

Chapter 7: Conclusions

Artificial Life (AL) is a new and still rapidly growing research field. AL combines multidisciplinary attempts to explain complex phenomena in nature using new procedures, typically a synthetic i.e. bottom-up approach and computer simulations. Thus AL helps to understand such complex phenomena that could not be explained using familiar linear models but requested new methods and means.

AL has three main goals: studying biological issues, abstracting principles of intelligent behavior and develop practical applications based on these findings. In doing so AL uses computational techniques to understand biological issues and biological techniques to solve computational problems.

Referring to the connection between AL and biology AL can be characterized as the study of human-made systems that posses some essential characteristics of living systems.

Another way to describe AL is that it tries to give solutions to high-level problems by understanding low-level rules. Computer simulations show that complex pattern and complex behavior on a high level are emergent results of the application of simple local rules to small units and, of the simultaneous interaction of several of such units on a lower level. Expressed with few words: the sum is often more than its parts.

Another important finding of AL is that there is no need for central organization or control to reach such complex behavior as the behavior emerges from the low-level rules itself.

Examples of pattern formation in natural and artificial systems using simple rules are cellular automata, Lindenmeyer systems (L-systems), and fractals which can be used, to explain the growth-process of plants and the formation of patterns on seashell and, to develop artificial creatures in the game of life.

A similar result – the emergence of complex behavioral patterns – can be seen in robots and natural agents. In this context it is also called “distributed or swarm intelligence”. Through a process of mutual interaction, self-organization and interaction with the environment artificial and natural agents achieve impressive results they would never be able to achieve on their own. Good examples are self-organizing phenomena in insect societies (how bees organize their nest or how ants find the shortest path to a food source), the flocking of boids (a computer simulation of birds), or the heap building process of some robots (Didabots). Self-organizing artificial societies and agent-based models can also be used to understand and solve complex real-world problems such as distribution of resources, market predictions and data-mining. Again no central control is needed.

Another important topic in the broad research field of AL is artificial evolution. There are tree main types of evolutionary algorithms: genetic algorithms, evolutionary programming, and evolution strategies. These types have been developed at about the same time but with different intentions in mind. The application of evolutionary algorithms i.e. to get a wide variety of new solutions and offspring respectively, to evaluate their fitness and to allow only the best solution or the fittest offspring to reproduce leads to new and unexpected results. Methods from artificial evolution as optimization procedures, or more generally as design methods have proven very useful. Using evolutionary algorithms solutions have been found that humans could not easily have derived.

One limitation in AL is that it mostly uses computer simulations and models. Thus its findings aren't restricted to those of traditional biology but to the possibilities of computers. Despite the fact that simulations and models used in AL lead to new and unexpected results that can often not be predicted since too many interactions happen simultaneously they still depend on how the simulations or models are designed and what data is fed to the computer. Simulations and models always have to simplify the world and cannot fully reflect real-world situations. Another limitation is that results have to be interpreted and such interpretation depends strongly on the intention and background of the interpreter. One way to set aside such restrictions is to connect AL and its findings to the real world e.g. by building robots which have to interact with, and learn from, the physical world rather than by designing agents and environment on a computer.

AL is a rapidly growing branch of science that introduces new means and methods to find new solutions to existing problems. Thus it helps to a better theoretical understanding and practical application of existing biological knowledge and to formulate new ideas that can be applied to other fields of science and real-world problems.