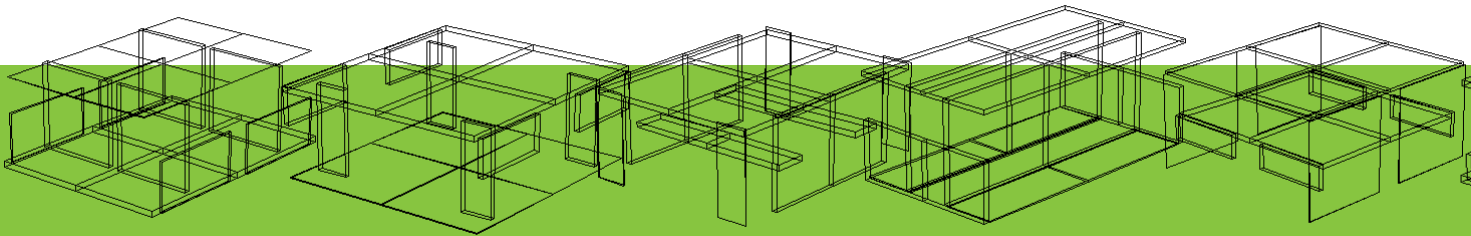


# Evolutionary

Technological advances open new design frontiers



**Evolutionary design is a computer process of creating large sets of solutions to a design problem, then whittling down the set of solutions by finding those that work best. Computer scientists have been aware of the potential power of this principle as a design tool since the 1970s, but it is only recently that computers have achieved the necessary speed and data storage capabilities to make it feasible. Today, experts in the field say it would be a simple matter to create programs capable of determining the optimum layout for a kitchen or inventing novel furniture designs unlike anything a human would invent. All we are lacking is the necessary investment in software development.**

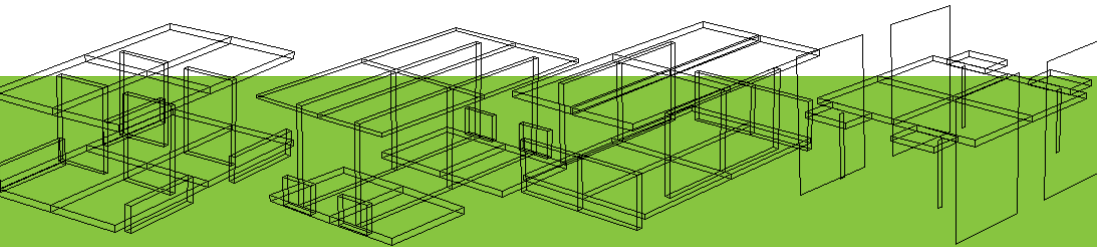
**P**eter Bentley is a computer scientist at University College in London, England, a contributing editor of *Wired* magazine and the author of *Evolutionary Design by Computers* and *Creative Evolutionary Systems*. One day, in 1999, Bentley did not like the design of the flat-pack coffee table he had purchased. Bentley programmed the dimensions of the various pieces into the evolutionary design software he had developed for his doctoral thesis, along with some basic parameters outlining the characteristics a table must have (a flat surface on top, legs of equal lengths, etc.) The software set

to work like a million monkeys at a million typewriters, generating thousands of possible ways for the pieces to fit together and discarding those that did not fit within the established parameters. In the end, the computer displayed 20 solutions, from which Bentley chose one to build. Using modern computers, Bentley says this processing takes only seconds to complete.

Evolutionary design has some important advantages, at least in theory, over design by humans. A computer brings no baggage to design problems. It is not influenced by preconceived notions of what is possible or desirable or what will be accepted by its peers. It is not tempted to speed up the design process by recycling old ideas. Equally, it is not bored by the tried-and-true, and has no motivation to show off or to amuse itself with self-indulgent efforts. As an engine of pure creativity, it is completely unfettered within the limits of what it is told to do. Set the boundaries wide enough, and computers are capable of producing designs completely unlike anything thought of by a person, or anything likely to be thought of by a person.

Evolutionary design has been used to invent new satellite antennae, optical fibre solutions, water valves and bridges. Bentley says one of his students is experimenting with using the technology to program rapid prototyping machines to build objects with purpose-designed micro-structures, controlling the microscopic make-up

# design



Bentley's early evolutionary design system created 20 coffee table designs using the same set of cut wood.

of materials to achieve different performance outcomes. Such technology may someday make it possible for panel producers to deliver custom products with specified ratings for rigidity, air permeability or screw retention.

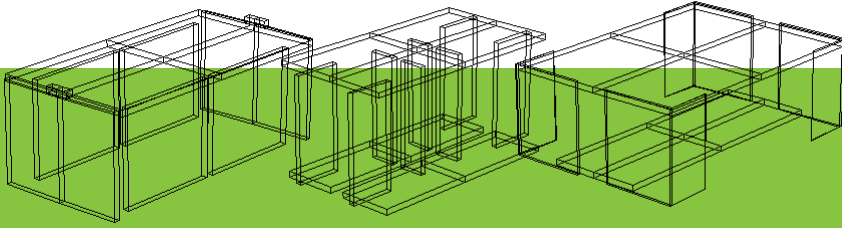
Bentley has applied the technology to lay out whole hospital floors, which is a very large, complicated problem with hundreds of parameters. By comparison, he predicts adapting evolutionary design for kitchens and furniture would be relatively easy. "The difficulty often can be that the program is too creative," he says. "If we leave the parameters too loose we get these amazing, flowing shapes that look incredible, but are probably unbuildable." Software using evolutionary design would be ideally suited for solutions that offer the most storage in the least space, but could also be programmed to consider such factors as a short person's reach, space to walk around, workflow and any other parameter that could be expressed mathematically.

**S**ahryar Rahnamayan, an assistant professor at the University of Ontario Institute of Technology, has some specific ideas about how evolutionary cabinet design software could work. He says there are two possible directions the software development could take: interactive and non-interactive. An interactive program would create a generation of designs then allow the user to rank them in order of preference. Working off this list, the computer

would then be able to optimize the designs further, incorporating more of the desired features and eliminating design elements that rank lower. The software would then generate another set of designs for the user to rank, and the process would continue until the user settles on a final design. It is easy to imagine software like this in use in some future cabinet showroom, with the customer selecting designs off a touchscreen and sending the final result to the back for production. The other, non-interactive approach would see the computer applying its own fitness algorithm to the solution set, eventually showing a finished, optimized design. This approach could potentially generate some wildly creative solutions.

**C**hristian Jacob, an associate professor of computer science at the University of Calgary, has taken the problem one step closer to woodworking by investigating how evolutionary design systems and another concept called "swarm computing" can generate better architectural solutions. Swarm computing works by creating agents: small, individual programs designed to act like humans do within a defined space. Evolutionary design is used to create a floor layout, then a swarm of these agents is "released" into the virtual space to move around and do the things a group of people might. By analyzing the agents' behaviours, the user can see bottlenecks where movement is restricted, inefficient patterns of movement

# Evolutionary design



where agents are forced to double back repeatedly, and dead zones of wasted floor space where few agents need to go. These results can be fed back into the evolutionary algorithm to generate successive generations of improved designs. The application for kitchen design is obvious. Jacob has found that these systems not only produce novel and highly optimized solutions for architectural layouts, they are also highly “constrained,” meaning the solutions are not so out-of-this-world that no human builder would attempt them.

**C**reative designs are all well and good, but the design must also be reasonably easy to manufacture. Again, this comes down to careful selection of the fitness parameters the computer uses to select its next generation of solutions. The computer could even be told to consider only four-sided boxes, but to alter the sizes and positions to find the best solution for a given kitchen space. Rahnamayan says an interactive program would allow manufacturers to tweak and adjust each generation to make sure the design never becomes too difficult to produce.

None of the sources above are aware of any initiative to develop evolutionary design systems for cabinet or furniture design, but all said it would not be extremely difficult or expensive to do so. Bentley and Rahnamayan say the project could be a master’s thesis for a computer science major with the support of an interested company, yielding useful design software in about two years. Such government funding organizations as the Natural Sciences and Engineering Research Council (NSERC) are mandated to assist companies in sponsoring research of this kind.

Design separates you from the competition. Evolutionary design could be the technological advance that automates custom design, changing the design table in much the same way CNC machining changed the production floor.

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