

## Abstract

The present thesis embodies an in-depth study of the theory of additive cellular automata and its applications. A brief review of earlier works on CA and similar homogeneous structures have been presented. Subsequently, new characterizations of the state-transition behaviour of CA are reported from the general viewpoint of additive sequential machines. A major contribution of the work is the detailed characterization of machines with XOR/XNOR logic as the next-state function. Based on this sound analytical foundation, different application areas are next explored. CA based schemes for general and perfect hashing have been presented. These schemes are much faster than the commonly used hashing techniques and performs at par with the existing methods in respect of performance metrics used to judge the quality of hashing. Database access is one of the fundamental operations in many computer applications. To expediate the query processing, we have presented a CA based classifier as an alternative to the multi-level indexing employed in conventional databases. The next application deals with CA based error correcting codes. We have proposed a new CA based decoder for byte error correcting code. The most important feature of the scheme is its ability to have a trade off between the area overhead and throughput. Further, the theory of CA based byte error correcting code is also employed in designing a scheme for diagnosing faulty chips on a board. Next we have studied the application of programmable CA structure in computing the Reed-Muller coefficients of boolean functions. The capability of programmable CA to realize different AND-XOR functions is also exploited in designing the architecture of a new logic block for Field Programmable Gate Arrays (FPGAs). The associated procedures for realizing combinational functions with a network of such blocks have been developed. For XOR dominated functions, this FPGA architecture displays superior performance compared to existing FPGAs.

**Keywords:** Cellular Automata (CA), Programmable Cellular Automata (PCA), Additive Machine, Complemented Machine, Hashing, Perfect Hashing, Pattern Classification, Byte Error Correcting Codes, Fault Diagnosis, Reed-Muller Expansion, Field Programmable Gate Arrays (FPGAs), AND-XOR Minimization, Technology Mapping, Boolean Function Equivalence.