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# VLSI Cell Partitioning Using Data Mining Approaches

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***Abstract-*** Theoretical studies on various cell partitioning methods are lucidly presented in the current research pertaining to design and development of VLSI circuits. Owing to the difficulties in designing complex VLSI systems, it is extremely crucial to partition the large circuit into tiny logic blocks to reduce time complexity, space complexity and power consumption. To envisage the same, this communication scrutinizes a heuristic technique by using various data mining algorithms such as K-means algorithms, K-Nearest Neighbor (K-NN), Fuzzy c-means and Support Vector Machine (SVM) for resolution of complexity in VLSI circuits, where K-NN and SVM are employed for classification purpose and Fuzzy c-means and K-means methodologies are deployed for clustering purpose. The upshot of the research revealed that K-NN and Fuzzy c-means methods bestow optimum result pertaining to VLSI cell partitioning.

***Keywords***: K-means algorithms, K-nearest neighbor, Fuzzy c-means, The Support Vector Machines, Partitioning, and Data mining

## I. INTRODUCTION

The main challenges in development of a VLSI circuit lies in design of efficient cell partitioning into circuit components. Towards achieving this objective, several parameters such as: (a) fabrication of the circuit with low-power and (b) high-speed computing structures allotted for different applications needs to be addressed. The highly designed VLSI circuit must satisfy several constraints that include: circuit area, no of pins, power consumption, noise, and throughput [1]. The physical architecture of VLSI comprises of three prime prospects: Placement, Routing, and Partitioning. Placement comprises the process of appointing locations to the constituents within the area. The method of interconnecting the placed constituents, subject to the restraint of less wiring, is called as Routing. Separation of a complex system structure into the sub- components, to reduce the complexity, is described as partitioning.

The objective of the partitioning is to separate the complex circuit into numerous components such that designing these components individually and then combining these separately, minimizing the complication level of the whole design to a much larger extent. The algorithms of Data mining present a means to investigate the data and extricate information from them. Incorporating data mining methodologies into the VLSI partitioning gives a new dimension to the research domain. The Data mining methodologies generally falls into two categories: Clustering algorithms and Classification algorithms. Both these kinds find their usefulness in recognizing the hidden forms in data. This arrangement necessitates in forecasting a firm conclusion based on the given input. In order to foresee the result, the algorithm exercises a training set that carries a group of attributes and their corresponding result, usually known as prediction or goal attribute. The algorithm endeavors to govern relations among the attributes that makes it practicable to forecast the result.

Cluster study is distinguished as a process of generating batch of clusters, or objects in a way that identical objects are located in one cluster and the objects in disparate clusters are divergent [2].The prime rewards of cluster methodologies is that it may be applied to a defined objective standard regularly to form categories. The consistency and speed of the clustering mechanism in arranging the data together form an alluring reason to utilize clustering in the partitioning.
The rest of the paper is organized as follows. Section 2 elaborates the four algorithms of data mining in detail. Section 3 describes the implementation of different data mining algorithms in VLSI cell segregating. The outcomes are narrated in Section 4. Finally, Section 5 concludes with future scope of research.

 

## II. RELATED WORK

The authors [3] discusses about the available optimization algorithm addressing to VLSI large-scale partitioning, floor planning and mixed-size placement problem by adopting multilevel hyper graph, so that the complexity is reduced to a great extent. Darwin’s theory of survival of the fittest principle is used by the authors [4] for circuit partitioning, to have number of sub-circuits, calculates the fitness value and discard the solutions that results in low fitness value. The authors [5] discusses about the hold and jump process to improve the throughput in VLSI testing. The paper [6] presents a firefly algorithm for the partition driven global cell placement in an efficient way and compared with its genetic counterpart. The authors [7] introduces hybrid PSO and SA algorithm - a new circuit bi- partitioning algorithm for efficient reduction in the number of interconnections among the VLSI circuit elements. A new interconnection oriented clustering algorithm is proposed by the authors [8] of combinational VLSI circuit partitioning, by capturing clusters considering highly interconnected ones, in a circuits.

## ALGORITHM DISCUSSION

This section briefs about the categorization algorithms: K-means algorithms, K-nearest neighbor, Fuzzy c-means and Support Vector Machines. Though categorization and Clustering algorithms are believed to be cryptic, their differences are very incomparable. There are previously defined set of classes in the categorization process and decision has to be taken on allotting the already existent class to the newly data set. The underlying methodology in clustering technology is to find out some relation among the data sets and grouping them based on their respective relation.

### II.1 CLASSIFICATION ALGORITHMS

The central idea behind classification algorithm isthe selection of a hypothetical set from the existent sets that best suitable for the given input data set. This segment involves detailed analysis of the identified data mining categorization algorithms: Support Vector Machine Algorithm and K-Nearest Neighbor Algorithm.

### II.1.1 K NEAREST NEIGHBOUR ALGORITHM

K Nearest Neighbor (KNN) algorithm [9] is an indolent research algorithm. It is also a non-parametric by nature. Suppositions are not made by taking the underlying data

as the actual data does not pursue any hypothetical suppositions. There is no definite generalization phase or it is very insignificant. On the basis of the below assumptions, KNN algorithm is accomplished. The algorithm pretends that records are in cadenced space described based on the distance (The distance is determined by any one of the followingThe data may be in scalar form or multidimensional form. Each and every data point have notion of distance as they are in feature space. The training data set holds a vector set and a class tag interrelated to the vector. However KNN works fine with arbitrary number of classes. A number "k" which signifies the number of adjacent that are methods: Mahalanobis Distance, Murkowski Distance and Euclidean Distance. The algorithm is simply known as the nearest neighbor algorithm if k=1.

### II.1.2 SUPPORT VECTOR MACHINE ALGORITHM

A Support Vector Machine algorithm(SVM) [10] builds a model that authorizes stated data set inside one group or the other group, from that the training data sets are belonged. So we may call that SVM algorithm is a bilinear classifier having non-probabilistic property. Data are produced in spatial domain, thus the training data set of various categories are partitioned by a distinct distance. Consequently the possibility of mismatching the stated data setis mostly reduced. But the

### 3.2.1 FUZZY C-MEANS Algorithm

In the fuzzy clustering, every data stage in the data set is associated with every other cluster by using a relationship function. The algorithm of c-means permits overlapping of data set, i.e. the stated data set may come from more than two clusters with the same duration. LetY=

{*y*1,*y*2, . . . , $y_m$} be a set ofnumerical datain $R^N$ Let j be an integer, 1 < j<M. Given *X*, we say that j fuzzysubsets

{ $a_k$:Y→ [0, 1]} are a j-partition of Y if the following conditions are satisfied[]:

0≤ $a_{k1} \leq 1$ for all k andl ...........................(1)

$\sum_{K=1}^{j} a_{k1}$ foralll ............................................................ (2)

0 $\leq \sum_{l=1}^{m} u_{k1}$ < n forallk ............................ (3)

 

where $a_{k1}$ = $a_k(y1)$ ≤ k ≤ j and 1≤l≤M. Let the j M values filling the above

condition be arrayed $a_{k1}$ as j×*M*matrix *A*= [ $a_{k1}$ ].Then the set of all such matrices are the non-degenerate fuzzy j-partitions of Y:

SVM algorithm apprehends more CPU memory and time than the KNN algorithm. The SVM algorithm deteriorates a serious blow as it is directly relevant only in two classes and there is no probability of calibrated class relationship.

### 3.2 CLUSTERING ALGORITHMS

The objectives behind the clustering algorithms are to categorize objects into clusters or various subsets based on their defined relationship with each other. Data in the same cluster will have similar attributes whereas those in separate clusters will have dissimilar attributes. The algorithms explained under this segment are Fuzzy C means algorithm along with K means algorithm.

$$M_{FCM} = \{A \epsilon R^N : a_{kl}\ satisfies\ conditions\ (1,2,3$$

If all $a_{kl}$ are either 0 or 1,we have the subset of hard j partition of Y

$\forall\ k\ and\ l$ $M_{CM}$={$A \epsilon M_{FCM} : a_{kl}$=0or1

This Fuzzy j-segregations is treated as Fuzzy C-segregation. Fuzzy clustering is utilized in the mining complex along with multi- dimensional datasets. The algorithm Fuzzy- C-means (FCM) is widespread, in that a chunk of data has limited relation with each of the pre-specified cluster centers [5].

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### 3.2.2 K- MEANS ALGORITHM

The K means algorithm is devised to cluster various data on the basis of the cluster centre known as mean. The summation of clusters *k*is pretended to be static. The algorithm starts for primary k number of clusters, by designating the residual data to the adjacent clusters and continuously modifying the relationship of various clusters between each other till the membership becomes stable. It has two phases: Initialization and Iteration phases. During the former stage, the data is allocated to *k* clusters. In the latter stage, the length between the data set along with each cluster is determined and data set is allocated to the adjacent cluster. But, K means algorithm never employ overlapping of the data sets.

## III. IMPLEMENTATIONAND EXPERIMENTALRESULTS

All the experiments are conducted using Xilinx 9.1i, FPGA Board and MATLAB 15 environment, in a Intel Core-2 processor with 3GB RAM and 80GB HDD. The categorization and Clustering algorithms arecarried out for the beneath circuit. The doorway at each nodule is characterized by the GM, gate matrix, and the assembly of gates is characterized by an input matrix, IM. The gate matrix is outlined one column at unit time, with every consequent column holding the gates. The input of the gates can be from the gates of prior column or wires; so the total number of columns in CGM, GM, is equal to the utmost number of gates on any path from the circuit input to output [12]. A simple representation of Gate matrix is shown in Table1.

Table1

| NUMBER | TYPE |
|---|---|
| 1 | AND |
| 2 | OR |
| 3 | XOR |
| 4 | INV |
| 5 | WIRE |
| 6 | NAND |
| 7 | NOR |
| 8 | XNOR |
| 9 | BUFFER |

he count of rows in RGM, GM, signifies the cut size of the circuit. The gate in every node is denoted by a number in gate matrix. The analogous numbers for every gate are mentioned in Table 1.The relation among gates in the gate matrix is mentioned in input matrix, IM, where the count of columns in the input matrix and the gate matrix are same[12]. Finally, the count of rows in the input matrix, RIM, is the multiplication of RGM and the utmost fan-in of each gate in the circuit. So, the encouraging values for the column X are {1+RGM× [X–1], RGM×X} [12].
The quartetalgorithms discussed are enforced to the example circuit. But the matrix is stated as input to the categorization and clustering algorithms.

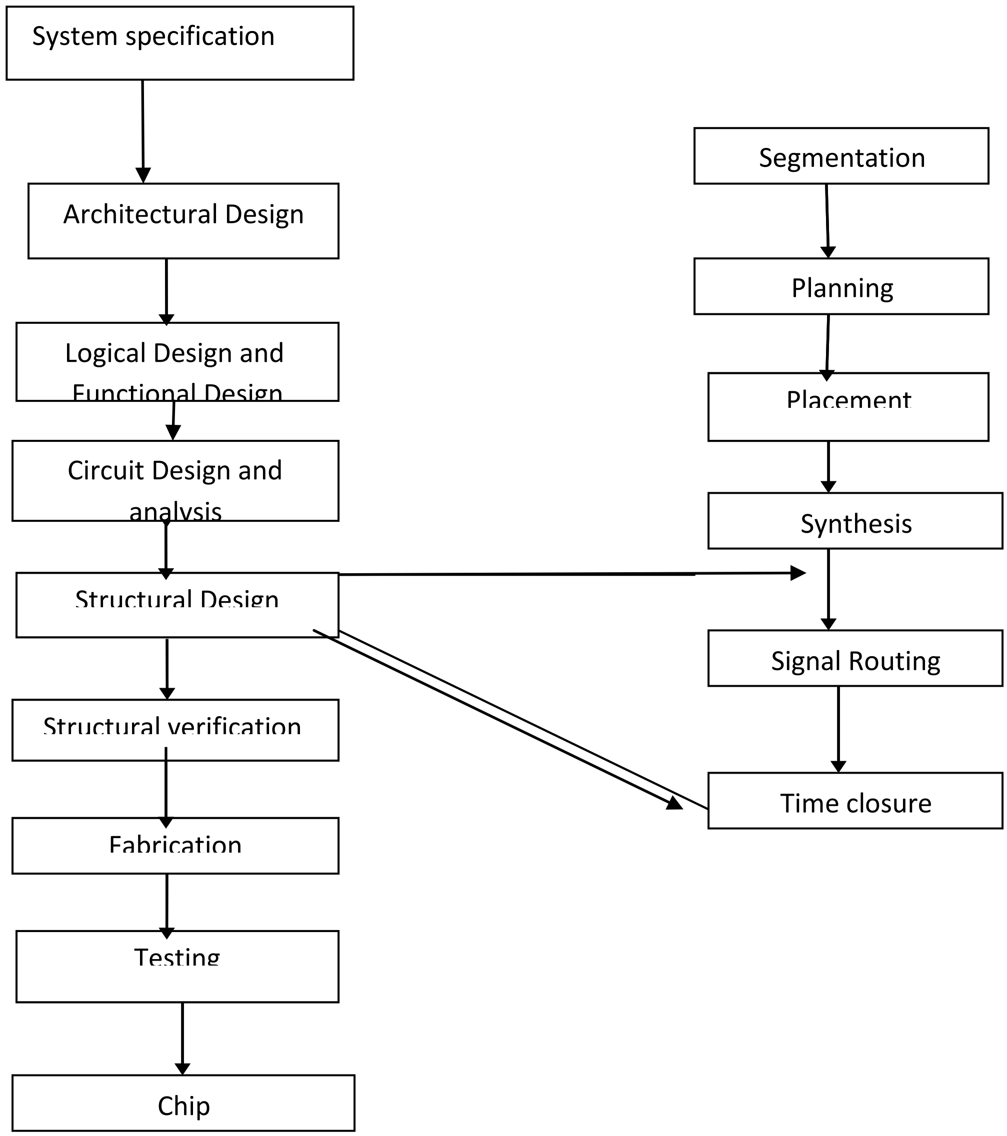


Figure 1

**The flow chart of the proposed implementation is shown in Figure1**

The input circuit and the corresponding output in terms of gate level view with its look up table are shown in Figure 2, Figure 3 and Figure 4 respectively. Further, a sub-circuit of the input circuit is shown in Figure 5 with its truth table in Figure 6.logical design placement

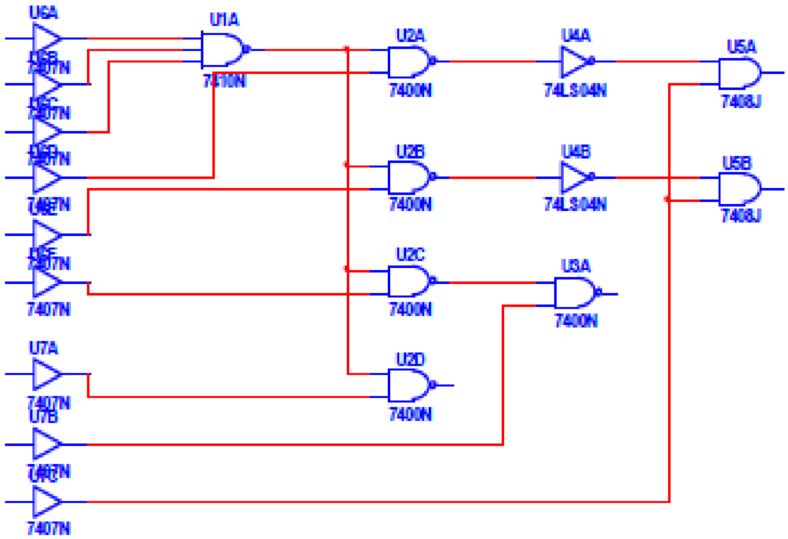


**Figure 2: Input Circuit for VLSI cell partitioning**

Circuit Design and

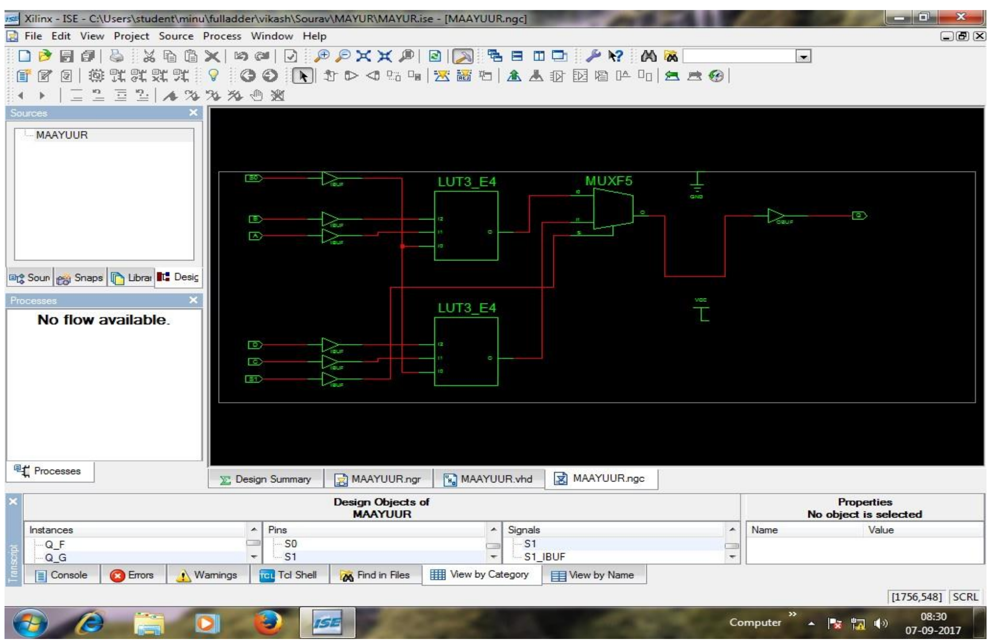


**Figure 3: output Gate level view of the input circuit**

 

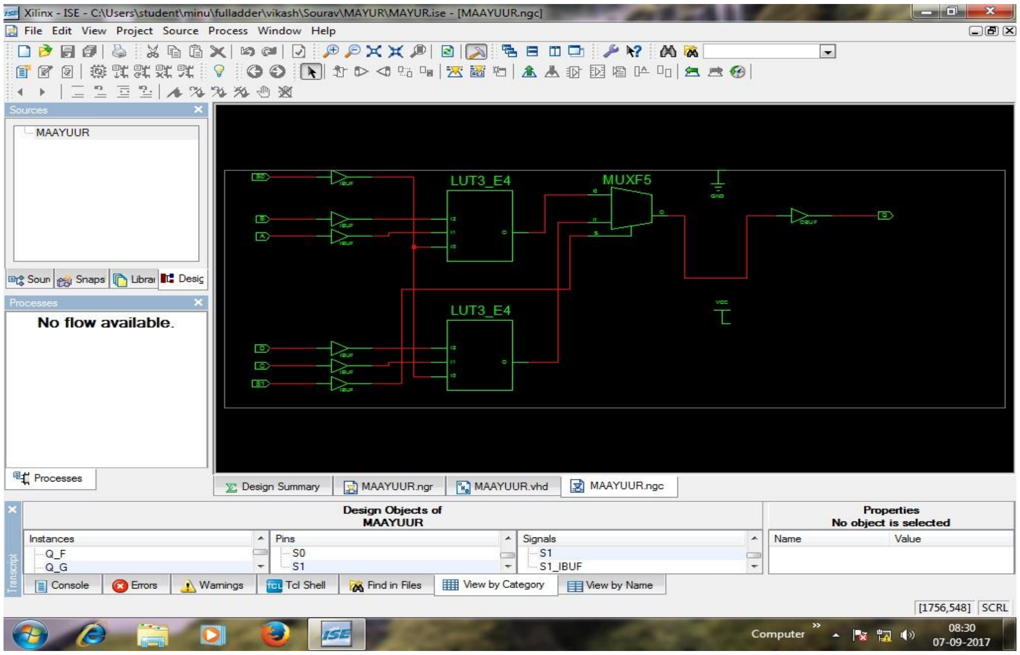

**Figure 4: Look up Table for the input circuit**

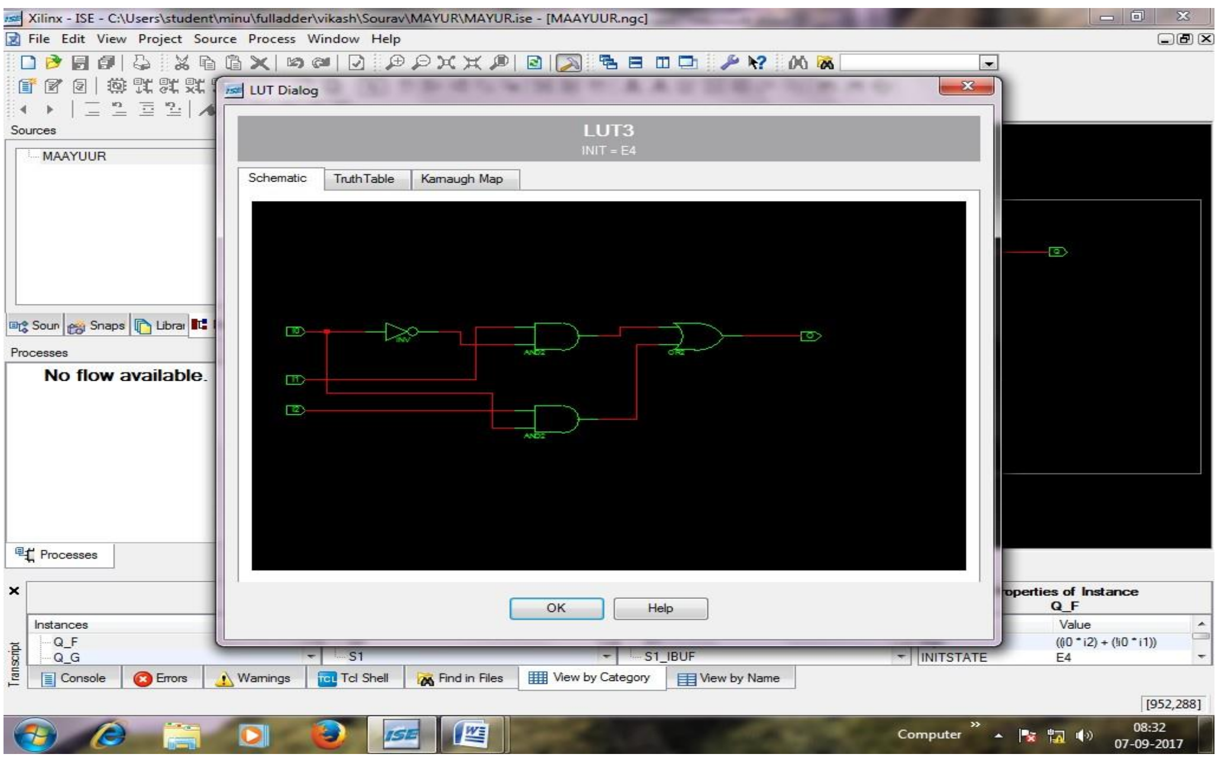

**Figure 5: Sub-circuit view of the input circuit**

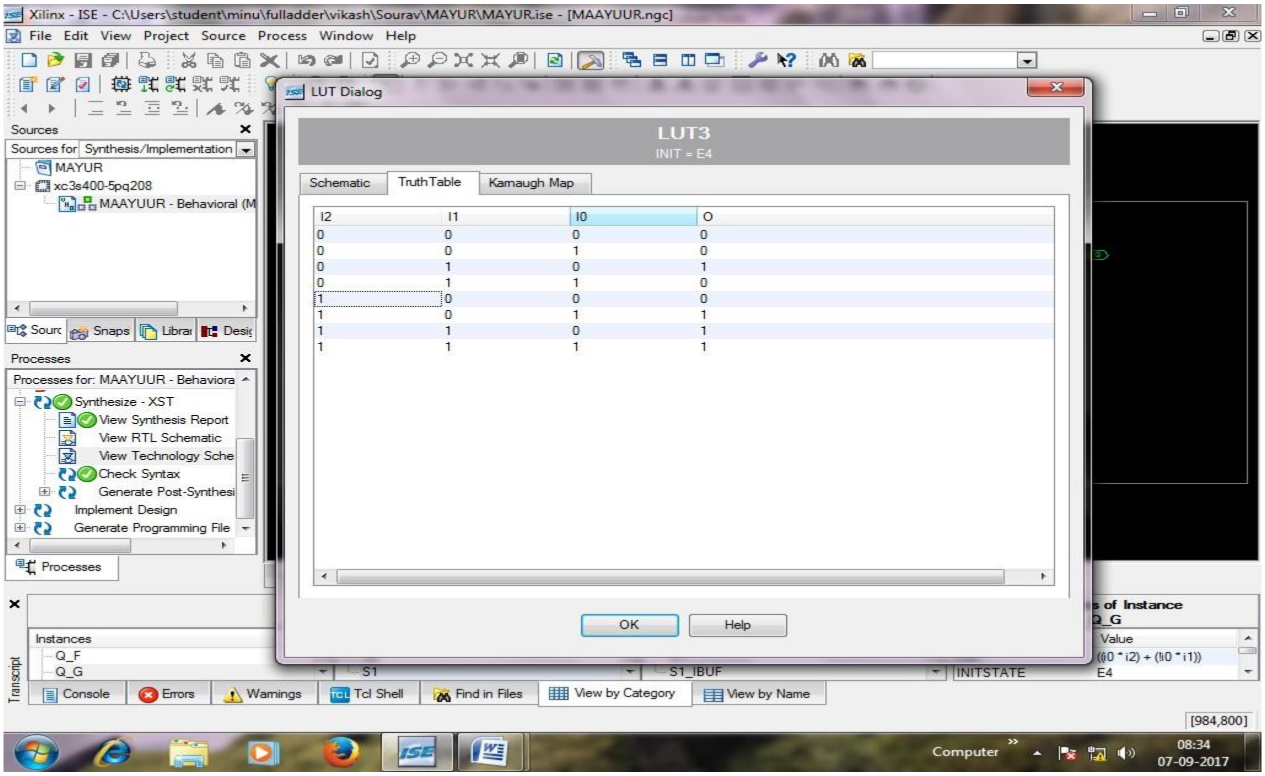


**Figure 6: Truth Table of the input circuit**

## IV. RESULT ANDDISCUSSION

The results obtained with the use of K-nearest neighbor and support vector machine, are displayed in Figure 7 and Figure 8 respectively. The K Nearest neighbor shows better categorization result than SVM algorithm as the VLSI cell partitioning employs numerous classes. The SVM algorithm disappoints to produce efficient outcome while operating for different classes.
Further, the results obtained after using K- means and Fuzzy C-means Clustering algorithms are shown in Figure 9 and Figure 10 respectively, when enforced on the circuit. The objective function is considerably minimized in Fuzzy C-means algorithm with very less count of repetitions whenever compared to the K-means algorithm. Furthermore, permitting overlapping of the data sets makes the fuzzy C-means to be more competent than K- means algorithm.

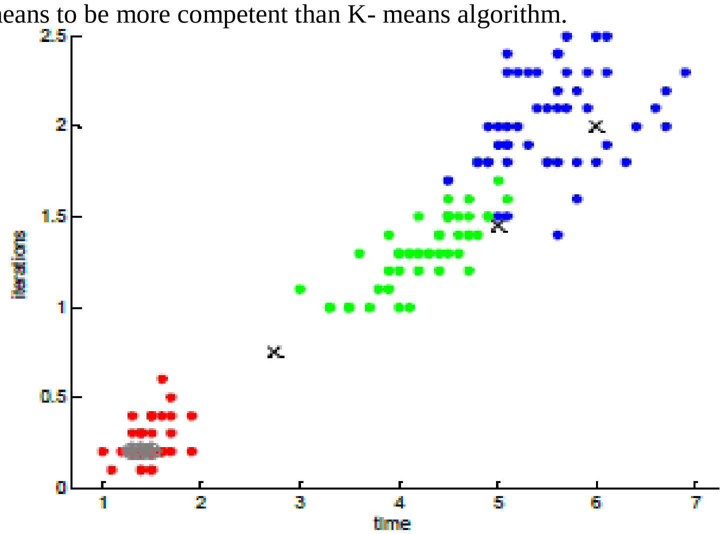


**Figure 7: K-NN Algorithm**

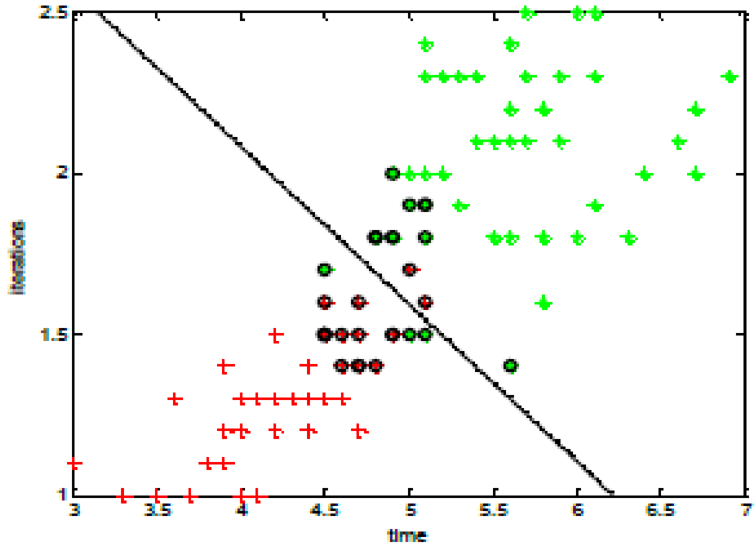


**Figure 8: SVM Algorithm**

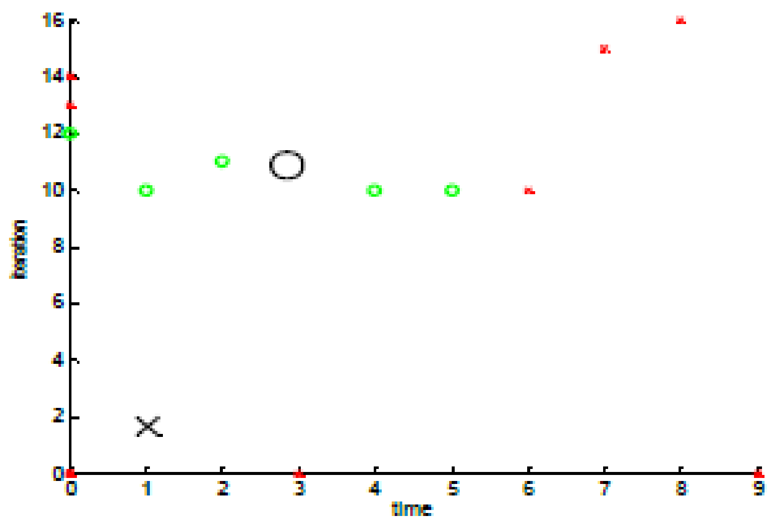


**Figure 9: K- Means Algorithm**

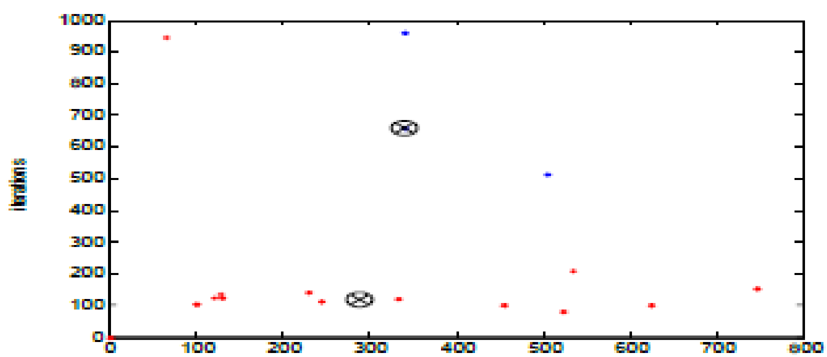


**Figure10: FCM Algorithm**

 

## V. CONCLUSION

In this research, the VLSI cell partitioning using classification (K-NN and SVM) and clustering (K-Means and FCM) are examined. It is observed that K -Nearest neighbor provides the optimum result with contemplate

to the VLSI Cell segregating. Further, from the clustering algorithms, it is identified that Fuzzy C-means gives optimum result to VLSI cell partitioning. Finally, while comparing K-NN and FCM, FCM wins the race being the most efficient ones. In future, we shall focus on the other efficient algorithms with their hybrids for best VLSI cell partitioning optimization.

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