Heuristic evolutionary rule-based artificial life

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This paper deals with artificial life. Our goal is to show, that artificial organisms living in virtual world are able to adapt through evolution and natural selection by creating a set of rules that help them survive in changing environment. Our project consists of the implementation of artificial life simulator, which is controlled by the rule based system of genes (i.e. genes are rules in the form, 'Conditions → Actions').

Artificial Life (Alife) is "an area of research aimed at understanding life through experiments on the abstraction of the basic dynamic principles for the biological phenomenon and the reconstruction of a dynamic system in a medium so that it can be studied and manipulated it in new ways". Artificial life varies from many different areas of artificial intelligence by using bottom-up approach - intelligent behavior it seeks is achieved through collaboration of simple basic components. Artificial life is divided into three subgroups - soft Alife (based on representations of software), hard Alife (hardware representation) and wet Alife (biochemically created artificial life). The concept of artificial life is often also used to refer to the first group alone - represented by artificial life software. This project belongs to this group of Alife.

In software terms it is possible to program an artificial life as a sequential evolutionary algorithm using a certain set of instructions. In this project, however we will deal with an alternative representations - rule based system. Genes and hence the actual behavior of organisms is characterized by a system of rules in the form: 'Conditions → Actions'. Such rule based system consists of a set of rules, which are composed from basic conditions and actions. Various rules will be composed with the intent to create unique patterns of behavior for individual types of organisms and their composition will therefore specify the species.

Rule based system in general, along with a set of rules, requires the existence of a mechanism to decide which specific rules from the knowledge sets will be used in each step of processing the input. There are two basic types of mechanisms - sequential and random. Sequential mechanism goes through the rules sequentially, and selects the first rule that satisfies the condition. Random

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mechanism, unlike the sequential one, chooses rules randomly. By combining of these two approaches different types of mechanisms can be developed as well.
For the purpose of our research we created simulator that allows us to run a simulation of multiple species living and evolving in a customizable world. These species have a set of adjustable parameters that can be set and so create various distinct species. It is possible to simulate this world for an unlimited amount of time and to pause/resume the simulation at any time. It is also possible to save and to load settings for various species to/from a file. The application/prototype allows user to easily set the parameters for simulation and the simulation world and gives access to real-time visualization of the simulation. Visualization displays state and process of the simulation and allows dynamic manipulation with the camera (zoom in/out, move in four directions).
The prototype is currently reporting only the most basic simulation statistics such as population size, average age of organisms, the average energy and so on. These data are reported into the file and are also displayed in a graphical visualization window. The prototype also allows the use of custom maps/grids of the world that user can create in form of a text file (following given format).
Settings accessible in the prototype can be divided into following four subgroups.
Parameters of the world:

- world map
- rate of mutation
- food growth – method and intensity (period and quantity)
- food energy

Parameters of species:

- initial population size
- set of available actions and conditions
- number of genes and number of actions/conditions in them
- gene selection method
- maximum possible energy for members of given species
- maximum age limit (death of old age – this mechanism can be disabled)
- color of the species (for visualization purposes)

Parameters of actions:

- energy cost
- unsuccessful execution penalty (in units of energy)
- duration

Parameters of reporting:

- reporting period (time between two consecutive reports)

Overall the product allows the user to set-up and run simulations of evolutions in customizable world. This customization includes specification of several species of organisms with a wide variety of parameters, specification of world and the environment. Application creates statistical reports during the simulations and allows the user to “watch” the evolution thanks to attractive visualization of the world. It is also possible to easily use the application for powerful testing of various sets of parameter values across multiple simulations in attempts to find and determine their effects on the evolution process.