On the Roles of Redundancy and Neutrality in Evolutionary Optimization: An Experimental Study

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ABSTRACT

An experimental study was performed to explore whether it is neutrality itself or simply the larger neighborhoods associated with neutral representations that influence the results achieved by evolutionary algorithms on NK fitness landscape problems. Markov chains were used to model the behaviour of a stochastic hill-climber on NK fitness landscapes, using two different types of representation: a neutral network representation which exhibits neutrality and a redundant representation without neutrality which implements the same neighborhood induced by the corresponding neutral representation.

Categories and Subject Descriptors

I.2.8 [**Artificial Intelligence**]: Problem Solving, Control Methods, and Search; I.6.5 [**Simulation and Modeling**]: Model Development

General Terms

Design, experimentation

Keywords

Redundancy, neutral network, NK fitness landscape, hill-climber, Markov chain

1. NEUTRAL VERSUS NON-NEUTRAL REPRESENTATIONS

The family of binary representations inspired by error-control codes proposed in [1] exhibits various levels of neutrality, connectivity, synonymity and locality. In the same work, another family of redundant, but non-neutral, binary representations was proposed, which can be defined in terms of a linear transformation between the genotypic and the phenotypic spaces:

$$u = G \cdot v \tag{1}$$

where the columns of the binary matrix G consist of the phenotypes which are reachable from the all-zero phenotype through single gene mutations. Therefore, the connectivity of the representation can be explicitly designed to match the connectivity of given neutral representations. In this way, pairs of analogous representations differing mainly with respect to neutrality may be obtained.

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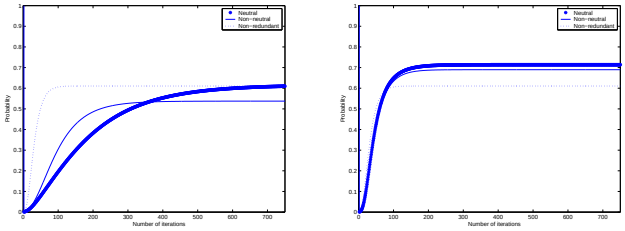

Figure 1: Results on two different NK-landscape instances

2. EXPERIMENTAL RESULTS

As the NK fitness landscapes can be gradually tuned from smooth to rugged, it is a good fitness model to study different types of neutral networks. The behaviour of a stochastic hill-climber on an NK fitness landscape was modeled as a Markov chain, and the long-term probability of reaching the global optimum was computed for neutral network representations, their non-neutral analogues, and the original, non-redundant binary representation, on various NK-landscape instances. Figure 1 presents the results obtained using one particular neutral network with three redundant bits on two different NK$(11, 1)$ landscape instances.

3. CONCLUSIONS

The results obtained suggest that the influence of the neutral representations considered on the behaviour of a stochastic hill-climber on NK-landscapes may not only be due to the larger neighbourhoods induced by neutral networks, and that neutrality itself may improve the probability of finding the global optimum. However, the choice of a suitable neutral representation instance for a given problem remains an open question.

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4. REFERENCES

[1] C. M. Fonseca and M. B. Correia. Developing redundant binary representations for genetic search. *Proceedings of the 2005 IEEE Congress on Evolutionary Computation (CEC05)*, 2:1675–1682, 2005.