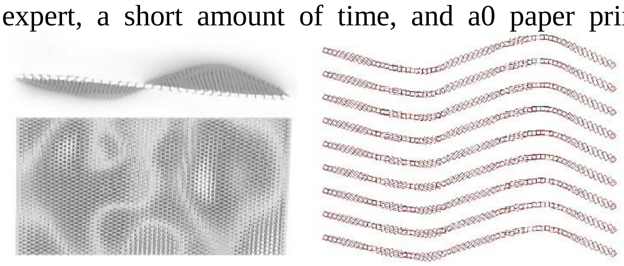

Fig. 2 (a) A elevation and a top view of the wall (b) The first 9 sections in the wall.

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(a)

Fig. 3 (a) early stages of the fabrication process. (b) mid-way in the fabrication process. (c) the final touches on the wall.

With all these resources, the fastest method that was thought of is to build this wall is to work in parallel with leaders to lead in specific tasks. The main tasks were to take the sections of the wall and preparing them to be printed, aligning, taping, and cutting the prints to make whole parts of the sections, fabricating the parts of the section, and putting all the fabricated sections together. The first task after having the design is to take the sections of the wall and preparing them for printing, it was a simple task but having over 70 sections to prepare and each section took 3 a0s to prepare. The sections were split 35 sections to be built and 35 sections to be used as a reference between the built sections. The built sections with the lever on top of it at the same time to have both sections linked in a single piece. In the beginning, the preparation for the files to be printed was split into a few members to get it done as quick as possible and start printing. After having the printed sections, the students started working in parallel with the rest of the processes. 2 groups of 2 align, tape, and cut the sections that were printed to prepare for fabrication. With people preparing the sections, 3 to 4 groups of 2 students were fabricating the sections to be built and prepare them to be merged with the rest of the wall. With the sections being built, we had 1 group merge the sections using the reference. Sometimes we would get another group to help merge the sections faster since the built sections were being built faster than a single group can merge them. Building the wall kept on going until we reached the day before, which made it up to 2.2 meters. On the last day, we spend the day to clean the wall the reference sections from between the blocks to make it look cleaner.

CONCLUSION

Just like any other project, the parametric wall had a big impact in learning and social aspect.

D. In Learning

Students are able to understand what parametric design is, how it works structurally and how to apply it. They learned that they can have a dynamic load bearing wall without it collapsing using s to line method.

Students were able to learn how to fabricate such a design, using different tools, methods and techniques. What materials to use to make such a design possible.

E. In social

For the first time in the department, students from different batches worked together on something. Senior students worked with 4th year students. Basic design students worked with design 2 students. This way people had a lot of opportunities to socialize, interact with each other and gain more friendship.

At the end of the project as a reward for students and supervisors hard work the department did a small ceremony were the students were rewarded, certificates were distributed, and a dinner was held. It was the first time in the department students and teachers interact and have an activity together as collogues and not as teacher-student relationship.

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