Málaga, Mes de 2013

Executive Summary

TITLE: **D2.2.1: Complexity analysis of canonical algorithms**

PAPERS RELATED:

- F. Chicano, A. M. Sutton, D. Whitley and E. Alba, Fitness Probability Distribution of Bit-Flip Mutation, Evolutionary Computation (accepted for publication), arXiv:1309.2979

ABSTRACT: We develop results from the theory of landscapes and Krawtchouk polynomials to exactly compute the probability distribution of fitness values of a binary string undergoing uniform bit-flip mutation. We prove that this probability distribution can be expressed as a polynomial in p, the probability of flipping each bit. We analyze these polynomials and provide closed-form expressions for an easy linear problem (Onemax), and an NP-hard problem, MAX-SAT. Using these theoretical results we can compute the first hitting time of a $(1+\lambda)$ Evolutionary Algorithm. With this framework we are able to compute exact expressions for the expected runtime of the EA solving Onemax-based functions as a function of p, the probability of flipping a bit in the mutation.

GOALS:

1. An exact expression for the probability distribution of fitness values of a binary string undergoing uniform bit-flip mutation
2. Exact expressions for the expected runtime of the EA solving Onemax-based functions.

CONCLUSIONS:

1. We derived an expression for the probability mass function of the fitness value after applying bit-flip mutation to a given solution. The expression takes an elegant matrix form in which we can distinguish a problem-dependent part and an operator-dependent part. The problem-dependent part can be obtained using the elementary landscape decomposition of the objective function of the problem and their powers. The operator-dependent part depends only on the probability of flipping a bit.
2. The probability mass function allowed us to derive the exact expression for the runtime of a $(1 + \lambda)$ EA for solving Onemax, finding a connection between landscape theory and runtime analysis. Using this expression we obtained the optimal probability for bit-flip mutation as a function of n, the number of bits.

RELATION WITH PAST DELIVERABLES:

PRE: D2.4.1 (advisable reading)

POST: D2.4.2 (advisable reading)