

Creative Evolution

You are amazing. Your brain is an example of the most complex computer we know of - as you read this it is performing more parallel computations than our best supercomputers. Your immune system is better than any army as it fights a never-ending battle against viruses and bacteria for your survival. Every part of you is a miracle of design, from your beating heart right down to the DNA within the individual cells of your body.

But you are not the only miracle in this world. Every form of life on this planet shares the same honour. We are all astonishing solutions to the continuously changing problem of how to survive and propagate our genes to the next generation. And nature is unsurpassed in her ability to find innovative and creative solutions to this problem. Can *we* make a machine three millimetres long that is capable of flying under its own power? What about giving it sight, or the ability to keep itself functioning by converting chemicals into energy, or even the ability to make copies of itself? We simply do not have the know-how to achieve these marvels. But this is what nature has achieved in a creature as simple as a fly. We do not have to wait for some science fiction scenario where aliens from other worlds give us superior technology - the technology of the natural world is already all around and within us - and it is vastly superior to our technology.

This is really good news, for we know how the solutions of life were generated. Life *evolved*. When things make copies of themselves, when those copies inherit features from their parents with some variation, and when some of the things have more children than others because of some kind of selection pressure, then evolution just happens. Generation by generation, the reproducing things slowly change. They become better at flying, or seeing, or running, or hiding, or digesting or any number of other things. Evolution changes life, shapes it and fine-tunes it for a million different purposes. Evolution is inventive, creative and powerful.

Evolution is also *independent of medium*. In the same way that text is still text whether written on paper or displayed on a computer screen, evolution is still evolution whether it acts in nature or in other media. Computer Scientists like Dr Peter Bentley at the Department of Computer Science, UCL, find this very useful. By creating digital environments within computers, and allowing

populations of digital solutions to reproduce with inheritance, variation and selection, the solutions start to *evolve*.

Using this principle, the field of Evolutionary Computation has become highly successful in the last ten years. Today, researchers worldwide investigate the use of computers to evolve solutions to every conceivable problem. Evolution has been used to optimise designs of flywheels, electricity pylons, space stations. Neural networks capable of controlling robots are evolved, artists have evolved their art, architects have evolved innovative building designs.

And it seems that evolutionary computation is just as inventive, creative and powerful as natural evolution. The most recent application of evolution in our computers has been to problems traditionally thought to be beyond the capabilities of computers. The results are often surprising. Evolution allows our computers to compose music, generate art and create original and novel designs. Dr Bentley, editor of the successful book *Evolutionary Design by Computers* knows this all too well - he now has two pieces of furniture at home that were evolved by computer. Peter's team at UCL explores the use of evolution for a large number of problems. Ms Jungwon Kim is investigating how evolution can generate an immune system within a computer network, capable of detecting hackers and other unwanted intrusions. Sanjeev Kumar is discovering how computational embryology can be used to *grow* solutions from evolved digital DNA. Tim Gordon is examining how coevolution could generate electronic circuits which enable efficient compression/decompression of data across networks. Peter also uses evolution to generate novel designs, from architecture to aerodynamic cars. He has combined evolution with fuzzy logic and enabled fraudulent home insurance claims to be found automatically. He has also shown how evolution can be used to compose music that is indistinguishable from compositions of talented human composers.

The success of evolutionary computation is surprising, but perhaps it should not be. It uses the same process responsible for the creation of life on our planet. Evolution is shaping the capabilities of our computers, just as it shapes the natural world.

Dr Bentley will be exploring these ideas further in his next book, entitled: *Creative Evolutionary Systems* and in the popular science book *Digital Biology*, which he is busily writing now.