Chapter 10

Hardware Implementation of a Genetic Algorithm for Motion Path Planning

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ABSTRACT

The aim of this chapter is to investigate the hardware (H/W) implementation of Genetic Algorithm (GA) based motion path planning of robot. The potential benefit of using H/W implementation of genetic algorithm is that it allows the use of huge parallelism which is suited to random number generation, crossover, mutation and fitness evaluation. The operation of selection and reproduction are basically problem independent and involve basic string manipulation tasks. The fitness evaluation task, which is problem dependent, however proves a major difficulty in H/W implementation. Another difficulty comes from that designs can only be used for the individual problem their fitness function represents. Therefore, in this work the genetic operators are implemented in H/W, while the fitness evaluation module is implemented in software (S/W). This allows a mixed hardware/software approach to address both generality and acceleration. Moreover, a simple H/W implementation for fitness evaluation of robot motion path planning problem is discussed.

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INTRODUCTION

The H/W implementation of genetic algorithm allows the use of parallelism for speedup decision in problems such as motion path planning. In this chapter, the genetic operators are implemented in H/W, while the fitness evaluation module is implemented in S/W. This allows a mixed hardware/software approach to address both generality and acceleration.

The Genetic H/W Engine itself is composed of three modules (Hortensius et al., 1989) as shown in Figure 1. FPGA is used for implementing these modules. In this work, design and simulation results of these modules implementation are presented. A random number generation module (RNG) based on Cellular Automata CA is designed and implemented to provide the other three modules with H/W generated random numbers. The RNG supplies pseudo-random bit strings to the selection module for scaling down the sum of fitness and for the crossover and mutation modules to choose crossover and mutation points.

RANDOM NUMBER GENERATOR

The 1st module to be considered is the Random Number Generator (RNG). Hybrid Cellular Automata (CA) Figure (Hortensius et al., 1989), is used due to its maximal length binary sequence production from each site. CA based generators compare favorably with the other types such as Linear Feedback Shift Registers (LFSR) and mixed congenital RNG in terms of quality of randomness, and silicon area used. They use less silicon area in their implementation (Hortensius et al., 1989; Bland &
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