# Computational Craft

CODE2110

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# Analog & Digital

Computational Craft is the process of using digital design and fabrication processes to increase the efficiency and complexity of manual construction. I believe that a level of both analog and digital methods are required in designing and making, especially in terms of aggregate structures. The structure and fabrication of granular morphologies incorporates digital and analog processes in an ideal way. Digital processes can be used to design, analyse and simulate the structure. However, once constructed the structure relies on analog processes to be fabricated and reconfigured. In my experiments I used digital methods to control the parameters of the aggregate module. However, analog processes were also used to create a controlled environment and to observe how these parameters would affect the outcome.

The composition of granular morphologies allows the aggregates to adapt and reconfigure in a very flexible manner, because they are not attached to each other. Thus, the granular structure itself has a sense of awareness and responsiveness to the environment.

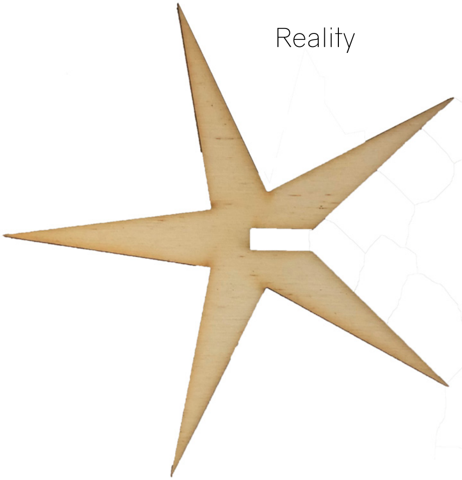
For example, in the project "Hygroscopic Aggregates," by the University of Stuttgart 2013, explores how digitally fabricated aggregates with "re-active ... hooks" can be programmed to occur at different stages in construction (Dierichs and Menges, 2008, p89). Therefore, these granular modules can form a responsive system,

like those discussed by Hen sel, Sunguroglu and Menges in 'Material performance.' Through experiments with certain materials, they determine ways in which traditionally undesirable characteristics can be used to develop the field of architecture. Much like the "re-active hooks" designed at the University of Stuttgart, Menges undertook an experiment testing how wood responds to changes in air humidity and moisture. This provides a direct relationship between material performance and environmental changes without the need of mechanics or programming. Further, once constructed the granular structure analog processes are required to fabricate and react to environmental factors.

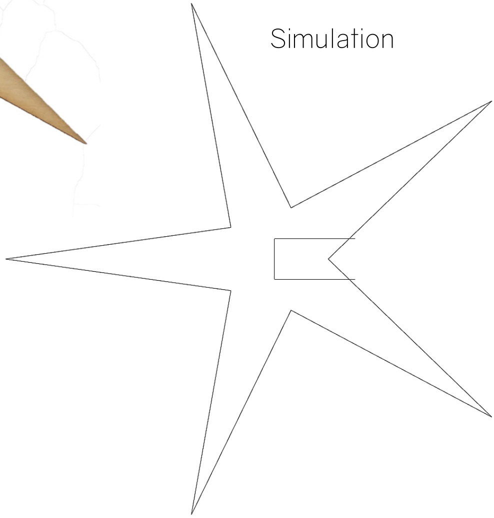
Designers using digital fabrication and design processes will often use simulation to predict and communicate how the design will work and look. In 'Granular Morphologies', Dierichs and Menges explain that simulations of the granular system, are used for "predictive behavioural modelling" (Dierichs and Menges, 2015, p.90). Further, simulation is used to retrieve complex information such as the number of contact points and loads placed on each module. However, it is then difficult to replicate the simulated result physically since experiments with granular modules rely heavily on the environment they are in.

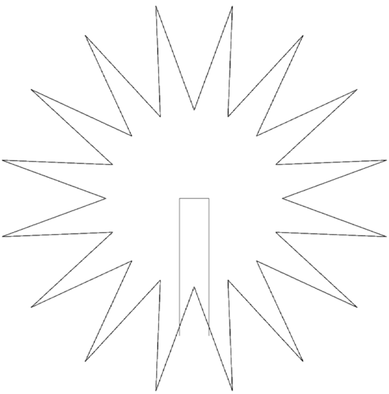
Results can be vastly different based on where the aggregates are stacked, the weather, and the size, shape and material of the container in which they are placed. Thus, no two experiments can be the same unless an enormous amount of time and effort are put into stacking the modules accurately. This is further explored in 'Granular Morphologies' by Dierichs and Menges, when they state that by controlling the "individual grain", this "allows for the prediction of behaviours and performances, but not for the exact geometry" (Dierichs and Menges, 2008, p.87). Comparatively, Turkle introduces the idea of simulation replacing reality. When taking her daughter to an exhibition, Turkle is surprised to find that her daughter would rather see a simulated turtle rather than a real one. This is because, authenticity "comes with aesthetic inconvenience" (Turkle, 2007, p.1), unlike a simulation, reality is not perfectly fabricated. This is like the simulation and reality of granular morphologies. The simulation of the aggregate form is just a prediction of one outcome of the experiment, but it does not factor in the "inconvenience" (Turkle, 2007, p.1) of reality. Therefore, a digital simulation and a physical model are not exact copies of each other and provide different information to the designer about the structure. In my making experiments, this concept can be seen in the fabrication of my aggregate modules. When looking at my final digital design compared with what was laser cut, you can see that they are not exact copies of each other. Due to an issue with the laser cutter, the slots in some of the modules are larger than others. The thickness of the laser itself also alters the size of the module as well and leaves burn marks on the material. Further, due to the actual shape of some modules, they were snapped and did not have sharp edges unlike the orginal digital design. Thus, while digital processes are required to design and analyse granular structures, this does not always effectively translate into reality.

Reality



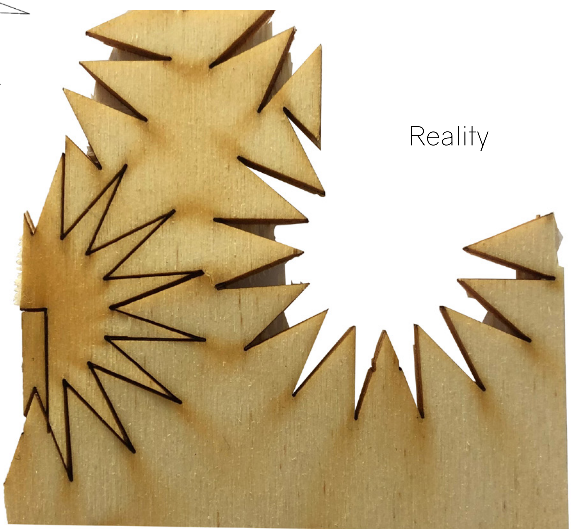
Simulation





Simulation

Reality



# Experiment 1

The aim of my first experiment was to find a shape which would create the best aggregate module. I was inspired by how sand stacks on top of each other. So I started with a simple spherical shape. However, I predicted that with its smooth edges it would not interlock with the other modules (as seen in image 1). So, I decided to make a spherical shape with grooves or spikes which would catch onto the other modules (as seen in image 2). I played around with the parameters in my grasshopper script to create several variations that I could fabricate and test. Thus, I can determine the best characteristics for an aggregate module. When designing the aggregate modules, I adjusted the parameters in my grasshopper script to create 4 different variations to test. I adjusted the inside radius and divisions of the shapes, which changes the sharpness and size of the spikes/grooves in the modules. Further, to make the modules 3D I will laser cut 2 flat segments of wood and slot them together (as seen in image 3).

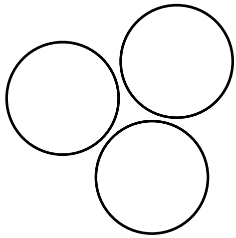


Image 1: smoother edges won't interlock

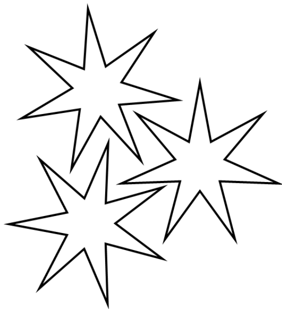


Image 2: shapes with grooves or spikes can catch onto each other

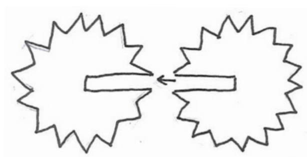
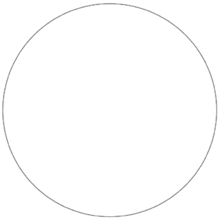
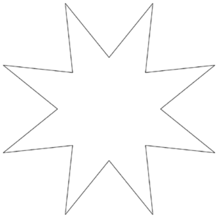


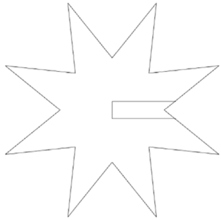
Image 3: the two laser cutted segments will slot together to form a 3D module



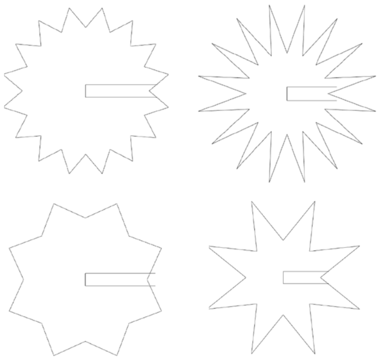
Create basic shape in rhino



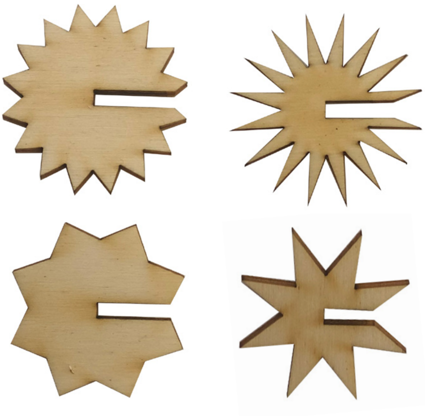
Add detail in grasshopper



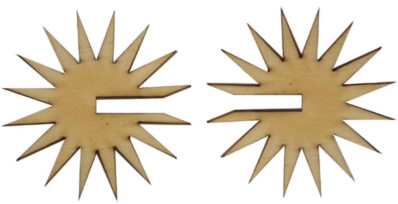
Add slots for assembly



Change parameters to create 4 different modules



Laser cut each variation



Slot the two pieces together

3D Module

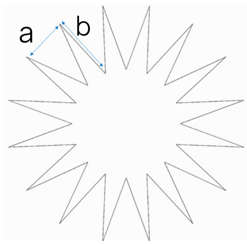
To test how the aggregates perform, I undertook an experiment with the different variations. I placed a small balloon in the base of a clear container and piled the modules on top. I then popped the balloon with a pin to see if the structure held its shape. The variations that hold better after the balloon was popped are better at interlocking with each other and thus make better aggregates. I predict that the modules with sharper grooves will stack better than those with milder spikes, because there will be more area to catch onto.

As you can see from my experimentation on the right, all of the modules except for the last, totally collapsed. Through undertaking these experiments, it was clear which parameters create better aggregates. The modules with more and sharper spikes lock onto each other better and hold their structure after the balloon is popped.

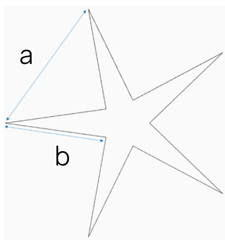
Most successful aggregate

# Experiment 2

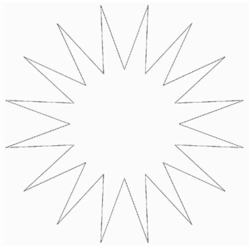
In my first making experiment, I developed 4 variations of aggregate modules to test as see which stacked better. I found that shapes with thinner and longer spikes stacked on top of each other better than the other shapes. However, I also found these shapes harder to fabricate. Because there were many long and thin spikes close together, they were difficult to pop out once laser cut. This meant that a few modules were snapped and therefore unusable. Further, with more spikes, more material is used and the total laser cutting time is increased. I started by taking my most successful module from last experiment and analysed why this module was successful. The long and thin spikes made this shape a better aggregate. Thus, I would need to retain these features when developing my shape. Then I determined the features which made it difficult to fabricate. The small distance between the spikes and number of spikes made it harder to pop the shape out of the wood without snapping it. Further, the number of spikes increased the total time laser cutting and the amount of material used. So, I increased the distance between the outer and inner points of the shape (a) to create longer, thinner spikes and I decreased the number of spikes, increasing the distance between two spikes (b). I then added a slot to the shape for assembly of the 3D object. This shape was then laser cut from 3mm poplar ply wood (same as the first experiment) and assembled to create the 3D module.



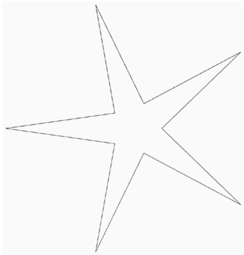
Original module



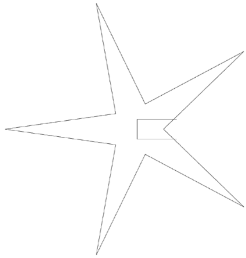
Developed module



Start with original module

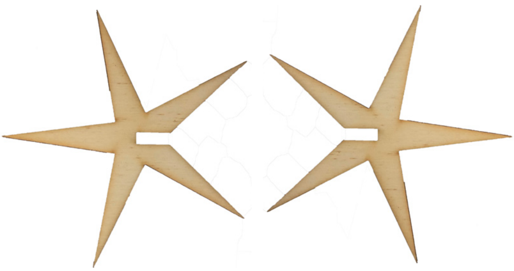


Change parameters to create a new module



Add slots for assembly

Laser cut



Slot pieces together

3D Module

The developed shape was significantly easier to digitally fabricate than from the previous experiment. After fabrication I found that the new shape had much cleaner edges with no spikes snapped at all (as can be seen below). Every cut module from this experiment was able to be used, thus reducing material waste. Further, the print time was almost half the time of the previous experiment. However, in the last print I cut a variety of shapes so this factor wouldn't signify the success of the digital fabrication. Thus, the developed module was significantly easier to digitally fabricate than the original shape.

But is it still a good aggregate?

Like the last experiment, I will test the capability of the aggregate modules by undertaking a "balloon test". I will stack the modules over an inflated balloon, then pop it. If the aggregates hold their shape and do not collapse, the modules were successful. I tested my original aggregates against my new aggregates to properly compare them. As you can see from the images on the left, the new aggregates performed substantially better with only 1 module falling.

Therefore, through parametrically adapting my original design I was able to create a successful aggregate module which is easily fabricated.

# References

Dierichs, K. and Menges, A., 2015. Granular morphologies: programming material behaviour with designed aggregates. Architectural Design, 85(5), pp.86-91.

Hensel, M., Sunguroglu, D. and Menges, A., 2008. “Material performance.” Architectural Design, 78(2), pp.34-41.

Turkle, S., 2007. Simulation versus authenticity. What is your dangerous idea, pp.244-247.