Cooperative Co-evolution of Robot Control, Sensor Relevance and Placement

Robert S. Goldsmith and Julian F. Miller
School of Computer Science, University of Birmingham, Birmingham, B15 2TT, UK
{R.S.Goldsmith, J.Miller}@cs.bham.ac.uk

Naturally evolved systems are not built of separately designed parts bolted together at a later date but symbiotically, each component is reliant on other components and evolves in such a way as to work even more closely with the whole. The result is a highly robust, dynamic system where components that once evolved for one task can be reused for other purposes and where each component takes on multiple roles. Man-made systems, such as robots, are the antithesis of these evolved systems - modular, brittle and completely incapable of adapting in any way to new environments or situations.

Technical difficulties prevent many interesting experiments into robot evolution from being carried out on real robots and this has restricted most of the research in this field to simulations. However, simulated environments are only as rich and diverse as they are programmed and, as one of the driving forces behind evolutionary adaptation is a rich and varied environment, simulations have inherent limitations. The research presented focuses on robot sensors, an area of robot design that can be easily adjusted by evolutionary techniques, using real robots interacting in real environments. The benefits of this are twofold; the robots have a much richer environment in which to evolve and real practical techniques and solutions to real world evolution can be found and documented.

Any robot capable of hardware evolution must have mechanisms or resources by which it can modify itself and this has been one of the major stumbling blocks of real-world hardware evolution. After all, how do you build robots that can rebuild themselves? This problem has driven many researchers to use simulation instead but, as mentioned briefly above, there are recognized limits to this approach. The research finds a middle path between the two extremes. A hardware platform has been developed with a very large number of light sensors (almost 200) which uses an onboard processor to gather information from a programmed subset of these sensors. Instead of rebuilding the platform with new sensor positions for every offspring, the platform is reconfigured to collect sensor data from the specified sensors. This gives back some of the flexibility of a simulation while maintaining the real-world richness and imprecision that is so hard to build into a software environment.

All the units will participate at once in a single environment and the generational approach has been discarded in favour of a more natural progression between generations where a new offspring is introduced into the environment as an old one dies. The experiment will try to maintain an average of 6 or 7 active units in the environment at any one time. Food (which gives the units energy) is in the form of blocks in the environment that emit coloured light. Different colours denote different types of food. A unit can die through running out of energy or through old age. Fitness evaluation has also been made implicit to the environment and is based partly on the energy level of the units and partly on chance encounters. When two robots bump into each other, their relative energy levels are taken into account in deciding whether a 'potential offspring' will be generated. This potential offspring is added to a pool of potentials and when a unit becomes available, an offspring is randomly picked from the pool.

Fundamentally, every experiment revolves around the ability of a unit to find food and reproduce. Starting with the most basic setup involving a bare environment and a single food cube, units will be encouraged to evolve more and more complex behaviours requiring more specific sensor placement. Adding more food cubes, turning the food cubes off and on over time, and adding different colours of food into the environment will force scouting and the evolution of colour detection. Once a unit has evolved in one environment, the flexibility of the evolutionary approach will be put to the test by placing units of this type into very different environments and seeing how and if they cope.