Application of Fuzzy Logic to VLSI Cells Placement

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The application of fuzzy logic structures in computer aided design (CAD) of digital electronics substantially improves quality of design solutions by providing designers with flexibility in formulating goals and selecting tradeoffs. In addition, the following aspects of a design process are positively impacted by application of fuzzy logic: utilization of the domain knowledge, interpretation of uncertainties in the design data, and an adaptation of design algorithms. We successfully applied fuzzy logic structures in VLSI cells placement algorithm for the physical stage of the design process. We modified the matrix connection by using fuzzy relation. In the attempt to apply the fuzzy set theory to the problem of physical design, the connectivity matrix was modified and then the fuzzy set theory was used to construct clusters for placement.

1. Introduction

Placement is one of the important steps in VLSI design. Many placement algorithms [1] [2] have been introduced in the past few years. All these algorithms do not explicitly consider two important aspects of the placement problem: the presence of multiple conflicting objectives and the utilization of expert knowledge in decision-making. These aspects of the placement problem can be addressed by a technique based on the fuzzy set theory [3]-[5]. Attempts to apply the fuzzy set theory to problems of physical design were made in [6][7]. In [6], the connectivity matrix was modified and then the fuzzy set theory was used to construct clusters for placement.

This paper is divided into three parts: a short description of the basics of the fuzzy set theory (definitions of fuzzy set operations or relations); a fuzzy logic approach to placement problem; and the modification of connectivity matrix followed by the construction of clusters for the placement algorithm using Kohonen network [8]. Indeed, in [8] we study the relative placement of the cells at the integrated circuit. Studies showed that a particular type of artificial neural network, the KOHONEN network, can be used to position cells of identical size and form on a plan of mass without rails of connections. At first, we used an algorithm with simplifying assumptions that did not give us satisfactory results. It pushed us to improve it into a very powerful algorithm. Then, we approached the phase of the extrapolation of the algorithm, where the cells were of different size. We introduced the concept of terminal, where each cell is represented by a set of terminals, and where connections were done between these same terminals.

2. Main results

The fuzzy algorithms have been successfully applied to a variety of placement problems. Here we present some typical experimental results. Fig. 5 shows the best placement configuration constructed for the connection matrix shown in Fig.3.

We carried out a series of tests with the algorithm using the Kohonen network [8], on three circuits, respectively, with 6, 9 and 11 cells. The results show that the modified matrix connection reveals implicit connections between cells. A better placement is given by optimizing certain criteria such as the length of connections and the size of the circuit (density). These results are illustrated in Tables 1, Table 2 and Table 3.

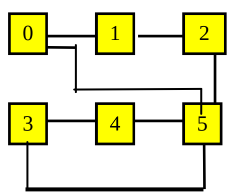

Fig.1: Circuit with 6 cells.

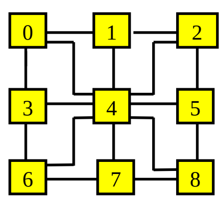

Fig.2: Circuit with 9 cells.

Table 1: Results of circuit with 6 cells.

Network (neurons number)	Fuzzy placement		Ordinary placement	
	Iteration	Density	Iteration	Density
10 x 10	65	6 x 10	41	10 x 8
12 x 12	65	6 x 10	41	10 x 8
14 x 14	65	6 x 10	41	10 x 8
16 x 16	65	6 x 10	41	10 x 8

Table 2: Results of circuit with 9 cells.

Network (neurons number)	Fuzzy placement		Ordinary placement	
	Iteration	Density	Iteration	Density
12 x 12	42	6 x 12	38	8 x 11
14 x 14	38	6 x 12	38	8 x 11
16 x 16	38	6 x 12	38	8 x 11

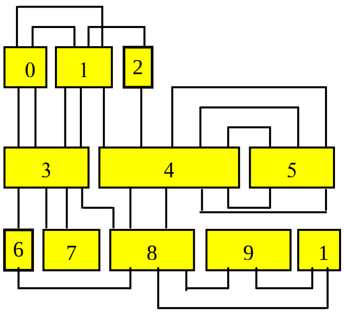

Fig.3: Circuit with 11 cells.

Table 3: Results of circuit with 11 cells.

Network (neurons number)	Fuzzy placement		Ordinary placement	
	Iteration	Density	Iteration	Density
4 x 4	28	4 x 4	20	4 x 4
6 x 6	27	5 x 4	16	5 x 4
8 x 8	24	4 x 4	16	4 x 4

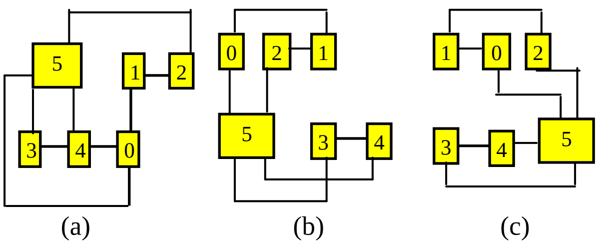

Fig.4: Ordinary placement for circuit fig.1 with various networks (a) 4 x 4 (b) 6 x 6 (c) 8 x 8.

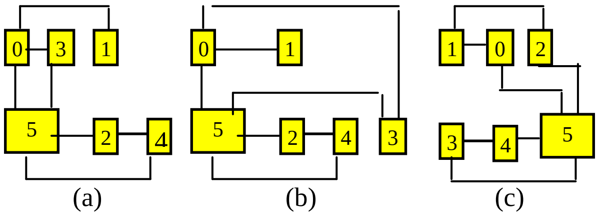

Fig.5: Fuzzy placement for circuit fig.1 with various networks (a) 4 x 4 (b) 6 x 6 (c) 8 x 8.

3. Conclusion

Fuzzy logic was successfully applied for solving the problem of **VLSI** placement. It was shown that one can easily use the matrix connection modified. Such a system gives designers much greater flexibility in problem formulations and allows them to consider wide range of tradeoffs. It also demonstrates that the fuzzy logic decision maker can be incorporated into traditional constructive or iterative design flow, where each sub-problem can be solved by an analytic method, but their relations are described by fuzzy logic rules.

References

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