A VLSI Implementation of Robust hybrid approach Of Arabic character recognition

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Abstract: This paper describes a method of Automatic Arabic Character Recognition (ACR). This system is articulated around four distinct modules which are the main image processing given by: a module of treatment, a module of segmentation, a module of recognition and a module of detection of symbols of classification. For classification; we have used Fuzzy Logic (FL), Genetic Algorithm (GA), and Expert System (ES) to recognize all presented shapes. This approach must make the system able to achieve these tasks: to extract the components of QV (Quantification Vector) and to take an intelligent decision to classify all different shapes of Arabic characters. The Fuzzy classifier is combined with the Expert System to extract the topological and contextual informations of each character. The exit of the system will be combined with the one of the recognition module for the reconstitution of each character. The training has used 180 descended pictures of the database of ACR. To deal with Artificial Intelligence (AI), a new design methodology has been introduced to give a best rate of recognition. The new design methodology based upon a VHDL description of recognition has the two (02) advantages: to present a real behaviour of good automatic system recognition for Arabic texts, and being generic and flexible and can be changed at the user demand. To validate our approach, a VHDL description of *ES_GA_FL* is passed through a synthetic tool, Galileo for FPGA implementation.

Keywords **:** Fuzzy Logic (FL), Genetic Algorithms (GA), Expert System (ES), classification, rules, Optical Character Recognition (OCR), Quantification Vector (QV), Artificial Intelligent (AI) , training, inference, FPGA implementation VHDL, and Synthesis.

1.Introduction

Optical Character Recognition (OCR) systems for Latin script are widely available and perform well on high quality printed text. OCR systems for non-Latin script including Arabic, however, are not commercially available and this is still an important area for research. A wide variety of approaches have been considered, but these can broadly be categorised into on-line and off-line techniques. On-line techniques record the movement of a pen on a drawing table and use its speed and direction of movement as a part of the recognition process. Although on-line recognition tends to give better results than the off-line approaches, often the text to be recognised is only available as hard copy and therefore on-line recognition is not possible. The recognition of non-Latin and Arabic script in particular has been far less extensively studied. The structural approach is a popular approach since it is widely used for Latin script, however while such techniques are successful for Latin script, the same approach is not as effective for cursive script such as Arabic. This approach requires the character to be thinned to a skeletal form and structural information such as the number and position of holes and strokes to be extracted [3]. There are numerous problems with thinning large, poor quality cursive characters as described by the authors. In addition, the process of thinning and feature extraction is relatively slow. Furthermore, the number of dots and their position does not determine the meaning of Latin characters, but this is highly significant for many non-Latin scripts. In Arabic, there may be one, two or three dots, which may be positioned above, below or in the middle of the character. However, the recognition of isolated Arabic character using template comparison is a proven approach to achieving a robust recognition system. In practice, however, the accuracy rates are rarely achieved. Most systems break down when the input document images are highly degraded, such as scanned images of carbon-copy documents, documents printed on low-quality paper, and documents that are n-th generation photocopies. Besides, the end user cannot compare the relative performances of the products because the various accuracy results are not reported on the same dataset [1]. Today, many approaches of classification proposed to classify Latin characters cannot be applied into Arabic characters. Therefore, the recognition rate of Arabic characters is lower than that of disconnected characters, such as printed English. The problems arising in any OCR (Optical Character Recognition) system are not only related with data acquisition, but also with the nature of the input. The nature is based on the feature selection of each shape presented to the reader. More, Arabic characters are cursive in general and have the main features to characterise it . Furthermore, Arabic characters recognition need to understand the nature of text presented before all operations of treatments , that means that, the feature extraction aspect of image analysis seeks to identify inherent characteristics, or features, found within an image . In Optical Character Recognition problem, these characteristics are used to describe the character, prior to the subsequent task of classification. Before recognition of picture, a several operations are done for the image as: filtering, analysis, segmentation and recognition. These operations are solicited to give the correct form of one shape and therefore the extract vector information is the right used for recognition . The extracted character versions may have one, or more, of the variations such as scaling, rotation, and translation. In this present work, we present one way of a simple for cursive Arabic characters classification. To present a real intelligent task including all features Arabic characters: a single SRAM based Field Programmable Gate Array (FPGA) has been introduce to deal with all criteria patterns. This new technology has revealed the soft computing in order to give a high speed processing that could be provided through massively parallel implementation management and so more autonomy requirements such as power, thermal and communication management are obtained in real time. The new architecture *ES_GA_FL* can be implemented either in analogue or digital way. Digital circuits are much manufactured and are functionally identical. Analogue circuits, on the other hand, are sensitive to noise and temperature changes and inter-chips variations make manufacturing functionally identical circuits, very difficult. Nowadays, FPGA are gaining momentum in digital design. They are used for a wide range of application including rapid prototype, glue logic for microprocessor, and hard –wired simulation. Moreover, the relatively low cost, an easiness of implementation and recognition of FPGA, offer attractive features for the hardware designer in comparison with other VLSI implementation techniques. In other words, FPGA has emerged as the ultimate solution to time –to-market and risk problems because they provide instant manufacturing and very low –cost prototypes [3]. In this paper, we discuss the possibility to deal with this hurdle by proposing a new approach permitting the mapping of an entire *ES-GA_FL* into a single Xilnx's FPGA, this new architecture presents a robust opportunity since the massively parallel computers, a real intelligent component, short time of execution, high speed processing and the objectives of navigation are obtained.

2. Image processing: Before recognition of picture, a several operations are done for the image as: filtering, analysis, segmentation and recognition. That means that the need to understand the image itself before finding a function of classification for recognition process. The feature extraction aspect of image analysis seeks to identify inherent characteristics, or features, found within an image [56,57,58,59,60]. In Optical Character Recognition problem, these characteristics are used to describe the character, prior to the subsequent task of classification. In this work, we present a new technique of imagery to recognize a print Arabic characters, this technique doesn't hold in consideration the font, the size and the surface of each character [61,62,63,64,65,66]. The essential objective is to recognize the character in different shapes on which it is presented. In the figure 1 we present our recognition system proposed for Arabic character where our decision algorithm makes use of seven phases, as outlined below**:**

- Read the input Character.
- Treat every picture presented and execute the flirting process.
- Picture segmentation into isolated characters.
- Extract the features vector for every element to be recognized.
- Compare the component character vector extract against the prototype in the database.
- Take a decision about what type of shape presented.
- Discuss the recognition results.

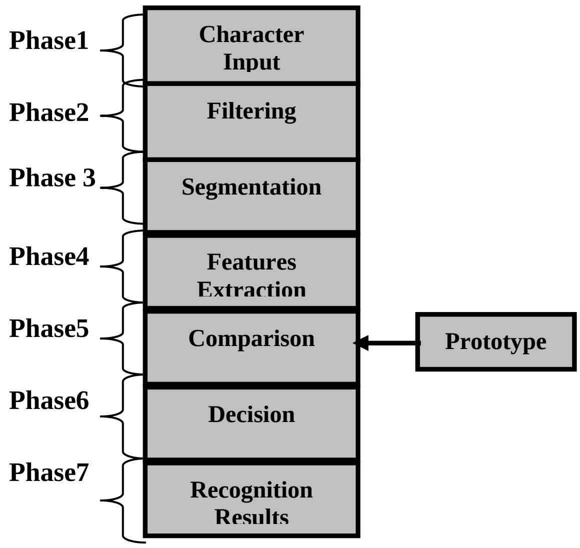

Fig. 1: Recognition system proposed of Arabic characters

This figure describes clearly the main steps to be considered to recognize the input Arabic character. After an ordinary cleaning of image (filtering), a generation of a carving of the picture into elements susceptible to be recognized by the classifier is done. The segmentation is a very important operation for the problem of Arabic character recognition. Segment by segment, the process of recognition can be facilitated while shelling the character into simple coins characters to be identified. The feature selection vector of QV (Quantification Vector) of each shape must be compared by those in the database, and after a decision algorithm we can distinguish every presented shape and also classify and list intelligibly the chain of characters. After that, the extract features are compared with those in the data base. The hybrid intelligent decision is taken by the system where the results are discussing for the recognition.

3. The hybrid proposed approach for Arabic character recognition:

3.1. Fuzzy Logic: To build machines that are able to perform complex task requiring massively parallel computations, knowledge the environment structure and interacting with it involves abstract appreciation of natural concepts related to the proximity, degree of danger, etc. The implied natural language is represented through fuzzy sets involving classes with gradually varying transition boundaries. In effect, human reasoning is not based on the classical two-valued logic because this process involves fuzzy thrusts, fuzzy deduction rules, etc. This is the reason why FL is closer to human thinking and natural language than classical logic [10,11,12,13,16,30,31,32,34,35,36]. Also, FL can be viewed as an attempt to bring together conventional precise mathematics and human-like decision-making concepts [42,43,44]. FL can be a valid approach solving control problem in a wide range of applications. In particular, embedded architectures are likely to use fuzzy logic in the future for dedicated applications. The Fuzzy Logic Controller FLC can be considered as a system given an input vector computes, and an output vector by a linguistic rule. To define the complexity of a fuzzy controller we consider some typical parameters such as the number Input and the number output, the dimension of the rule base, the number of membership functions per input, the precision and the methods chosen to performed the three well known steps: fuzzification, inference and defuzzification steps. Fuzzy logic is based on the concepts of linguistic variables and fuzzy sets.

3.2 Genetic Algorithms (GA) : The Genetic Algorithms GA, which are evolutionary, have recently emerged from study of the evolution mechanisms and are searching strategies suitable for finding the globally optimal solution in a large parameter space. They are based on learning mechanism. GA's has been theoretically and empirically proven to provide robust search capabilities in complex spaces offering a valid approach to problems requiring efficient and effective searching [65]. Before the GA search starts, candidates of solution are represented as binary bit strings and are prepared. This is called a population . A candidate is called a chromosome (in our case: the selected quantification vector of primitives QV is a "chromosome" and components are the "genes"). Also, an evolution function, called fitness function, needs to be defined for a problem to be solved in order to evaluate chromosome. As fitness function, we should define distance for each chromosome to give an evaluation function. This evaluation is the goal of the GA search and goes as follows: two (02) chromosomes are chosen randomly from populations are mated and they go through operations like the crossover to yield better chromosomes for next generations. This is repeated until about n populations with new chromosomes. To determine execution of the GA, we must specify a stopping criterion, in our case, it could be determine, by a probabilistic function: as we have m chromosomes and we choose randomly two chromosomes, we have used the combination given by the theorem in the probability: 2^m-1 (here m is the number of the all components "QV" presented are candidates), we subtract with number one (01) because it is impossible to combine and to compare one QV with itself. The crossover is the comparison operator . Therefore, after several generations of GA search (The problem of mutation), relatively low fitness of chromosomes remain in a population and some of them are chosen as the solution of the problem (the most preferable QV).

4. Classification and Recognition process

The recognition of an Arabic Character is the last stage of vision by computer after the decision. Recognition Systems of the writing require two stages: a stage of extraction of primitive and a stage of classification, this earlier is done in order to separate the classes between the shapes presented. Several works are carried on the development of new primitive to procure a good discrimination while minimizing intra-classes variability. These primitives are the main tasks of comparison shapes by those in the database. More, they are considered as the most significant elements of QV. These primitives are generally classified into two families: the morphological primitive (buckles, …etc) and the statistics primitive that drift measures of spatial distribution of pixels (zoning,...etc). Several works have shown that there are complementarities in the measure or two ways of properties are put in relief between the morphological primitive and the statistics primitive. The visual human system seems to fear the same approaches to recognize stages or objects. We have opted for the primitive hybrid combining figures on the contour and on pixels defining some morphological shapes in order to characterize our pictures of characters.

4.1. Morphological primitive: The morphological aspect is very important in the perception human, and its spatial tense is just as an important measure of local information, which is not sufficient to be able to represent a given motive. It is why it is taken into consideration in our approach. At the time of the extraction of the primitive, the picture is divided into: first lines, second words and third character. For each character, we extract the number of pixel of each edge selection of given shape see figure 2. At the time of the extraction of the primitives, the shape is divided into edges. The number of pixels of each edge contour and the curvature form of each character, belonging to each of the edges is determined. After learning, this system becomes intelligent when the several training give it the ability to learn and to understand every shape of character. The Vector of morphological primitives is compound into n values of edges and m values of curvature of the grid (see the figure 3).

4.2. Statistics primitive: The statistics primitive are used here are based on the code of chain of the contour of each character. This is calculated by a follow-up in run-length of each shape presented. This whole of primitive is a vector of n values representing statistics on edges, and directions and curvatures of pixels of each shape. The values of curvature and edges calculated are quantified until four values ($curv_1$,…,$curv_4$) with take into account the diacritic points. See Figure 6. To list the Arabic characters in parallel with a logical, applicable, and intelligent decision; we have used a hybrid approach: the fuzzy logic, genetic algorithms GA and the Expert Systems ES to give the ability to classify all shapes presented into our system The exit of the fuzzy classifier must be combined with the one of the module of Arabic characters recognition. Our database is composed of 180 pictures. The rules of classification and the functions of fuzzy whole adherence that define our primitive are learned on the parameters of each picture gotten after training, it will be interpreted in IF-THEN rule.

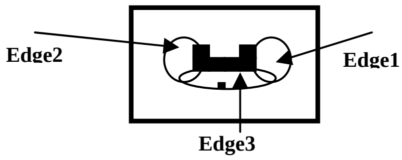

Fig. 2: Example of extraction of Features Of Arabic Character "Ba"

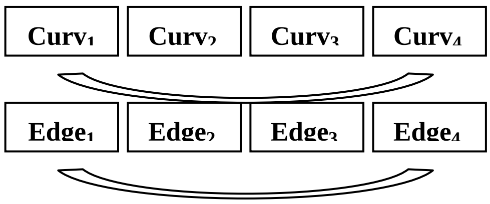

Fig. 3: Vector of morphological Primitive of each character.

Number of pixels in the first edge of each character	**Number of pixels in the I …edge of Each character**	**Number of pixels in the M .curvature of each character**

Fig 4 : Format of the vector of primitives

4.3 Fuzzy classifier Architecture

The fuzzy logic proves to be a robust tool to solve all one imprecise problem. The three well-known stages used generally are: the fuzzification, the Inference rules and the defuzzification, which are the stages keys to realize the fuzzy principle [19,20,21,22,23,24]. The fuzzy model used at the time of the conception is illustrated in the figure 5, the algorithm to follow during the recognition phase is described in the figure 7. The entrances of this model are the primitives described above. The label terms used in fuzzy linguistic are Diacritic Character DC and No Diacritic Character NDC. The membership functions of truth degree of the input of the fuzzy system are shown in the figure 8. The training of the classifier is marked in two stages. A stage of rule generation and another one of adaptation of the adherence feature. Generally, the generation of rules operates itself according to the distribution of the training whole in fuzzy linguistic terms (DC, NDC). The inference rules are illustrated in the figure 6. The exit of our fuzzy classifier is N that will take the fuzzy linguistic terms: DC and NDC. The rules governing a fuzzy system are often written using linguistic expressions, which formalize the empirical rules by means of which a human operator is able to describe the process in question using his own experience. More, it is a way of linking input linguistic variables to output ones. If x and y are taken to be two linguistic variables, fuzzy logic allows these variables to be related by means of fuzzy conditional rules of the following type **IF** (x is A) **THEN** (y is B).; Where (x is A) is the premise of the rule, while (y is B) is the conclusion. The premise defines the conditions in which the conclusions define the actions to be taken when the conditions of the premise are satisfied. More specially, the degree of membership of the premise is calculated and through application of a fuzzy logic inference method to the conclusion, it allows the output y to be determined. In general in a fuzzy conditional rule "**IF** premise **THEN** conclusion" is made up of a statement in which fuzzy predicates P_j of the general form are combined by different operators such as the fuzzy operators AND . To apply an inference method to the conclusion, it is first necessary to access the degree of membership of the premise, trough assessment of the degree of membership of each predicate P_j in the premise. In our case, the principle of the technique consists in verifying for every unknown shape character a whole of rules, or each rule is the shape: IF <cond> THEN <name of the stain>, Where <cond> is a combination of predicates translating the spatial relations between the primitive of the unknown shape (if the logic used by the ES is the one of predicates). The membership functions of the output of the fuzzy model are illustrated in the figure 9. Defuzzification is the output of the fuzzy system, it is a decision-making logic (written in a formula) adopted for the compute of the real value of the output. The final decision (*defuzzification*) is achieved to give the output of fuzzy controls and to converts the fuzzy output value produced by rules. The system must decide how to give the right output using **FL** from a fuzzy linguistic formulation. The generation of rules operates itself according to the distribution of the training whole in fuzzy linguistic terms. The final decision (deffuzification) is accomplished to convert input of the fuzzy system after treatments with the inference rules. The deffuzification is calculated by the following formula (gravity center) : $G= (Sum (\mu_i * g_i)) / (Sum\ \mu_i)$ .....(4)

Where : $1 <= i <= m$ **,m** : the number of rule ,**g:** centroid of the backend membership , function correspond for each rule, **u:** factor of membership correspond for each rule.

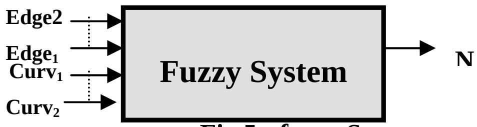

Fig 5: fuzzy System

IF ($Edge_m$ is DC and $Curv_m$) Then (N is DC)IF ($Edge_m$ is NDC and $Curv_m$ is NDC) Then (N is NDC)

Fig 6 : Rule inference

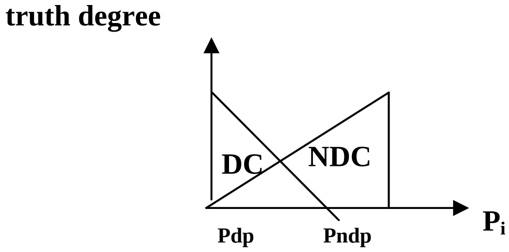

Fig. 8 : Membership function of P_i.

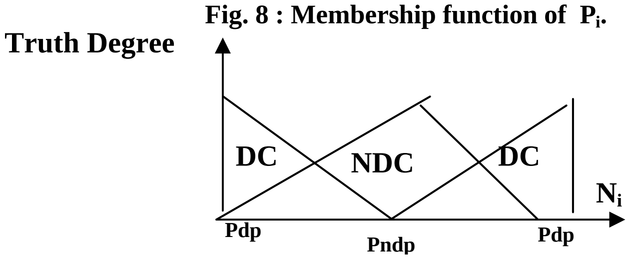

Fig. 8 : Membership function of N_i.

This intelligent task uses the fuzzy linguistic terms and calculates for each degree of membership functions under shape of an expert system ES. An ES is a computer program that functions, is in a narrow domain, dealing with specialized knowledge, generally possessed by human experts. ES is able to draw conclusions without seeing all possible information and capable of directing the acquisition of new information in an efficient manner [26,27]. The expert system represents a good part of activities of the Artificial intelligence that makes call to knowledge on the domain treaty, these systems are capable to reach human expert performances for various types of tasks (diagnosis, conception in restraint domains). In our case, the principle of the technique consists in verifying for every unknown shape character a whole of rules, or each rule is the shape: IF <cond> THEN <name of the stain>, Where <cond> is a combination of predicates translating the spatial relations between the primitive of the unknown shape (if the logic used by the ES is the one of predicates).

4.4 Results: For the training we have used 180 descended pictures of the database of ACR. We have used a hybrid technique to be able to list characters. This technique is based on the fuzzy logic and the expert systems. The such approach combination permits to reach performances of expert human while taking a logical, intelligent and applicable decision in the large space huge solutions by genetic algorithm for a classification of an Arabic character data. These problems are always related into the components of vector when we compare each shape with those in the data base.

5 Digital Implementation of *ES_GA_FL* [66,67,68,69]

Configurable hardware is an approach for realising optimal performance by tailoring its architecture to the characteristics of a given problem. When the characteristics of a problem are known in advance and they never change in time, it is relatively easy to build configurable hardware using programmable devices like FPGA (Field Programmable Gate Array) because the designers know how the hardware should be configured. However, for problems where designers cannot know in advance how to configure the hardware, it is required for configurable hardware to have a capability of on-line adaptation to a given problem [17]. That is why we have implemented our approach, this digital implementation of *ES_GA_FL* can make the use of full custom VLSI, semi custom, ASIC (Application Specific Integrated Circuits) and FPGAs (Field Programmable Gate Array). Particularly, FPGAs Implementation of *ES_GA_FL* is very attractive because of the high flexibility that can be achieved through the reprogramability nature of these circuits. The complexity of VLSI circuits is being more and more complexes. Nowadays, the key of the art design is focused around high level synthesis which is a top down design methodology, that transform an abstract level such as the VHDL language (acronym for Very High Speed Integrated Circuits Hardware Description Language) into a physical implementation level [1.2.24.15]. In addition, the synthesis tools allow designers to realise the mainly reasons: the need to get a correctly working systems at the first time, technology independent design, design reusability, the ability to experiment with several alternatives of the design, and economic factors such as time to market . In this section , we present a new design methodology of *ES_GA_FL* based upon a VHDL description and using a synthesis tool Galileo [9]. The result is a netlist ready for place and root using the XACT . The intended objective is to, realise an architecture that takes into account the parallelism, performance, flexibility and their relationship to silicon area [9].

5.1 Design methodology : The proposed design method for the *ES_GA_FL* implementation is illustrated in fig.12 as a process to follow. This status is followed by the VHDL description of the navigation approach. Then the VHDL code is passed through the synthesis tool Galileo. The result is a netlist ready for place and root using the XACT tool. At this level, verification is required before final FPGA implementation.

5.2 The *ES_GA_FL* architecture : The simplified model of *ES_GA_FL* is presented in Fig.10. Thus, we can represent it in its hardware equivalent model. The hardware model is mainly based on :

5.2.1 Memory circuit RAM: the data of camera sensors are stocked which are mainly the co-ordinates of milestones. In effect , these points are the elements of image matrix. The depth of RAM is equal to the number of data input.

5.2.2 Hardware component *ES_GA_FL* : Each component is composed in general into multi sub – component tasks, the most general view about it is described on the Fig.11 and Fig.13.

5.2.3 Fuzzy control : This task is to control point to point the reference trajectory obtained from hardware genetic algorithms. The GA process search for a better hardware where it is initialised. The better performance is given to fuzzy part to be controlled and treated in the next.

5.2.4 Optimal Path: this level gives the results of *ES_GA_FL* which is the best path suitable to recognize.

5.3 GA and FL chip: The top view of architecture of *ES_GA_FL* at level is building block for the implemented approach. The GA chip has a binary tree of training process component. The binary tree is very useful when the process is executed. A training set of the data point was generated at every generation. The processor FL in the *ES_GA_FL* chip executes the process of FL. After the optimization given, by the level GA, each component of FL calculates the degree measured data belonging to the membership function for the input variable. The FL is based on the inference rules where the association of these rules is done among membership function of different inputs, and the processor is achieved by giving the right output after learning the navigation approach problem. We present the top view of GA and FL structure respectively in Fig.11 and Fig.13.

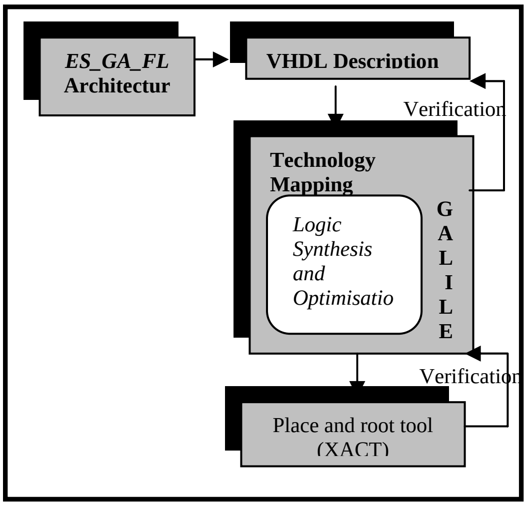

Fig.10: Design methodology of *ES_GA_FL*

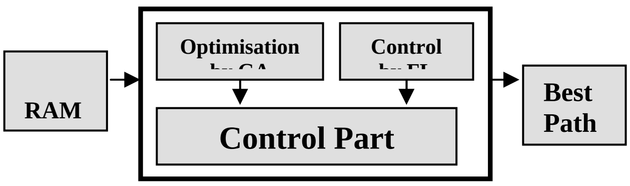

Fig.11: Architecture of *ES_GA_FL*

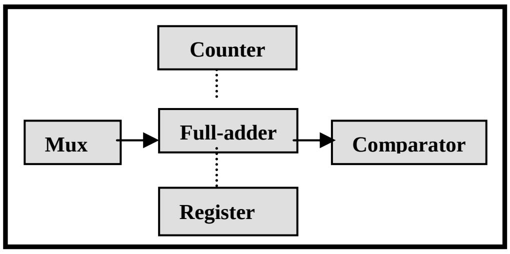

Fig.12: The Top view of GA structure

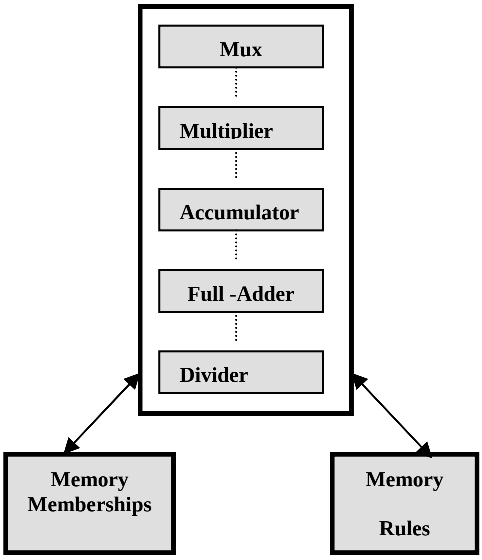

Fig.13: The top view of FL structure

6 VHDL description of the ES_GA_FL and synthesis implementation results

6.1 VHDL description of the ES_GA_FL

Synthesis of this design is achieved by using the VHDL language with register transfer logic (RTL) style description. The choice of VHDL comes from its emergence as an industry standard . The RTL style is used because it is well adapted for synthesis. The description of the *ES_GA_FL* begins by creating the components. The flexibility of the design is introduced by *generic* statement illsutred in the body of the program

6.2 **Synthesis and implementation results**: The described methodology has been used for FPGA using the synthesis tool Galileo. At this level, and depending on the target technology, which is in our case, the FPGA Xilinx XC4000 family, the synthesis tool proceeds to estimate area in term of CLBs (Configurable Logic Blocs). The table II

presents the best synthesis results for *ES_GA_FL* .The output (XNF file) generated by the synthesis tool is passed trough the XACT place and tool . For this, our file is tested in a different entities of XC 4000 FPGA and it is in the development in another laboratory to
be able to give all the netlist into XACT to root and place, that means that, as we have an electronic carte (a specific chip) ready to be implemented after rooting and place each element in the adequate place with the choose of the best family component .

Design	***AREA (in terme of CLBs)***
ES GA FL	***190***

Table II : Synthesis results

The output (XNF file) generated by the synthesis tool is passed trough the XACT place and tool. For the resulting FPGA implementation of recognition approach has been implemented into a single FPGA mapped.The Xact tool give as the best family of Xilinx cheap and the adequate archtecure taking into account : the parallelism, performance, flexibility and their relationship to silicon area.

6. Conclusion

In this paper; we have presented a new technique to recognize all Arabic characters in either their font, size, surface, inclined or no, and another presentations such as scaling and rotation. This technique is based on hybrid intelligent systems. The combination of FL and ES which are powerful technologies and are alternate to classical technologies has been very useful to build and realize intelligent task. In this second part of our project, is to find a meaning of classification with really intelligent task. In this paper we present, a prototype of an automatic reading Arabic characters system. The results gotten are very satisfactory when we compare by those in the first part of our project. Our main objective is to obtain a really intelligent system in order to recognize and to read automatically all presented shapes. At this effect, this article essentially articulated around two parts. A part of training and a part of recognition. We have presented in the first a new game of primitive based on the morphological and local features, the second uses the fuzzy principle for the classification and itself identification. For that to make, we have considered a whole of geometric primitives and own topologiqueses to classify and understand all characters. We have used one technique based on techniques of Artificial Intelligence ES and FL.ES will provide the software programs with more ***intelligence*.** Trough this paper, we have attempted to exploit complementary of these technologies (ES,FL,GA). This complementary measures an important opportunity in the measure that the system marked no dismissal. More, a powerful intelligent gives a reasonable decision to classify all shapes. To deal with the intelligent pattern recognition, a new design methodology of ES*_GA_FL* is introduced based upon a VHDL description and using a synthesis tool Galileo. The proposed VHDL description has the advantage of being generic and can be changed at the user demand. Furthermore, the specific VLSI implementation is introduced to take into account the time, parallel executions, and heavy treatments in a specific architecture to be executed. However in the future, it is necessary to use a “micro-product” in some specific applications by using advanced micro-product control systems, furthermore, to reach the market with new product in the shortest possible time, and so reduced development and production time. The financial risk incurred in this development of new product can be limited so that more new ideas can be prototyped.

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