GENETIC CONTROL

Building Artificial Nervous Systems and Artificial Embryos

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Genetic Control is an example of a new programming methodology called "Genetic Programming" (GP) which is the application of the Genetic Algorithm form of artificial evolution to build and control hyper-complex systems whose dynamics or interactions are too complex to be fully understood. The philosophy of GP is that it is still possible to exercise effective control over complex systems even though one has (partially) abandoned the traditional sc of fully understanding how they work. Two concrete examples of this philosophy presented, namely the construction of an artificial nervous system and a embryo. Building such systems would normally have been considered impossible with traditional control techniques, but the power and simplicity of the level of complexity of the underlying mechanism is irrelevant to its creation simply measures the performance (fitness) of systems and is indifferent to performance. Those randomly mutated (bitstring) "chromosomes" (specific performance) which do well, simply have more offspring in the next generation.

Artificial Nervous Systems: The GA was used to evolve the weights of fully connected neural network modules (called GenNets) such that the neurons controlled behaviours in desired ways. For example, an artificial lizard-like (called LIZZY) had the angles of its 4 two-part legs specified over time by the outputs, such that LIZZY walked straight ahead, or turned left or right ebe behaviour per GenNet. By using detector and decision GenNets (in a GenNet determine which behaviour to be switched on and off, LIZZY was able to behave coherently to its environment. An artificial nervous system was thus created.

Artificial Embryos: The GA was used to evolve birth and death rules of cells in cellular automaton such that the final shape of a colony of cells resembled a possible any desired target shape. This work (still in progress) has been successful for 2D (convex) shapes with overlaps of target shapes of 93-95%. I will be w MIT (Dec-Jan 1991) to put these ideas onto a Connection Machine, the idea build an artificial embryo. If one can build arbitrary shapes in 2D, they can 3D, and if one shape can be built, so can many, and sequentially, so that possible to build first a body and then limbs and head, then fingers, nose, e hoped that this type of "Genetic Assembly" will form the basis for a new field of Embryonics" (Embryological Electronics), i.e., the art of growing (self assem electronic circuits in VLSI and then testing them in Darwinian fashion in specia called "Darwin Machines".