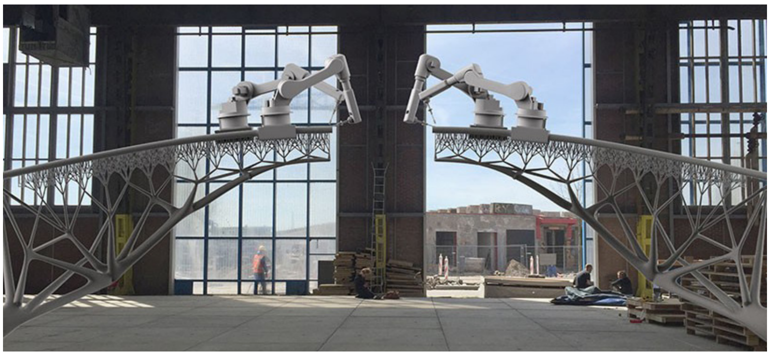
Evolving objects / Braitenberg morphs - a draft proposal for T472, drawing on M366 - Philip Hughson A3695969 - August 2016

> *Very few things actually get manufactured these days, because in an infintely large Universe such as, for instance, the one in which we live, most things one could possibly imagine, and a lot of things one would rather not, grow somewhere.* (Douglas Adams 2009 ch. 9)

If Darwin and Dawkins' trumpeting of evolution has done for the design argument for God, could we follow Douglas Adams' suggestion and do the same for designers? If we conceive of design space as an infinite, highly dimensioned space of possible objects, could we use a genetic or evolutionary algorithm to explore this space, farming forms for usefulness, or at least visual interest - a Crufts for stuff?

Biomorphic design already familiar (clockwise from top left): Gaudi has us looking at a forest canopy in the Sagrada Familia (Wood n.d.), Neri Oxman (2016) has designed chairs based on the morphogenic processes of shellfish, Gavin Munro of Full Grown (2016) is growing willow chairs , Theo Jansen (n.d.) is famed creating life from plastic yellow tubes, and MX3D (n.d.) are working on a elegent steel bridge to be 3d printed by spot welding robots.




The Open Univesity's Natural and Artificial Intelligence course (Richards Smith & Dobbyn 2009) presented the notion of artificial evolution, exemplified by the Braitenberg vehicle thought experiments (1984) and its robot derivatives, where increasinly complex robot behaviours are devleoped by connecting sensors to motors, either directly or via a controller, perhaps an artificial neural network, as devloped by Floreano and Nolfi (2004). Released in an environment, these relatively simple creatures can exhibit complex behaviours such as following mazes, collecting and expelling rubbish or pursuit and evasion, behaviours which can be selected for and evolved by a genetic algorithm rather than explicitly designed.

What if instead of evolving behaviours in response to environmental stimulus we evolved form? Could a similar method be used, with simple units, akin perhaps to plant cells, able to sense their environment and take appropriate decisions, not to move but to grow? Could we design an artificial environment and organism where evolutionary forces explore the fitness landscape of a familiar object such as a tower, bag or bridge? Would this bring Douglas Adam's ratchet screwdriver fruit closer to reality?

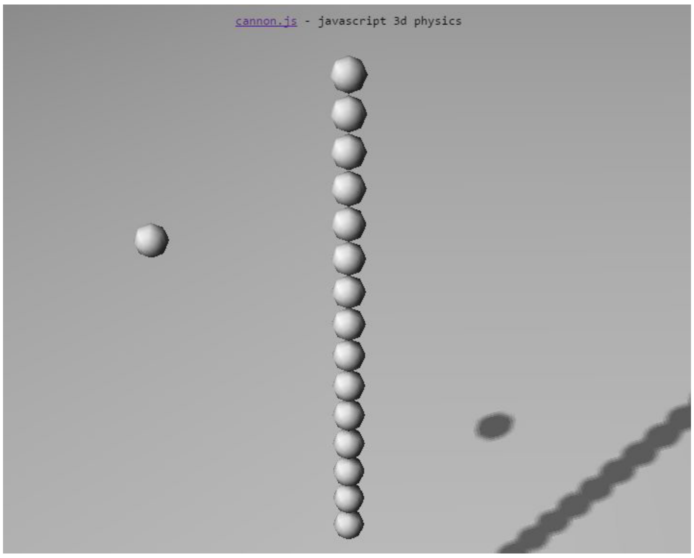
I would propose to use a computer physics engine to virtual world in which to explore this idea. Objects could be constructed from a series of agents or cells, each capable of sensing its environment and of behaviours such as growth, reproduction and binding, governed by a contoller specified by an artificial genome. These objects could be assessed for fitness somehow (e.g. by measuring the height of a tower, or counting the number of bodies that cross a gap in the presence of a bridge) to allow artifical evolution to take place.

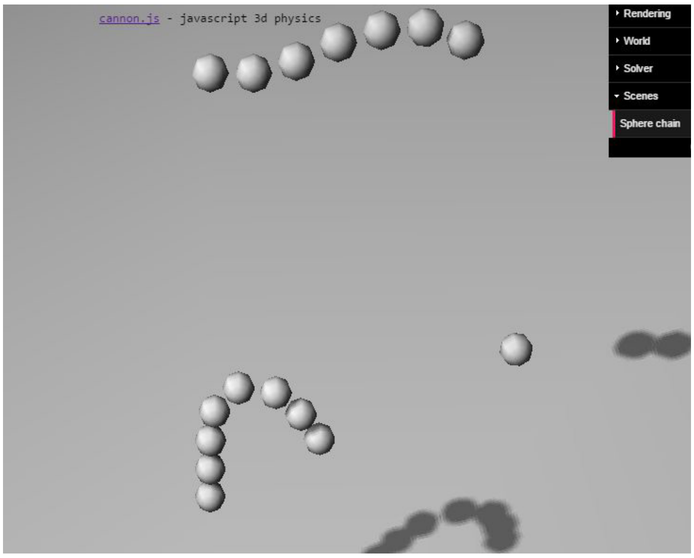
Of course, evolutionary computation has been used to design objects before. Oyama (2000) used a genetic algorithm to optimise wing shapes. My interest here lies in creating forms using the more indirect approach of having a genome specify a controller (of some kind) rather than specifying parameters for shapes. This too has doubtless been done before, but it would be interesting to learn how to think about the environmental forces required to create an object which develops in this way.

There are many foreseeable problems, and much of the interest of the project would come from trying to overcome these. Specifying a fitness function for objects is far from straightforward, though in the case of a tower aiming for maximum height in the presence of destructive forces is relatitvely simple. Care would be required to handle the "bootstrap problem", or to climb Dawkins' "Mount Improbable" (2006) without meeting cliffs: could we make one third of a bridge any use? Processing power may be insufficient for the many generations required by genetic algorithms, though this could perhaps be mitigated by simplifying the environment to two dimensions.

An ideal outcome would be the creation of viable and structurally interesting or surprising designs which could be created using a 3D printing technique, perhaps similar to that used by MX3D or Oxman, and a web interface which would allow experimentation with an evolutionary object design algorithm. A satisfactory outcome would be the better understanding of the techniques and difficulties involved in artificial evolution, along with one successful example of the evolution of a simple object!

The coding would be done in Javascript, allowing easy presentation in a web browser, using physics engine such ammo.js or cannon.js. These both allow the creation of tearable bonds between bodies, a minimum requirement for the simulation of structural strength. The accuracy of the physics engine though would only need to be enough to explore the ideas. (Alternatively software such as Grasshopper might work, though I still need to investigate this). Neural networks could either be implemented by hand or using a library such as synaptic.js. Genetic.js (Sub Protocol 2014) could be used to facilitate the running of genetic algorithms.





Cannon.js can similiuate the breaking of bonds between bodies under strain, as in this example where a projectile breaks a chain. This would be an essential requirement to simulate the evolution of forms able to resist forces up to a limit.

I favour Javascript because I have used it in previous work, both professionally and during my recent M.Des. course at the Glasgow School of Art and find it easy to write in. My interest in the creation of forms comes from my previous design work, where I've enjoyed looking at generative processes (see e.g. https://horse.press/palabragraphy). This proposal aims to combine this with the computational ideas covered in M366.

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