Abstract

Classical genetic programming (GP) solves problems by applying the Darwinian concepts of selection, survival and reproduction to a population of computer programs. Here we extend the biological analogy to incorporate epigenetic regulation through both learning and evolution. Using inheritable Lamarckian mechanisms as inspiration, we propose a system that allows for updating of individuals in the population during their lifetime while simultaneously preserving both genotypic and phenotypic traits during reproduction. The implementation is made simple through the use of syntax-free, developmental, linear genetic programming (DLGP) [1].

The representation allows for arbitrarily-ordered genomes to be syntactically valid programs, thereby creating a genetic programming approach upon which quasi-uniform epigenetic updating and inheritance can be easily applied. Generational updates are made using an in faster convergence, less bloat, and an improved ability to find exact solutions on a number of symbolic regression problems.

Motivation

Today, Lamarckian mechanisms are known to exist in biology and have been demonstrated in many studies. The studies constitute the growing recognition of the essential role played by acquisitions and improvements that are not necessarily reflected in the next generation. With this work, we aim to investigate how epigenetic mechanisms can interact to improve genetic programming for many applications. Namely, further work should address various levels of evolutionary inheritance, as well as the contributions of environmental factors or inheritance to the improvement in success.

Addition of an Epigenetic Layer to GP

We represented two characteristics of epigenesis in this implementation: 1) dependence on environmental factors by use of the EHC, and 2) inheritability by evolution of epilines with their corresponding genotypes. Unlike previous methods, our system allows offspring to inherit both the learned phenotypic traits of their parents as well as the genotypic underpinning. With this system we demonstrate higher success rates and lower solution bloat for a number of symbolic regression problems, with equivalent or lower computational effort required. We hope this work will provide the basis for further investigation into how epigenetic learning and evolution can interact to improve genetic programming for many applications. Namely, further work should address various levels of evolutionary inheritance, as well as the contributions of environmental factors or inheritance to the improvement in success.

Examples

This system identification approach is being used to identify wind turbine dynamics of the National Renewable Energy Laboratory’s CART3 turbine (pictured) and for developing bird migration models based on measured data. In the future, we hope to apply it to the design of nonlinear controllers for offshore wind turbines.

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